MODELLING POPULATION MOBILITY IN SOUTHERN BAFFIN ISLAND'S PAST USING GIS AND LANDSCAPE ARCHAEOLOGY

by

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Abstract

Evidence of chert stone tools on southern Baffin Island of Canada dates back thousands of years, yet most of these materials are found far from coastal areas of use. In the central interior lakes region of Baffin Island, chert can be found but this area is extremely remote and hard to access. If past human populations moved inland from the coast to acquire chert toolstone and pursue seasonally specific subsistence-related activities, many archaeological sites should exist between these respective locales. Historically, it has been difficult to locate such intermediate sites given the expansive of the landscape and the logistical challenges of surveying it. In this study, free and open-source geospatial data were used in geographic information systems (GIS) to predict archaeological site formation and potential inland travel routes. The models created link the archaeologically dense coastal and inland regions. These were constructed with a landscape archaeology theoretical approach and validated by comparisons to Inuit ethnographic accounts of interior-bound pathways. A new archaeological-GIS method was created, using a flood allocation function on a 'humanistic' cost surface. This 'mobility-shed' method generates vast networks of areas most conducive to human movement, aids in solving problems about past human population movements for Baffin Island history, for an ongoing chert provenance study, and will lead to future research through ground-truthing and more in-depth geospatial studies. Most significantly, this research created a new GIS method for archaeological survey, which was effective in narrowing down search areas for no cost and will save a lot of time and money for future field research.

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Dedication

To Heather and Auberon: their love encourages my best work.

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Chapter 1- Introduction

On southern Baffin Island, the Inuit and their predecessors devised innovative lifeways that allowed them to thrive in a challenging landscape. This required regular seasonal movements to capitalize on the most abundantly available resources. To maximize the ability to annually replicate these seasonally-based settlement patterns, they needed to mentally 'map-out' those physical spaces. The action of physical movement places the human body in the cognitive realities of beliefs, curiosities, goals, thoughts, and traditions. When studying hunter-gatherer populations, this movement is called mobility as it pertains to the way they move across landscapes during their seasonal rounds (Milne et al. 2013:49; Kelly 1988:717). Each of those cognitive realities shapes what and how humans perceive their surroundings based on their environment, temporality, and tasks (Ingold 1993). Perceptions, formed between physical movement and these cognitive realities, directly relate humankind today to those that existed in the past. Unveiling this relationship is an ultimate goal in archaeology—to get 'into the minds' of past peoples and to understand socialization of similar landscapes (Tacon 1994). Understanding population mobility across a common landscape advances this goal. Thus, landscape archaeology presents an opportunity to relate contemporary experiences with those in the past.

This research uses geographic information systems (GIS) to digitally reconstruct pathways on southern Baffin Island, Nunavut, Canada. The purpose is to find out where and to suppose how Baffin Island's past populations moved from coastal locations to the deep interior region for caribou, chert, and human-companionship (Milne et al. 2013). GIS are a series of digital analytical tools from which various forms of spatially related data can be used, manipulated, created, stored, and presented. As a spatial technology, GIS in archaeology has enhanced "how we find and record archaeological remains, manage data, and investigate the historical relationship between our species and the world around us" (McCoy & Ladefoged 2009:279). GIS can provide answers to spatially related questions or questions of scale (Molyneaux 2006). Therefore, understanding how the past inhabitants of Baffin Island moved across the landscape can be accomplished through the use of GIS. Uses of GIS are only placed on the actual physical movement across a physical landscape without socio-cultural reflections of why those people are moving in their constructed 'cultural landscape.' Therefore, this research calculates mobility corridors that statistically favor terrestrial movement from southern Baffin Island's coasts to its interior lakes region.

Introduction to the Study Area

The study area comprises a large swath of land within a north/south extents (in degrees [°], minutes [‘], seconds[“]) of 65°0'0"/61°59'58.5" North (N) latitude and east/west extents of 63°59'58.5"/74°0'1.5" West (W) longitude (see Figure 1). Since the study area is north of 57°N latitude, it is categorized as tundra and, more specifically, low or continental tundra (Shelford 1963:182-183). This study area rests just south of the Arctic Circle situated at 66°33'44"N latitude. At these latitudes, there is nearly continuous sunlight for six months of the year (Shelford 1963:187). Then there is a very rapid decline in sunlight leading to two months—December and January—of near total darkness. Autumns spans September to early November and is marked by steadily decreased daylight and rapid declines in temperature. February and March represent the swift spring, marked by rapid ascent of daylight and a more gradual increase in temperature (Shelford 1963). Nunavut's territorial capital, Iqaluit, is located within the study area.

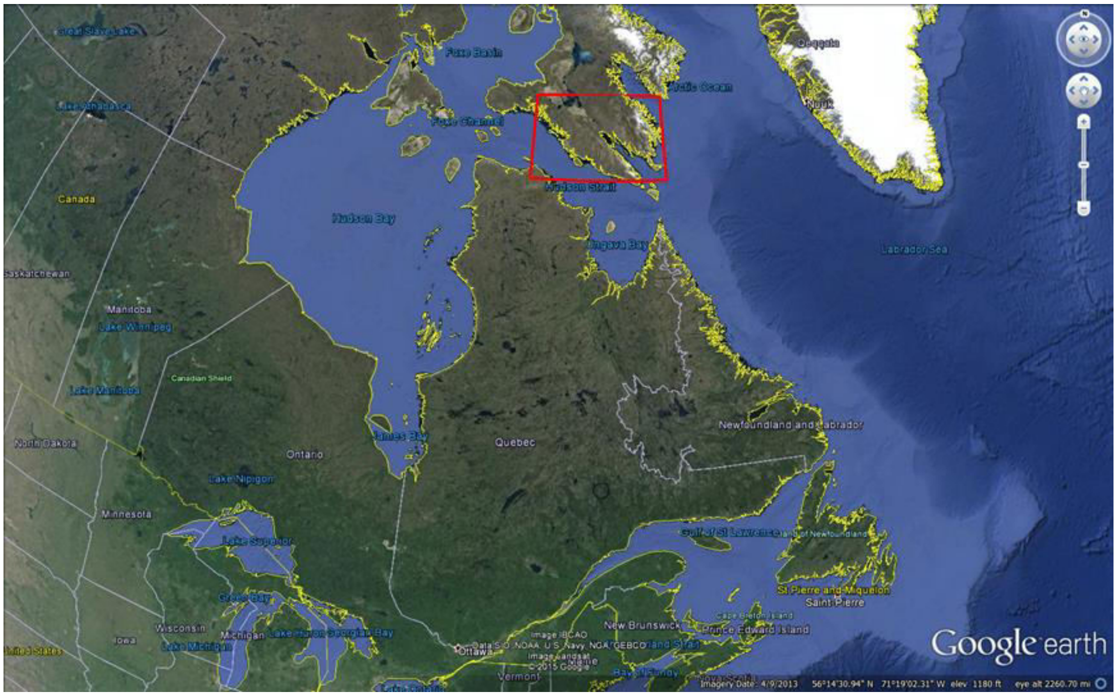

Figure 1. Outline of the study area in red (Google 2013).

The climate of the study area is classified as low Arctic with average temperatures between -32° to -28° Celsius (C) in January and 5° to 8°C in July (Stenton 1989:91). Annual precipitation averages between 175 and 250 millimeters (mm), coming from an approximate fifty-fifty split between rain and snow (Stenton 1989). Although precipitation rates would technically classify the study area as a dessert, there is an abundance of freshwater sources. The retreat of ice sheets around 10,000 years ago, after the end of the last ice age, left millions of kettle lakes and carved innumerable rivers, streams, and tributaries. Deglaciation left many larger inland lakes in the study area with the two most important, for mentioning here, being Amadjuak Lake, Baffin Island’s second largest lake, and a much smaller, but incredibly significant, Mingo Lake (Jacobs et al. 1997).

Southern Baffin Island's geology consists of two distinct zones: igneous and sedimentary rock. Natural Resource Canada's most recent geologic map exemplifies the geologic dichotomy of the study area. This map mirrors the study area, because the boundary of the study area was drawn in part for the ease of coordinating the various data available at Natural Resource Canada's website called GeoGratis (http://geogratis.cgdi.gc.ca/geogratis/Home?lang=en, English language search portal). The latest geologic map of the area (St. Onge et al. 2006) differentiates the two geologic zones at first glance. Deep red, orange, and yellow colors stretching from the coast to inland represent the igneous rock dominated area. Blue peaking to the south and southeast of Amadjuak Lake and spanning along its west on the Plain of the Koukdjuak exemplify the limited areas where surficial geology consists exclusively of sedimentary rock (St. Onge et al. 2006; see Figure 2, p.5). These two zones will prove incredibly significant. The former provides challenging obstacles in moving across the study area's natural environment, whereas the former provides the only areas where suitable raw material for chipped stone tools may be acquired in addition to providing suitable habitat for subsistence resources.

According to the classifications derived from satellite imagery by Natural Resources Canada, the study area consists of fourteen different types of land cover (Geobase 2009). Generally, these can be categorized by snow/ice, water, wetlands, wet sedge, exposed rock, shrubs, and other vegetation composing a tundra landscape (Geobase 2009:8; see Figure 3, p.8). However, the fourteen land cover types do not distinguish the vast array of specific rock types and plant species that would become visible on the ground. Although these specifics are important, generalization of land cover types help in geospatial analyses that use characteristics to determine factors influencing human behavior, including, but not limited to, ease or difficulty of moving across, access to food, access to fuel, and access to toolstone. Additionally, these land cover generalizations highlight the geologic zones described in the previous paragraph, because the sedimentary zone proves to have more diverse land cover characterized by the many forms of Arctic tundra vegetation. Broadly, the general land cover categories aid this research by distinguishing areas of land more suitable to movement by human populations on foot.

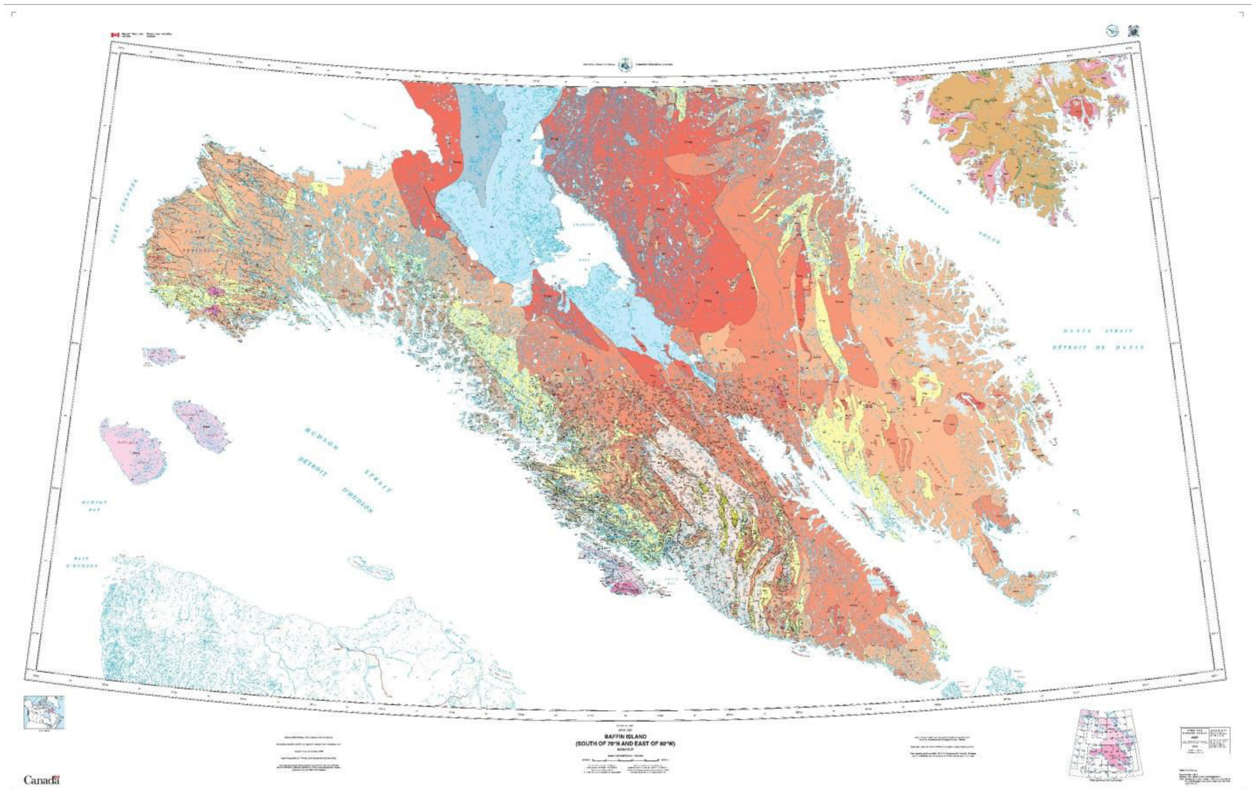

Figure 2. Geology Map of Study area (St. Onge et al. 2006). Blue in middle is sedimentary rock while red, orange, and yellow around it is igneous.

Landscape Perception and Archaeological Problem Solving

Demonstrating the effectiveness of using landscape as the unit of analysis requires a thorough case study. This research provides such an example by using landscape archaeology to critically solve land-based problems for an ongoing archaeological project on southern Baffin Island. Inuit ethnographies recorded from this region (see Bilby 1923; Boas 1964 [1888]; Hall 1865; Müller-Wille & Barr 1998; Stenton 1991c) describe an inland journey between the spring and late autumn to harvest caribou (*Rangifer tarandus*), Arctic char (*Salvelinus alpinus*), and nesting waterfowl such as the snow goose (*Chen caerulescens*).

The centrality of the interior, which is easily accessible from the neighboring coastal uplands, also afforded people opportunities to visit with other social groups who wintered in distant coastal areas (Milne 2005, 2011, 2012; Milne et al. 2013; Stenton 1991c). Archaeologists (e.g. Milne 2005; 2008; Park 1993; Park et al. 2014; Stenton 1989,1991c) use these Inuit accounts to construct testable interpretive frameworks to reconstruct land use patterns followed by the region's earliest occupants, who are known archaeologically as Pre-Dorset (4500-2500 BP) and Dorset (2500-1000 BP). Remains of sites dating to these cultural periods indicate an intensive seasonal exploitation of caribou and waterfowl (McAvoy 2014; Milne & Donnelly 2004; Milne et al. 2012). However, unlike more recent Thule-Inuit populations, these earliest inhabitants also went inland to procure chert toolstone to refurbish their chipped stone toolkits (Milne 2003, 2005, 2012; Milne & Donnelly 2004) – a raw material not widely used in Thule-Inuit technology (Stenton & Park 1998). Chert is localized in its geological distribution and can be readily found near Mingo, Amadjuak and Nettilling Lakes.

Archaeological surveys have been conducted along southern Baffin Island's coastal areas (e.g. Maxwell 1973; Park 1997; Stenton 1987) and in the interior region (e.g. Milne 2003, 2007, 2008; Park 2008; Stenton 1989, 1991 a/b/c). However, systematic archaeological survey to explore the vast landscape separating these regions has never been done. Therefore, little information exists about how human populations moved between southern Baffin Island's deep interior and coastal locales over a period of 4500 years. In 1991, Stenton (1991c), who was building on his pioneering archaeological investigation in the interior, attempted to survey an interior pathway described by Inuit elders, but was unable to do so due to weather. Although it was once attempted (Stenton 1991c), some Inuit interior pathways have been loosely drawn (Boas 1888), and in one case thoroughly documented based on accounts recorded from living Inuit elders on northern Baffin Island (Aporta 2009). Herein lies the problem: interior movement occurred prior to Inuit habitation more than 1,000 years ago (Friesen 2013; Park 1993) and as far back as 4,500 years (Milne 2005, 2008; Park et al. 2014), but where exactly did it occur? What routes did people follow and why?

Statement of Research Objectives

The objective of this study is to devise a 'landscape connectivity analysis' that predicts likely paths that past peoples would have travelled on. To meet this objective, this study uses a combined approach that integrates GIS with a theoretical/methodological approach known as landscape archaeology. More specifically, GIS is used to find most suitable pathways for human movement by manipulating geographic/environmental data, including elevation models, waterways, and land cover. Thereafter, landscape archaeology is used to contextualize these generated pathways with the goals past peoples may have had while travelling. Among these goals are the ideal routes these peoples could have used to efficiently extract and acquire chert toolstone, among other essential seasonally available interior resources. Simply stated, this study aims to:

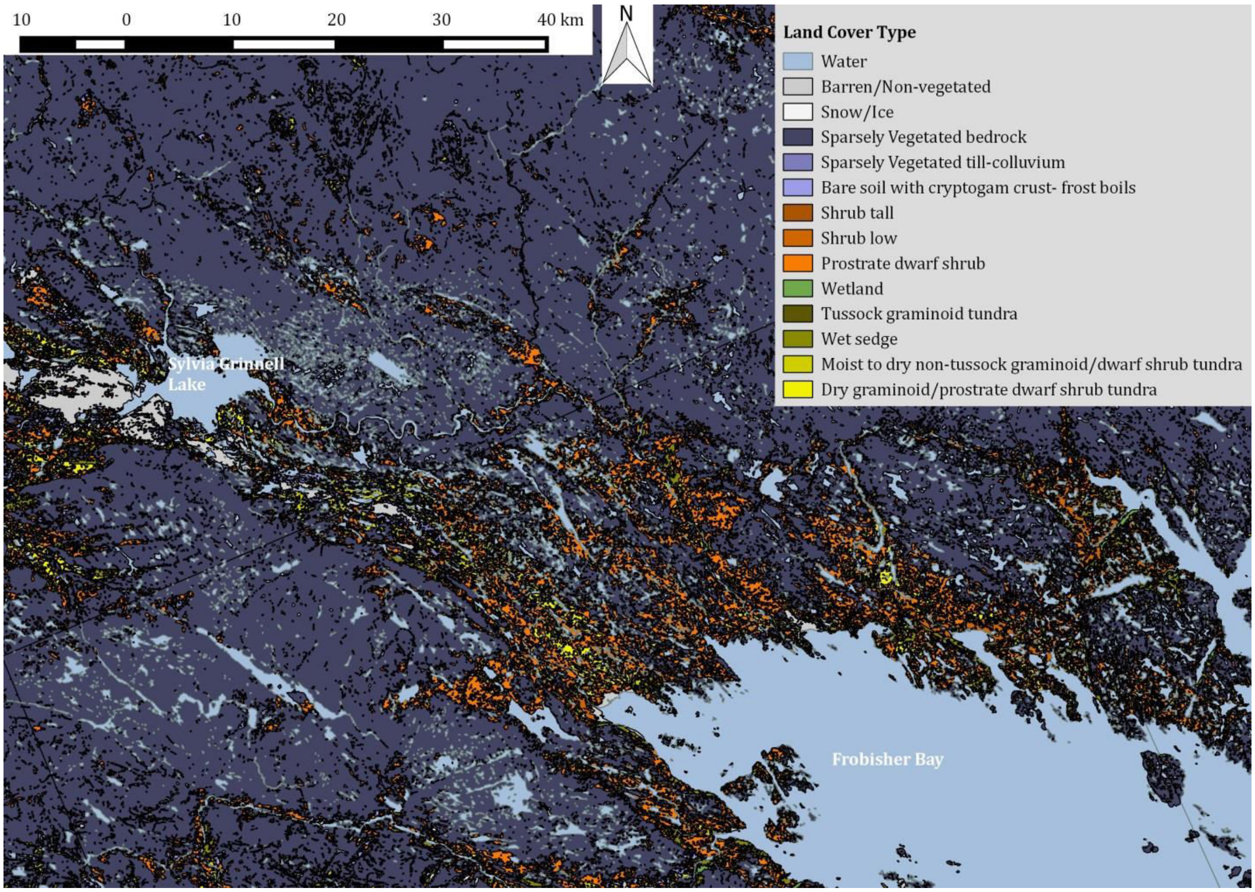

Figure 3. Cover Types (see legend) highlighted by zooming in to an area between Frobisher Bay and Sylvia Grinnell Lake (Geobase 2009).

1. Devise methods to generate plausible paths from Baffin Island's coast to its interior

2. Relate these digital paths to human experience: through oral history and toponymy

3. Lay the foundation for site predictive models using geography and geology of chert sources

In direct connection to Milne et al.'s Southern Baffin Island Chert Provenance Project (see Milne 2012; 2013; see also ten Bruggencate et al. 2014), my goal is to provide information to achieve objective three, "(3) combine our inland and coastal findings in order to reconstruct Inuit predecessors mobility patterns and settlement using chert as a proxy" (Milne 2012:4). I developed a model to predict potential archaeological sites in this natural environment on these long stretches between the archaeologically dense areas on the coast and interior lakes region. Results of the analysis to follow elucidate places within the natural environment that are most conducive to human movement. I have generated pathways most plausible in reconstructing the spaces within which past peoples traversed, acted, and lived. Perhaps, most significantly, this research contributes a narrowed search area in an otherwise massive landscape that will greatly facilitate future field research that, by extension, will facilitate the achievement of the chert provenance project's greater objectives – i.e. to connect inland and coastal settlement areas through the identification of ancient travel routes.

A related goal of this research is to transparently convey a practical methodology that can be applied to an array of archaeological circumstances that reach beyond the study area. Just as there are potential spatial problems of connecting coastal and inland sites on southern Baffin Island, bridging assumed spatial correlation between two places proves problematic for archaeology as a discipline. The methods devised and used in this study have not been applied to archaeology in the eastern Arctic (i.e. Arctic archipelago and mainland, Greenland). Further, these methods may be of use to future research to archaeology in many geographic regions worldwide. Lastly, this research provides an opportunity to evaluate the application of GIS in archaeology. There has been much "theoretical" debate about the role GIS can and should play in archaeology (Barcelo 1998; Ebert 2004; Rennell 2012, Wheatley n.d.; Witcher 1999; among many others). However, GIS is a computer software program designed to be a series of problem solving tools. In the chapters that follow, this research clearly separates theory and method where the latter uses tools to produce data while the former seeks manners in which those data can convey the realities of human interaction with the places in which they live.

Significance of Research

The Southern Baffin Island Chert Provenance Project is trying to understand Palaeo-Eskimo population mobility by examining the access and acquisition of chert in the interior for toolstone (Milne 2012). This thesis provides information about chert accessibility by highlighting places chert is likely available and by showing ways in which people could have travelled to it. However, creating a predictive model for archaeological site formation based on chert availability was treated secondarily throughout the formulation and execution of this geospatial analysis. Focusing strictly on Palaeo-Eskimo movement would have resulted in falling for the *a priori* trap Least Cost Path (LCP) analyses and archaeological GIS tend to fall into. This major pitfall will be discussed more thoroughly in Chapter 3. Primarily, this analysis created a generative model for population mobility by modifying GIS functions designed to calculate entire watersheds. This devised 'mobility-shed' is applicable to all peoples who would have been moving across the various environments on southern Baffin Island, and depicts more fluid movement across the landscape instead of A to B paths (Fábrega-Álvarez 2006; Llobera et al. 2011). After the analysis was completed, it was then possible to expand on it by corroboration with Inuit oral histories, toponyms (i.e. place names), and potential chert sources that may have been exploited by Palaeo-Eskimo populations during their seasonal round.

Organizational Framework

The methods and theoretical frameworks used in this study, along with the results, are presented in six chapters. Chapter 2 presents the archaeology of the study area, briefly describes ongoing chert provenance studies, the culture history, and current southern Baffin Island chert provenance project. Chapter 3 discusses the theoretical perspective and methodology of this research. It starts with an introduction to landscape archaeology as a theoretical perspective. This is followed by a literature review of how GIS, LCP analyses, and remote sensing have been used in archaeology. The methodology section thoroughly describes the materials used, the processes of the GIS analytical methods. Chapter 3 concludes with the presentation of the study's research hypothesis. Chapter 4 presents the study's raw results of the GIS analysis and introduces the ways in which the generated pathways are significant representations of how southern Baffin Island's past populations moved between the coasts and the interior. Chapter 5 is the discussion chapter taking the results of the GIS analysis, among other spatial data, and contextualizes them within cultural meanings. These meanings include Inuit oral histories of inland travel routes, Inuit toponyms, a discussion on geographic and human-made landmarks, a preliminary examination of Palae-Eskimo site formation based on chert accessibility, and explores the significance of landscape movement to the Inuit and their predecessors. Finally, Chapter 6 concludes by summarizing the project, evaluating the hypothesis, proposing potential for future research, and promotes the use of landscapes as a unit for analysis in archaeological research.

Chapter 2- Study Area

Chert Provenance Studies in Southern Baffin Island

The Southern Baffin Island Chert Provenance Project originated as a research inquiry designed to identify the source of lithic raw materials, namely chert, used to make chipped stone artifacts excavated at an archaeological site known as LeDx-42. The site is located on the banks of the Mingo River, which connects Mingo Lake to Amadjuak Lake in the island's deep interior region (Hamilton 2008; Milne 2007; Milne et al. 2011). Investigation at LeDx-42 and other neighbouring sites in the region yielded evidence that appeared to challenge a common notion held by Arctic archaeologists that Dorset groups did not travel inland, like their Pre-Dorset predecessors, to acquire chert toolstone (Milne et al. 2012). Dorset type chipped stone artifacts were recovered from LeDx-42, among other sites, indicating southern Baffin Island's interior was an important place throughout the entire Palaeo-Eskimo period. Therefore, not only did the Thule-Inuit move inland for food and to rendezvous with other distant groups (see Stenton 1989), the archaeological record indicates that earlier Pre-Dorset and Dorset groups similarly went inland for the same purposes in addition to acquiring chert for chipped stone tools (Milne et al. 2013).

For stone tool using populations like the Palaeo-Eskimos, useable toolstone is an essential raw material needed to acquire subsistence resources and perform other technology-dependent tasks. In 2007, fourteen other inland sites along the northern shore of Mingo Lake (Figure 4, p.13) were visited to collect information on the use of local chert at inland sites (Milne 2007). A sample of chert debitage and raw chert nodules were examined geochemically in an effort to identify their provenance in the region. The results of this preliminary study appeared to indicate that local Palaeo-Eskimo populations were procuring and reducing the locally available toolstone in addition to other cherts whose provenance had yet to be identified (Hamilton 2008; Milne et al. 2009; Milne et al. 2011). This pioneering research served as the foundational springboard that kick-started the ongoing Southern Baffin Island Chert Provenance Project.

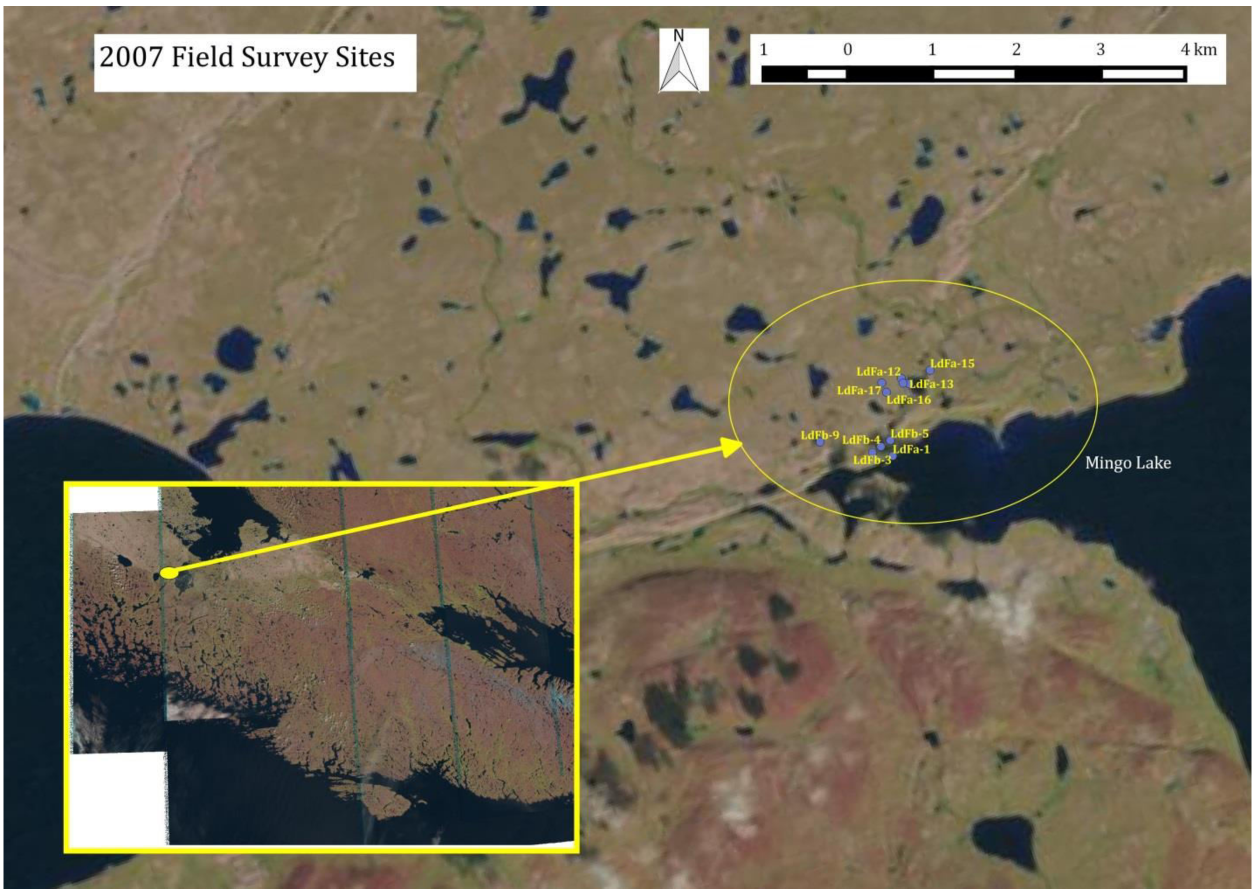

Figure 4. The 14 sites (yellow oval) around the northwest shore of Mingo Lake surveyed in 2007

Since these initial efforts, continued survey in the interior to identify *in situ* outcrops of chert toolstone resulted in the identification of two large quarry sites where chert is readily available. The first site is located on the southwest shore of Amadjuak Lake while the second is located on the banks of the Hone River, some 67 km to the southeast (Milne 2013; ten

Bruggencate et al. 2014). Preliminary results on the geochemical sourcing of chert from these locations appears to indicate they are distinguishable from one another, which will provide an important interpretive context to match archaeological chert from sites located in the region back to these discrete source locations (see ten Bruggencate et al. 2014). The present study aims to augment these findings by providing start and end points to human movement between these sites and source locations (among others), and could either verify or refute the generated pathways in addition to the appearance of archaeological sites. GIS and geochemical sourcing complement each other in both goals and results (Clarkson & Bellas 2014; Ekshtain et al. 2014).

Eastern Arctic Culture-History

Approximately 5,000 years ago, peoples of Siberian origin that had migrated into northern Alaska began moving eastward into the Canadian Arctic (Milne 2008a; Park 2014; Raghavan et al. 2014). The earliest archaeological evidence for these pioneering populations is characterized by the presence of microblades and other small lithic tools. The intriguingly small size of these implements led Irving (1957) to coin the name Arctic Small Tool Tradition (ASTt) (Ellis 2008; Friesen 2002; 2013). ASTt continues to be widely used by archaeologists when referring to sites where these tiny tools have been found (e.g. Friesen 2002; 2013; Hamilton 2008; Milne 2005; 2008; Milne et al. 2009; Milne et al. 2011; Milne et al. 2012; Park 1993; Stenton 1989, 1991c).

ASTt groups eventually colonized the Eastern Canadian Arctic and Greenland (Ellis 2008; Friesen 2002). Thereafter, these populations began to adapt to local environments and available resources, which led to the development of unique regional traits that are identifiable in archaeological record. Based on variations in stone tool types, subsistence patterns, and settlement structure, three early ASTt variants are recognized: Independence I, Saqqaq, and Pre-Dorset. Collectively, these populations are also known as early Palaeo-Eskimo – a term that is simply meant to recognize these colonizing populations inhabited the same regions as today's Inuit people (McGhee 1996). Late Palaeo-Eskimo refers to the descendants of these populations who are the Dorset (Milne et al. 2012). Both Pre-Dorset and Dorset remains have been found at archaeological sites located in the interior and coastal regions of southern Baffin Island.

While Pre-Dorset is widely accepted as ancestral to Dorset (Friesen 2002; 2013; Milne 2005; Milne et al. 2013; Park 1993; Stenton 1991c), the exact dates and mechanisms leading to a presumed period of transition from one to the other varies regionally and has been hotly contested for decades (see Nagy 1994; Milne & Park 2015). Archaeologists differentiate Pre-Dorset and Dorset site occupations based on typological changes in lithic bifacial tools, projectile/spear points, and the presence or absence of two diagnostic types of engraving tool: the Pre-Dorset spalled burin and the Dorset burin-like tool (Maxwell 1985; Milne et al. 2013).

Figure 5. Examples of Pre-Dorset spalled burin and Dorset burin-like tool

Pre-Dorset

Southern Baffin Island Pre-Dorset populations are characterized, in part, by their long distance seasonal between the interior and coastal regions. Remains from sites in both locales attest to the efficient subsistence strategies used by these populations to exploit both terrestrial and marine mammal resources (Maxwell 1973, 1985; Milne 2003; Milne et al. 2012, 2013). Other important subsistence resources available in the interior included abundant nesting waterfowl, fish including Arctic char, berries and other plant resources, and fresh lake and river water to drink (Milne and Donnelly 2004; Milne 2011; Stenton 1989). Opportunities to visit other distant peoples and a change in scenery after the long winter were also important motivators to make the journey (Milne 2008a; Milne et al. 2011; Milne et al. 2012; Milne et al. 2013). Lastly, the localized availability of chert toolstone in the interior was an essential resource required by the Pre-Dorset to maintain their toolkits (Milne 2008a; Milne et al. 2011; Milne et al. 2012; Milne et al. 2013).

Dorset

The Dorset culture first emerges in the archaeological record around 2500 BP and then terminates roughly 1000 years ago when the Arctic climate began to dramatically warm. Dorset toolmakers are largely identified by a number of changes in their lithic tool assemblages, lithic raw material preferences, settlement patterns, and subsistence strategies (Milne 2005; 2008a; Park 1993; 2008; Stenton 1991c). Dorset toolkits included high frequencies of implements associated with the specialized hunting of marine mammal resources including sophisticated harpoons used to hunt seals on the sea ice and near the floe edge (Milne et al. 2011; Milne et al. 2012). Not only do the Dorset lithic assemblages appear typologically different from those used by their Pre-Dorset predecessors, a shift in lithic raw material selection strategies appears to have occurred (Odess 1998). Specifically, higher frequencies of Southampton Island banded chert, Ramah Bay chert, and crytal quartz are described from Dorset site assemblages on southern Baffin Island, among other Arctic regions (McGhee 1996; Maxwell 1985; Milne 2008a; Milne et al. 2011; Odess 1998).

The location, density, and structure of Dorset archaeological sites suggest these populations followed a more sedentary, coastal-marine oriented way of life. Often, Dorset constructed more permanent shelters and relied more heavily on non-migratory ringed seals hunted from their breathing holes or from sea ice floe edges (Milne 2008a; Milne et al. 2012). This way of life led archaeologists, like McGhee (1996) to characterize the Dorset as an "ice-adapted species." However, recent fieldwork (Milne et al. 2012) challenges the notion that Dorset populations were more sedentary and rarely traveled to neighboring inland areas. Evidence from the interior of southern Baffin Island suggests Dorset populations, like their Pre-Dorset predecessors, maintained long-distance seasonal inland travels for at least part of the year to hunt caribou, socialize, *and* acquire chert toolstone (Milne et al. 2012, 2013; emphasis added).

Thule-Inuit

Thule-Inuit colonization of the Alaskan and Canadian Arctic occurred even more rapidly than that of the Palaeo-Eskimo. Whereas the Palaeo-Eskimo spread across the entire region within a few centuries, it seems the Thule-Inuit were able to accomplish the same feat over a generation (Friesen 2013:6-7). The Thule-Inuit groups established themselves throughout the Arctic around 1,000 years ago. For decades, archaeologists have speculated there was temporal and cultural overlap between the Dorset and Thule (e.g. Friesen 2000; McGhee 2000; Park 1993, 2000). However, no evidence for interaction between these two groups exists (Park 1993; 2014), and recent genetic studies have confirmed that no population admixture ever occurred (Raghavan et al. 2014). During the worldwide "Medieval Warm Period", around 1,000 years ago, Dorset tool-making groups would have been unable to maintain their sea ice based maritime subsistence (Friesen 2013; Milne 2008a; Stenton 1991c). Consequently, their population became unviable before or as the Thule-Inuit groups moved in (Friesen 2013; Park 2014; Raghavan et al. 2014).

The Thule-Inuit, who are the confirmed direct ancestral populations to today's modern Inuit (Friesen 2002; 2013; Milne et al. 2012; Stenton 1989, 1991c), had a prolific material culture including organic (e.g. skin, baleen, bone, antler, ivory, wood), slate, and in some cases meteoritic iron implements, among other materials. Many of these more delicate objects have been found encased in permafrost resulting in their unique preservation in the archaeological record (Park 1993; Stenton 1991c). In addition to the organic material tools, Thule-Inuit artifact assemblages include a variety of objects made from slate and soapstone including oil lamps, which provided efficient and smoke-free sources of heat and light during the Arctic winter. A signature eco-fact appearing in Thule-Inuit archaeological contexts are the skulls, in whole or part, of bowhead whales (*Balaena mysticetus*). These massive whales were a major component of Thule-Inuit subsistence and spirituality (Friesen 2013; Stenton 1991c). Other important components of Thule-Inuit technology included metal objects, dog remains, and dogsleds.

With the onset of the little ice age, the Thule way of life transformed into what is recognized as today's Inuit culture. The "Little Ice Age" started around 800 years ago, intensified around 400 years ago, and tapered off just over 100 years ago (Stenton 1991c:40-41). During the cooling, terrestrial adaptations became essential for prolonged survival (Stenton

1991c:47). For the Thule-Inuit on southern Baffin Island, caribou became such an important resource that it changed these peoples' subsistence and settlement strategies in addition to altering their social behavior and ideological practices. Caribou remain an important resource for local Inuit populations who continue to travel inland during the summer to hunt and camp (Stenton 1989).

Resource Availability and Land Use Patterns on southern Baffin Island

The following discussion focuses on resource availability within southern Baffin Island's interior lakes region. Flora resources were used as edible plants, fuel sources, and to scout caribou pasture (Stenton 1991c). By the summer and into fall, edible plants included sorrel leaves (*Oxyria digynia*), knotweed roots (*Polygonum viviparum*), bilberries (*Vaccinium uligininosum*), cranberries (*Vaccinium vitis-idaea*), bearberries (*Arctostaphylos alpina*), and crowberries (*Empetrum nigrum*) (Stenton 198994). Plant species used as sources of fuel included Arctic willow (*Salix Arctica*), dwarf birch (*Betula nana*), and the high-resin Arctic heather (*Cassiope tetragona*) (Stenton 1989:94). Stenton (1989) suggests that Arctic heather was preferred as a fuel source since its high resin content would make for a longer lasting fire.

Arctic char—a seasonally migratory member of the Salmonidae family—are widely available in shallower fresh water Arctic lakes (Stenton 1989). These fish are easily attainable and were the most important fish resource for human populations in the study area. During the annual fall migration, massive quantities of Arctic char can be caught (Stenton 1989). Other human-edible fish available in interior lakes include three-spine stickleback (*Gasterosterus* *aculeatus*), nine-spine stickleback (*Pungitius pungitius*), and, though extremely rare, Atlantic salmon (*Salmo salar*) (Stenton 1989:93).

Terrestrial hunting focused on two primary sources: snow goose (*Chen caerulescens*) and caribou. Snow geese molt in the late summer rendering these birds flightless for weeks at a time. With estimates of over a million of them breeding and nesting in the lowlands on the Plain of the Koukdjuak (Hamilton 2008; Milne & Donnelly 2004; Stenton 1989:94-95), these birds represented a rich and reliable subsistence resource that could be readily obtained by local human populations. Three resident caribou herds roam on the interior of southern Baffin Island. Although caribou can be found coastally and inland, the massive herds reside in the interior and have numerous satellite herds that graze on the tundra from the southeastern coast of Amadjuak Lake, west to Mingo Lake, and north to Nettling Lake (Boas 1964[1888]; Kemp 1976; McAvoy 2014; Stewart et al. 2004). Stenton (1989:95-96) states that one herd includes up to 60,000 animals that roam the interior of southern Baffin Island. The cyclical availability of caribou has led to many archaeologists (Friesen 2002; 2013; Hamilton 2008; Milne 2005, 2008; Milne et al. 2009; Milne et al. 2011; Milne et al. 2012; Park 1993; Stenton 1989, 1991c) to propose that caribou were the most important resource to all human populations that inhabited southern Baffin Island given their meat, hides for clothing, and raw material for tool construction.

The Pre-Dorset, Dorset, and Thule-Inuit groups of southern Baffin Island all respectively occupied the same landscape. Although climatic conditions varied, the geographical and geological features did not change dramatically during the human occupation of the area. Whether these respective cultures were "pre-adapted" to the Arctic environment or were able to simply adapt quickly to regional variations in climate and resource availability (Friesen 2013:6-7; Milne 2008a:194), all effectively established stable and rich cultural traditions that lasted for millennia. Archaeologically, all of these groups during their existence on southern Baffin Island maintained one identical practice: they journeyed long distances to the interior region to reach the shores of Mingo Lake and southern Amadjuak Lake (Hamilton 2008; Milne 2005, 2007, 2008a/b, 2012, 2013, Milne et al. 2009; Milne et al. 2011; Milne et al. 2012; Stenton 1989, 1991c). Caribou were one motivating factor to go inland. Additionally, the possibility of a change in scenery, a chance for adventure, and continuing the tradition of the generations before them may have made this journey physically, mentally, emotionally, and spiritually necessary. Additionally, chert in the interior motivated peoples who needed it as toolstone for survival (Hamilton 2008; Milne 2005, 2007, 2008a; 2012; 2013; Milne et al. 2009; Milne et al. 2011; Milne et al. 2012), and it served as a centripetal force (Molyneaux 2002) that comforted the weary journeyers by letting them know they have come to the right place.

<u>Chert Sourcing and Current Research in the Study Area</u>

In 2012, Milne et al. launched the four-year Southern Baffin Island Chert Provenance Project. Three seasons of fieldwork- 2012, 2013, 2014- have been completed with the final year of fieldwork planned for the summer of 2015. The main goal of the project is to clearly demonstrate the movement of Pre-Dorset and Dorset groups on Baffin Island to the interior in order to acquire chert toolstone (Milne 2012; 2013). Specifically, the projects objectives are four-fold:

> (1) Identify other potential sources of chert used by the Inuit predecessors in the interior of southern Baffin Island; (2) determine if the Inuit predecessors who used neighboring coastal regions also used chert from these same inland sources; (3) combine our inland and coastal findings in order to reconstruct Inuit predecessors mobility patterns and settlement using chert as a proxy; and, (4) develop a data base of chert distribution, both from archaeological sites and raw

> sources, and make it available as a resource of others studying stone tool technology in Nunavut (Milne 2012:4).

Unforeseen logistical problems prevented the field crew from exploring the interior during the 2012 summer investigation (Milne 2012). However, the survey conducted at two archaeological/geological sites- KkDn-1 and KkDn-2- located adjacent to the Sylvia Grinnell River within the Iqaluit city boundary (Figure 6, p.23) provided helpful information for the project (Milne 2012:5). It was determined that none of the local rock formations were chert bearing meaning that it was highly unlikely a local chert source location existed in the area (Mine 2012). However, chert artifacts are prolific among Pre-Dorset and Dorset sites in the area, meaning the raw materials from which the tools were made had to have been brought in from non-local sources (Milne 2012:6). Archaeological survey, geological mapping, and local oral histories attest to the presence of chert in the island's interior region. Research continues in an effort to link coastally derived samples of archaeological chert to known inland source locations.

Given the problems encountered in 2012, the main objective of the 2013 fieldwork program was to identify *in situ* sources of chert in the interior region. Fortunately, these efforts were successful with the identification of two distinct sources of toolstone quality chert. One of these sources is thought to be linked to an informal local Inuit story that recounts a place called "Chert Island," which was thought to be located near the southwestern shore of Amadjuak Lake (Milne 2013). Although no island was found, there was a substantial chert-bearing moraine-like peninsula with a thin and shallow isthmus, that may have once been submerged, connecting the feature to the shore (Milne 2013:19-20). In close proximity to an eroding boulder field containing *in situ* nodules of chert on an archaeological site, LdDx-2, that contains ten different areas characterized by the remains of stone tent rings, hearths, and expansive scatters of chert toolstone (Milne 2013:22).

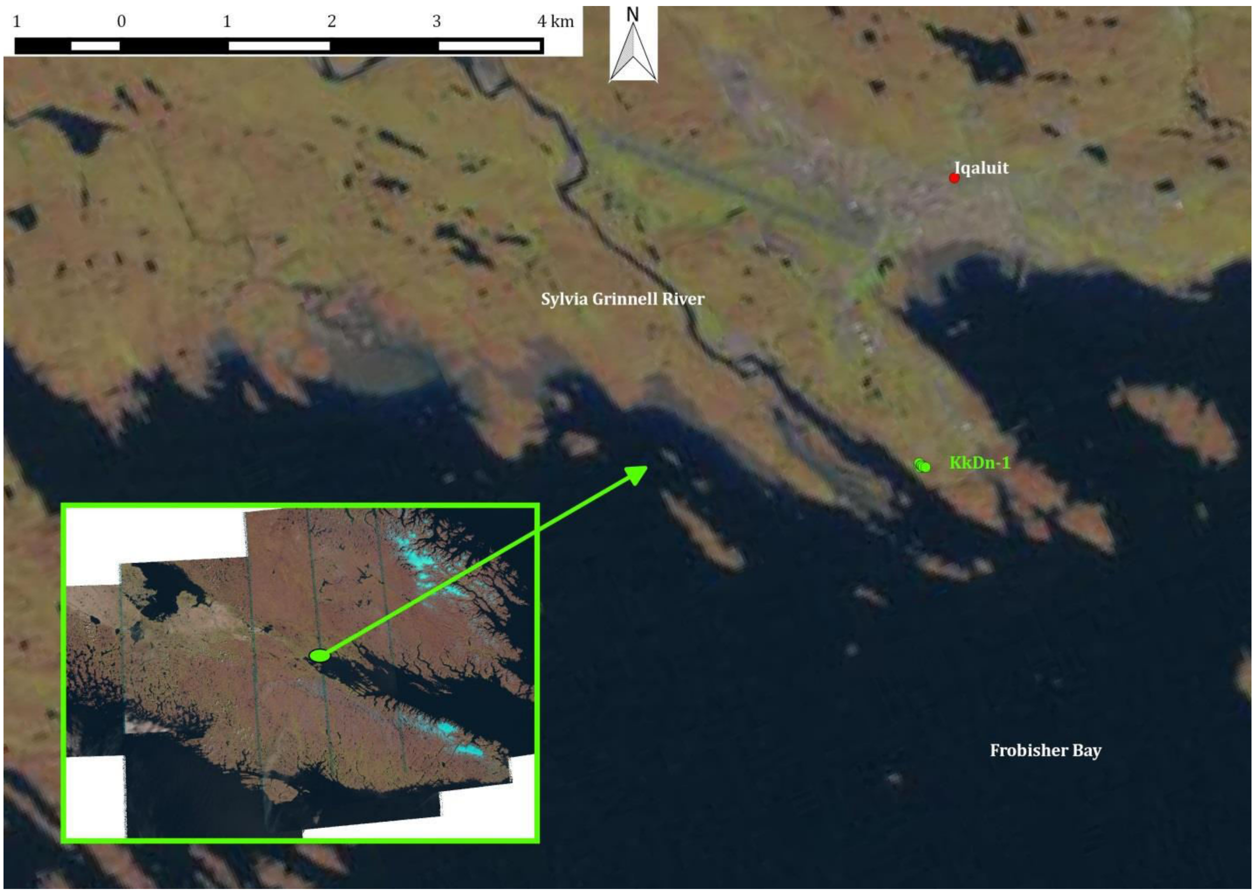

Figure 6. View of 2012 Field Survey site KkDn1 (green) where archaeological remnants were found, at the mouth of the Sylvia Grinnell River near Iqaluit.

The second chert source identified in 2013 was spotted during helicopter reconnaissance over the Hone River. Tent rings were observed and the crew landed at the site to investigate. There, they discovered numerous tent rings and massive areas, one about an acre in size, of chert debris (Milne 2013:26). Limestone outcrops with *in situ* chert nodules jut out and are eroding into a chert cobble beach on an eddy along a bend in the Hone River. The evidence of stone tool production and the ease of accessibility to high quality chert suggests this new archaeological site, LbDt-1, was a prolific quarry for past peoples (Milne 2013). Discovering two sites (Figure 7, p.25) where chert could and/or was being extracted by Palaeo-Eskimo groups shows promise for the future of the chert sourcing project, because this further validates that past peoples in southern Baffin Island were in fact going inland to acquire toolstone.

Both artifact and raw lithic samples were collected from all of the sites visited during the 2012 and 2013 field seasons (Milne 2012; 2013). These samples are undergoing various geochemical analyses to source them (ten Bruggencate et al. 2014, 2015), attempting to either match them to the raw samples collected from these seasons or the previous seasons dating back to 2004 (Hamilton 2008). If the raw materials do not provide a match then their chemical signatures can be entered into a database with the hopes that future discoveries will. So far, the first two years of the project have produced two facts. One, coastal areas do not have readily available sources of chert toolstone yet chert artifacts are present. Two, there are locations in the interior where tool quality chert is readily available. These evidences demonstrate the positive direction of the Southern Baffin Island Chert Provenance Project towards achieving its research objectives about technological organization and regional land use in the study area.

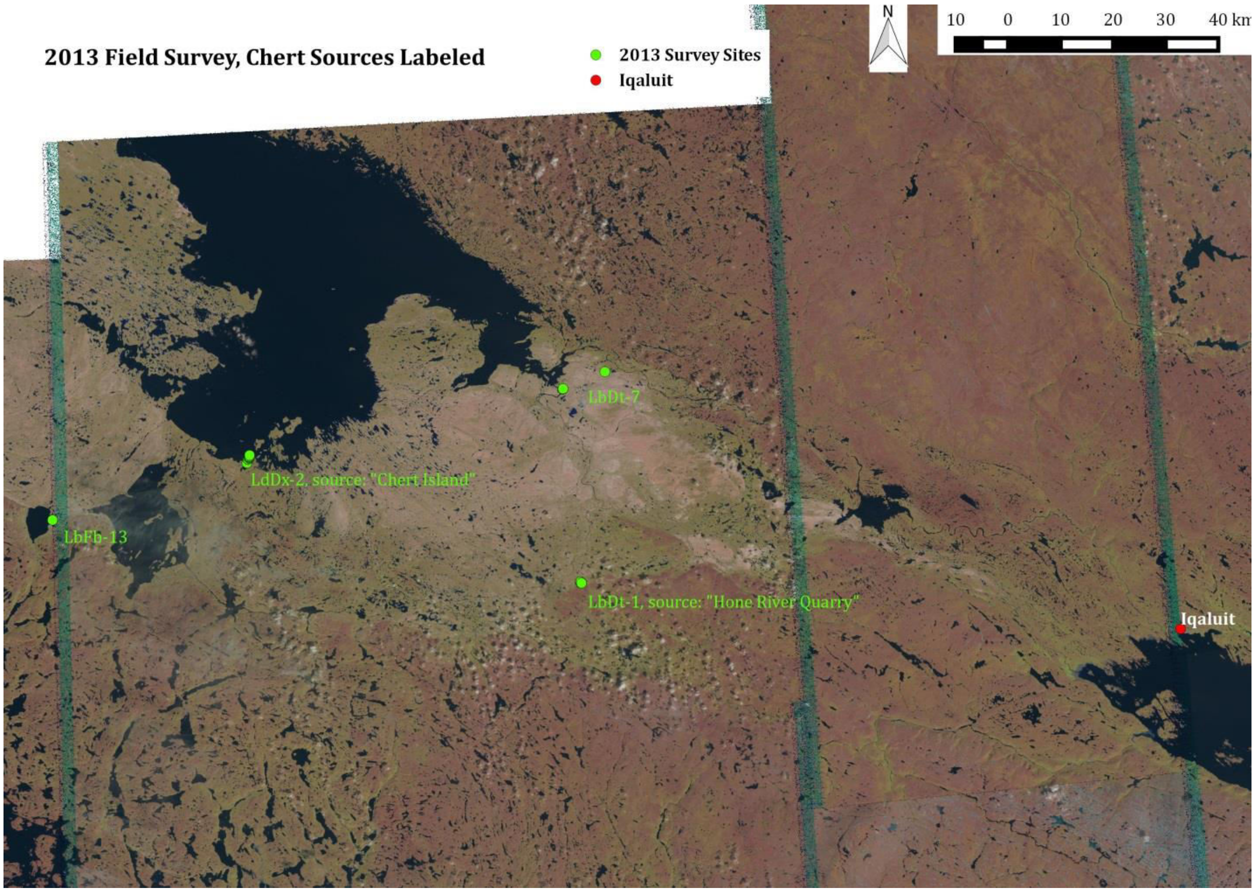

Figure 7. Locations of 2013 survey with chert sources labeled (green)

Chapter 3- Theoretical Frameworks and Analytical Methodologies

This chapter begins with an explanation of the theoretical frameworks used in this study. Landscape archaeology- the study of physical and cultural landscape- examines the relationship between land and how people act upon it (Ingold 1993). Both landscape types are important independently, but how the two are related proves most important. Attempts to relate the two landscape types have resulted in a schism of landscape archaeologists. Rennell (2012) has gone as far as to say that a "methodological dialogue" is needed to bridge landscape archaeologists who favor the empirically verifiable side of using GIS to those interested in its perceptual implications (Shanks & Tilley 1992). A theory-based goal of this thesis is to demonstrate how cultural and physical landscapes can be both differentiated and related. This achieved using a two-pronged approach involving a statistical geospatial analysis using GIS and a "perception analysis" (Witcher 1999) that draws on indigenous knowledge and toponyms, in addition to perceptual understanding, common sense, and phenomenology.

Phenomenology addresses human agency and how it pertains to action in response to their human surroundings (Heidegger 1996[1927]; Ingold 1993; Rouse 2006; Tacon 1994). Heidegger (1996[1927]) frequently discusses the significance of human beings interacting with objects. Also, he (Heidegger 1996[1927]) emphasizes the importance of how and why individuals use any particular object, which leads to any number of reasons people perform(ed) any given practice. Additionally, knowledge of place changes how and why people choose to act or use an object in a particular way at a particular time. A clear example of this is Heidegger's description of the hammer (1996[1927]; Rouse 2006). When a human picks up a hammer, they have to understand the context of a hammer's use like when it should be used or when certain techniques are necessary. Then, the person must know how hard and often they need to strike with the hammer. Finally, the hammerer must understand results. Does the product provide a feeling of satisfaction whether functional or aesthetic (Heidegger 1996[1927]; Rouse 2006:502-503)?

Heidegger's (1996[1927]; Rouse 2006) example of the hammer mirrors many of the basic desires archaeologists have. Archaeological data represents both being and time. Action took place in a particular space where that action served a purpose, which was understood by an individual in the past, conducted within a context, carried out in a knowledgeable manner, and resulted in a product. Objects, the archaeological remains, are the proxy upon which archaeologists reconstruct how and why an action took place. Other than the objects, archaeologists can use the landscape to piece together human behavior.

Perceptions, Ecology, and GIS

Perception and meaning transform the landscape into a place that is familiar to those who move across it (Bennett & Rowley 2004; Kelly 1988; Milne et al. 2013; Tacon 1994). Thus, to study mobility is to examine perception (Witcher 1999) based upon how a group socialized their surroundings into day-to-day tasks (Ingold 1993; Tacon 1994). GIS and the study of landscapes enable the archaeologist to serve as a human ecologist of the past. Human ecology is based upon understanding the relationship between landscapes, both physical and cultural, in what has also been called the study of "task-scapes" (Ingold 1993).

Landscapes

Physical landscapes (or natural environments) are perpetual, and constantly surrounding lands (Ingold 1993) and the physical world that humans socialize (Tacon 1994). The natural environment consists of animals, climate, geology, geography, plants, topography, topology, water bodies, waterways, and weather. In the most basic sense, the natural environment is what humans see and most often think of when hearing the word landscape. The natural environment changes so slowly that it remains nearly the same for generation after generation. Thus, landscapes possess stories to be told (Bennet & Rowley 2004; Ingold 1993) and people can transfer their understanding of a natural environment. Accordingly:

> "A person who can 'tell' is one person who is perceptually attuned to picking up information in the environment that others, less skilled in the task of perception, might miss, and the teller, in rendering his *(or her)* knowledge explicit, conducts the attention of his *(or her)* audience along the same path as his *(or her)* own" (Ingold 1993:153; emphasis added).

The landscape's ability to tell the past's stories can be clarified by two examples: resource availability and landmarks. Further, these examples start to demonstrate how people today can take the natural environment and socialize them into a world that is familiar, livable, and navigable (Bennett & Rowley 2004; Tacon 1994)

To understand landscape is to understand resource availability. There are a broad range of resources humans need to survive including clothing, food, shelter, and water. Throughout history, humans had to find, remember, and utilize their available resources. One such resource, used as an example here, is raw material for stone tools. Andrefsky (1994) demonstrates the impact of lithic raw material availability on human decision-making. He claims that availability of usable toolstone directly influences the choices humans make about the types of tools they produce, which indirectly affects "settlement configurations" (Andrefsky 1994:23). With three clear cases in Colorado, Washington, and Wyoming in the United States, Andrefsky (1994) shows that availability and qualities of toolstone forced humans to adapt to that resource. They must configure themselves to live in situations where toolstone can be acquired, efficiently shaped for purpose, and remain near enough to subsistence resources. Clearly, resource accessibility requires consideration when understanding past human decision making. Humans must make decisions based upon the natural environments in which they live, and this requires navigation and remembrance of significant places therein.

Physical movement across a natural environment requires consideration of resources necessary for survival. Movement necessitates navigation, and as humans move they must develop ways in which they can remember places of significance (Bennett & Rowley 2004), relating both to navigation and resource acquisition. Thus, landmarks provide that mark of significance. Landmarks draw humans to them, and their purpose differs based upon necessity or perception of the individual seeing it through their contemporary cultural lens, or "politics of vision" that are shaped by the ways in which one views the world around them (Molyneaux 2006:70). As a famous example to illustrate the significance of landmarks, Devil's Tower in eastern Wyoming, United States exemplifies a landscape feature that has proven its importance to humans for more than 10,000 years (Molyneaux 2002; 2006).

Presently, many indigenous peoples view Devil's Tower as a spiritual pilgrimage site. Millions of spectators visited the site with awe since its demarcation as the United States' first National Landmark in 1906, and archaeologists and historians alike have surmised that the Tower served almost strictly ideological purposes (Molyneaux 2006). Archaeology and indigenous oral history suggests Devil's Tower served numerous practical advantages beyond the modern perceptions of spirituality, ideology, and awe. Oral traditions describe Devil's Tower as an unmistakable landmark in seasonal rounds and it served as a wind block ideal for campsites with wild game in abundance along the nearby Belle Fourche River (Molyneaux 2006:73-74). Archaeological fieldwork around the Tower complements the oral history with unearthed campsites and projectile points; additionally, quartzite outcrops near the Tower showed evidence of quarrying with debitage (i.e. stone waste flakes; Molyneaux 2006:73-74). Thus, Devil's Tower demonstrates how modern perceptions draw contemporary people to a landmark that has held cultural significance, both sacred and mundane, from the end of the last ice age to the present.

Like Devil's Tower, landmarks reflect the most noticeable places of importance in a natural environment. Landmarks are permanent fixtures on the landscape so visually and spatially real that they can serve as a bridge for relating the natural environment and cultural landscapes to one another. These relationships can be seen through practical lenses as a navigational marker, great for a camp, and/or a provider of resources like food, water, or usable toolstone. Further, humans can observe these places and feel importance, thereby driving the relative feelings of spirituality, ideology, awe, inspiration, and other indescribable feelings of something greater. In regards to the importance of landmarks on the landscape, Molyneaux (2006:67), states, "while theoretical discussion tends to focus on the fit between the scale of analysis of archaeological phenomena and the scale of the cultural life that produced them, the crucial relation is our own, materially and socially, to the information we retrieve." Essentially, it is up to the present perception of a place to deem its significance by expressing thoughts derived from archaeological and any other evidences to reconstruct cultural landscapes within natural environments.

Cultural Landscapes

Reconstructing cultural landscapes could be viewed as an ultimate goal for archaeologists. Landscape archaeology differentiates cultural landscapes from natural environments. However, all archaeologists are interested in how their finds or "archaeological phenomena" (Molyneaux 2006) relate to their surroundings, to any degree or scale. According to the Pikangikum First Nation of northwestern Ontario, a cultural landscape is defined as "an area over which a particular people have inscribed their culture through their intimate use and understanding of the land" (Davidson-Hunt & O'Flaherty 2010:3). Thus, a natural environment affords many opportunities for a group of people to create their own cultural landscapes based upon the uses and meanings that they contrive and perceive as important.

Recreating these meanings, perceptions, and uses of an environment for past peoples provides an avenue in which archaeologists can express any sort of significance they can conceive about the natural environment around the sites they are investigating. When debating whether it was transportation or exchange that brought an anomalous obsidian artifact to the aforementioned Devil's Tower, Molyneaux (2002:147) makes a relevant point, "[In studies that consider problems of exchange,] it seems appropriate to model scenarios of socio-spatial behavior where action takes place: in the landscape surrounding the artifacts and their raw material sources." By using natural environments as a catalyst for modeling behaviors and actions in a certain space, the archaeologist may impute meanings that could otherwise be overlooked. No matter how seemingly insignificant, meanings ascribed to a landscape are legitimate in supposing how past peoples may have felt. Meaning about surroundings stem from a common experience of being in a place, observing it, and thinking about it. To some degree, meaning changes from individual to individual and across generations; therefore, they are ever changing. In some ways, cultural landscapes could be viewed "as a living landscape, [is] composed of layers of meaning, built up over time, as part of a dynamic, ever-changing set of relations between land and people" (Davidson-Hunt & O'Flaherty 2010:3). Whereas natural environments are unobservable in slowness of change from one generation to the next, how those areas are perceived changes fluidly. Therefore, critique or rejection of archaeological work that attempts to interpret meaning from place is moot; it is not anti-science or relativism (Shanks & Tilley 1992), but taking available data from the archaeological record and turning it into a human experience.

As previously differentiated and defined, landscapes represent the places where human behaviors have been acted out. For this reason, landscape archaeology has also been referred to as "an archaeology of place" (Wheatley n.d.). Landscape archaeology takes the focus away from the objects, the artifacts, features, and eco-facts. Instead, it turns a physical space and perceptions of it into the unit of analysis (McCoy & Ladefoged 2009; Witcher 1999; Wheatley n.d.). Wheatley (n.d.:3) defines landscape archaeology as, "a body of theory and method that permits us to explore the meaningful spatial configuration of archaeological remains." Therefore, an archaeologist takes the remains they are studying and seeks answers to questions such as: why was this located here, and how did it come to rest in this place? This replaces questions about the objects themselves by focusing on the reasons for context and behavior rather than the mechanisms and systems that produced them.

Although much landscape archaeology becomes automatically associated with the role of GIS in archaeology (McCoy & Ladefoged 2009; Rennell 2012; Witcher 1999; Wheatley n.d.), there are archaeological case studies that use this theoretical approach while adhering to more traditional objects of study. Ellis (2008, 2011) critically analyzes the context of lithic artifacts and surmises reasons for their appearance. His (Ellis 2008) article claims that the lithic tools of Palaeo-Eskimo and Palaeo-Indian (American) groups represent their interaction with the natural environment. Both tool types were designed since "meeting situational contingencies" proved vital because the environment was unpredictable and these peoples lacked efficient transportation aids (Ellis 2008:302, 307). These artifacts were produced, used, and deposited in the places of their discovery because the people were moving across and colonizing new natural environments.

Turning place into the unit of analysis allows archaeologists to address purpose of action as opposed to action for purpose. For example, Ellis (2008, 2011) uses a landscape archaeologist's mindset to answer critical questions about why North America's oldest cultural material appears in its place of discovery. The Fluted Points and Arctic Small Tools (AST) appear because those places represent locations most equipped with resources for those ancient populations' survival. Those tools allowed their users to adapt to their natural environment and move when that natural environment could no longer sustain them (Ellis 2008). Answering these kinds of questions more clearly vivifies a group's purpose on the landscape. Instead of answering questions like what were the groups hunting and how were they surviving, this theoretical perspective delves into questions such as why and how long are they moving. By using lithic artifacts as a proxy, Ellis (2008, 2011) is able to differentiate a population's behavior based upon their mobility across a landscape.

Mobility is a concept broadly and sometimes recklessly used by archaeologists to describe human movement. Mobility serves as action that archaeologists can capture and reconstruct. Most often, mobility has been associated with technological organization (Andrefsky 1994; Nelson 1991; Shott 1986). Technological organization describes the tools past populations used and focuses on reasons those specific tool types are selected. Nelson (1991:66) suggests technological organization reveals adaptive strategies and varying levels of material design such as reliability, maintainability, transportability, flexibility and versatility. Further, Shott (1986:35) defines flexibility as a broad range of functional attributes and versatility as a broad range of functions for a single attribute. In both Nelson's (1991) and Shott's (1986) articles, those authors contend that mobility results in selective behaviors regarding chipped stone tool production, selection, and use. That said, however, neither author begins to describe the purpose for the peoples' mobility, which is precisely where landscape archaeology can be inserted to answer such questions. Therefore, a landscape approach creates a sequence of purpose that can "distinguish association from causation" (Witcher 1999:14).

A population living in a natural environment needs to fulfill a certain task for survival, social, or ideological purposes. In order to fulfill this task, they must plan a movement. To complete the movement, they must be equipped to do so. Thus, they must know how to use that equipment in fulfillment of their task. Although each of these phenomena are different, each becomes unified by the fact they are being acted out in the natural environment where the people live and in accordance to the cultural structure they have created in that environment. The sequence stated previously sounds similar to the description of the hammer outlined by phenomenologist, Heidegger (1996[1927]). However, reconstructing this sequence requires archaeological remains to be placed by human action on the landscape. This placement can be done through the use of GIS in archaeology with a focus on using a variety of GIS analyses to predict archaeological site formation.

Methods in Predicting Archaeological Site Formation

Use of GIS in archaeology varies greatly, and philosophical links between social theory, behavior, and digital models is still a work-in-progress. Spatial technologies for their practical purposes have been fully embraced in archaeology (McCoy & Ladefoged 2009). However, this does not mean that there are not issues involved with its use. Often archaeological GIS falls into the trap of predictive modeling where archaeologists will simulate archaeological phenomena without the use of physical evidence (Barcelo 1998; Ebert 2004; Witcher 1999; Wheatley n.d.). Nowhere has this become more prevalent than in cultural resource management, or CRM (Wheatley n.d.). CRM is funded archaeology obliged by law that commits to protecting cultural heritage and historic places. Since CRM archaeology is obligatory and geared towards meeting minimum requirements, GIS and predictive modelling enable a short-cut that builds a façade of edgy technology over archaeological nothingness (Wheatley n.d.). This is not to say that all CRM does this, but it is a reality of recreating archaeological phenomena without the need for archaeological remains to be present.

Fear of archaeological fabrication created a fad within archaeological GIS known as visibility (Wheatley n.d.) and perception (Witcher 1999) analyses. Instead of having digital environmental data dictate where past peoples used the landscape, visibility and perception analyses attempt to capture how humans could have perceived the landscape (Witcher 1999:9). The desired product of a GIS analysis in archaeology is one that leads to feedback (Wheatley n.d.), which is to say that a good archaeological geospatial analysis is one that creates abundant opportunities for "ground-truthing" (McCoy & Ladefoged 2009). Inaccurate predictive models can turn into a good perception analysis, like Witcher's (1999) critique of a GIS method known as a Cost Surface Analysis.

Archaeologists have used Cost Surface Analysis to digitally reconstruct human movement (DeSilva & Pizziolo 2000; Howey 2007). The premise is taking a satellite image that states the elevation of a space in various, usually meter by meter, resolutions according to the image's pixel size and calculating some measure of friction. An example of friction is slope. The cost surface function in a GIS calculates the areas with the least amount of friction on that surface by creating new pixels where the value of bordering friction is smallest. One can then create lines on that image that represent paths of least resistance for the area. Witcher's (1999) critique is that archaeologists take these "paths" and label them as routes for human travel. Therefore, archaeologists can take an image, run a computer function designed to assess flood trajectories, and call it human action. This is not the same as human movement because it represents natural water movement not human interaction with an environment (Witcher 1999). Elevation change represented by slope is not the only form of friction. Friction can show complex measures of human consideration, like proximity to water or ability to walk on a type of ground, which turns a non-real cost surface into a humanistic "perception surface" (Witcher 1999:9). Now that a problem in archaeological GIS has been exemplified, this discussion turns to focus on the most common GIS analysis in archaeology: the Least Cost Path.

Least Cost Path Analysis

The cost surface analysis and its further refinement, a Least Cost Path (LCP), is likely the most widely used function of GIS in archaeology (e.g. Anderson & Gillman 2000; Bell & Lock 2000; Carballo & Pluckhahn 2007; Contreras 2011; DeSilva & Pizziolo 2000; Field et al. 2007; Hare 2004; Howey 2007; 2011; Fábrega-Álvarez 2006; Llobera et al. 2011; McCoy et al. 2011; Morgan 2008; Newhard et al. 2008; Poluschny 2006; Raccidi 2013; Taliaferro et al. 2010; White

& Barber 2012; Whitley & Hicks 2003; Wood & Wood 2006). An LCP is the "pathway" described previously, and is the product of a cost surface. The prevalence of LCP analyses indicates promise of this function for archaeologists. In fact, an LCP was the inspiration for the geospatial analysis conducted for this research on southern Baffin Island. Unfortunately, many LCP analyses fall victim to two inaccuracies: neglecting human agency in the cost surface or, more commonly, committing *a priori* experiments that connect two potentially unrelated points.

Neglecting human agency appears more common in the earlier days of doing an LCP, but persists in more recent works. Most often this occurs when archaeologists want to model population movement from one broad region to another. These demographic predictive models (Anderson & Gillman 2000; Bell & Lock 2000; Carballo & Pluckhahn 2007; Contreras 2011; DeSilva & Pizziolo 2000; Field et al. 2007; McCoy et al. 2011; Whitley & Hicks 2003; Wood & Wood 2006) attempt to vivify a groups movement across a natural environment. In finding the best routes along the landscape, they lose sight of the other factors humans would consider when moving. This happens when an LCP is done in its purest form by taking a digital elevation model (DEM) and calculating a single type of friction. For archaeologists studying movement (Anderson & Gillman 2000; Carballo & Pluckhahn 2007; Contreras 2011; DeSilva & Pizziolo 2000; Field et al. 2007; McCoy et al. 2011; Whitley & Hicks 2003; Wood & Wood 2006), this is done through the use of a *ruggedness index* (Riley et al. 1999) or a *hiking function* (Tobler 1993). These formulas only calculate a difficulty of moving from one elevation to the next and nothing else. So, these models create ideal routes, but neglect considerations of human behavior that would alter them.

A priori connection of two places is a creation of wanting two different places to have an empirically verifiable relationship. In a number of instances (Contreras 2011; Howey 2007;

McCoy et al. 2011; Morgan 2008; Raccidi 2013), the archaeologist knows there is a correlation between two sites. They want there to be a connection, so they run LCPs with the DEM bases and then add factors that make them more ‘human,’ like difficulty of moving across different land cover, assuming people use canoes, used wagons, and wanted to expend as little energy or time as possible (Contreras 2011; Howey 2007; McCoy et al. 2011; Morgan 2008; Raccidi 2013). So as part of the LCP function in (Arc)GIS, they connect two different sites and proclaim it as the route past peoples would have travelled. Unless there is some type of undeniable direct association, such as a stone’s geochemical signature, then there is no ground for connecting two very acute spatially designated sites and stating that the created connection is fact. Although movement from point A to B may have taken place, it is assuming to say a digitally reconstructed path was *the* route taken, because any person(s) could have taken other paths based on needs, wants, and curiosities or out of forced deviation like erosion, flooding, or inter-group conflict. A way to avoid *a priori* LCPs and archaeological GIS is to simply state the limitations of the analysis (Hare 2004).

None of the examples stated in either ‘inaccuracy’ are “bad” archaeology because they universally create foundations for future research, which is success for archaeological GIS (Wheatley n.d.). What makes them fallacy is the statement of the analyses’ results as something so matter-of-fact. In reality, there is no way to undeniably claim archaeological remains at one site move so precisely to another, especially if both points are sites people used for generations. Research for the present study found that only two archaeological works altered their LCP in such a way that recognized the fluidity of human behavior and movement (Fábrega-Álvarez 2006; Llobera et al. 2011). Llobera et al. (2011) and Fábrega-Álvarez (2006) use a hydrological flood allocation network to propose the potential expanse of hunter-gatherers in prehistoric

Spain. What makes this different than flood trajectories of a Cost Surface Analysis is that they used a hierarchy of human choices on an environment. Instead of focusing on cost, they (Fábrega-Álvarez 2006; Llobera et al. 2011) turned a surface into areas most likely to draw human attention.

When a watershed analysis is run on the values in this likelihood model, a network of routes are generated (GRASS tutorial n.d.). For archaeologists, the network represents pathways of favorability as a substitute for unintended flood or water flow trajectories. Llobera et al. (2011:843) themselves state why this type of analysis is a progressive stem for LCP analyses since, "it is important to remind ourselves that the great majority of movement was never formalized into roads or well-defined routes." That reminder holds especially true in the case of southern Baffin Island where roads between the populated coasts and once populated interior still do not exist. Thus, creating a likelihood model embracing the variability and contingencies of human wants and needs proves essential in narrowing down the ways in which past Baffin Islanders moved from coast to inland and back.

Multivariate Probabilities for Site Formation

One manner in which GIS has aided in finding archaeological sites has been through probability studies (Clarkson & Bellas 2014; Rogers et al. 2014). Probabilities for archaeological site formation can be based on multiple variables. For instance, Clarkson & Bellas (2014) use flaked stone tools to interpolate where potential sources for the tool's lithic parent material may be located. Concentrations of the stone tools' geochemical signatures formed a density cloud where the center potentially representing the source location of the lithic material (Clarkson &

Bellas 2014). Another multivariate probability model used forecasts of the last Ice Age's glacial movements in the Pennine Alps in proximity to an LCP to predict archaeological site locations (Rogers et al. 2014). Rogers et al.'s (2014) methods produced a map with areas representing graduated values of least to most likely to contain archaeological sites, and they recognize inserting more factors or criteria into the model could strengthen their methods. The geospatial analysis in the present study uses similar concepts to highlight places along the generated pathways where archaeological sites could be located. This multivariate probability model on southern Baffin Island uses pathway proximity to eskers, till-colluvium, and both to suggest areas of highest likelihood of chert accessibility in relationship to those features for Palaeo-Eskimo groups.

Archaeological Feature Identification and Extraction

During the planning and execution of research for the present study, there was hope that remotely-sensed satellite images of the study area would reveal archaeological features, such as tent-rings or structural remains. Remotely-sensed data have previously led to the identification of archaeological sites based upon feature identification and extraction (Rajani & Rajawat 2011; Saturno et al. 2006). Rajani & Rajawat (2011) identified anomalies along "palaeo"-river channels of northwest India that turned out to be old structural remains. The accuracy of these image-extracted features can be incredibly accurate. For example, Saturno et al. (2006) describe that their extracted feature locations were within a few feet (under a meter) of the real on-the-ground positions in the forests of Guatemala. A similar observation of satellite images for southern Baffin Island was conducted along this research's generated pathways. Unfortunately, resolutions of the open-source images were not high enough to reveal any features.

Materials

All of the materials required to fulfill the research objectives outlined for the present study were cost-free. GIS programs such as QGIS and GRASS in addition to many types of data are open-sourced and readily available to the general public. This fact provides useful implications for both the research being conducted on southern Baffin Island and to archaeology as a whole. Purposeful research can be conducted with low to zero cost, and geospatial analyses can be trialed by archaeologists without making monetary risks or unnecessary expenditures. After trialing geospatial analyses, one can then put forth the funds for higher detailed data and towards field work to ground truth the results. Professionals, students, and enthusiasts alike are capable of learning, sharpening, and honing a skill set, because it is, quite literally, at their fingertips without risk.

Finding GIS programs to accomplish the objectives of this research was a simple first step. The Environmental Systems Research Institute (ESRI) appears to have broadly monopolized student and professional access to GIS software programs. Likely, the easy to use point-and-click interface and data-processing efficiency facilitated its preference among GIS users and learners. However, the Open Source Geospatial Foundation (OSGeo, http://www.osgeo.org/) rebels against the corporate takeover of GIS. OSGeo freely provides access to GIS software packages, user manuals, tutorials, and data sets. For this analysis, a combination of GIS programs were used: Quantum (Q)GIS version 2.4 and its built-in counterpart Geographic Resources Analysis Support System (GRASS) version 6.4.4. QGIS's easy point-and-click interface combined with the processing efficiency of GRASS approximately equates to ESRI's GIS program, ArcGIS, with almost inconsequential differences when one realizes they are not paying a yearly registration of over $12,000 (US) at minimum. One additional GIS program, Google Earth, was used in this research, solely as a presentation medium but illustrative of the ease-of-access to free GIS.

To effectively generate a geospatial analysis, one needs spatial data. Everyday uses of programs like Google Earth, Google Maps, and Bing Maps show how helpful and useful imagery can be. These bird's-eye views are satellite imagery and are classified as a raster data type. Raster data are images created by pixels that are tiny rectangles/squares with assigned values that form a picture when put together (Price 2012). For presentation purposes, satellite imagery from the United States Geologic Survey (USGS) Landsat 7 series was used. USGS's global visualization viewer (glovis.usgs.gov/) provides free access to many types of satellite imagery depicting places all over the world (GLOVIS 2014a). Most imagery of the study area was of uselessly poor quality, except for a chain of satellite images taken by Landsat 7 satellite between 1999 and 2003 at resolutions "resampled to a pixel size of 180 meters from the original 30-meter data" (GLOVIS 2014b). Raster data used to conduct this research's cost surface/LCP derived from a digital elevation models (DEM; resolution 93 meters N-S by 65-36 meters E-W) provided free by Natural Resources Canada's open-source database, Geogratis (geogratis.cgdi.gc.ca/). The DEMs for the study area consist of both the east and west tiles of Canada's National Topographic System (NTS) sections 025h, 025i, 025j, 025k, 025l, 025m, 025n, 025o, 025p, 026a, 026b, 026c, 026d, 035p, and 036a (Geobase 2007).

In addition to imagery, shape based spatial data are necessary to help produce and contextualize the results of this analysis. Shape data, referred to as points, lines, and polygons, are called vector data types (Price 2012). Again, open-source Geogratis supplied the vector data used in the analysis. I acquired shape-files (*.shp) of the land cover (polygons) types, water bodies and ways (polygons and lines, respectively), and topographic contours (lines) for the entire study area (http://geogratis.gc.ca/geogratis/search?lang=en); enter Baffin Island as the (1) geographic location, (2) enter the NTS tile section as the key word, (3) check box “Data” in product type, and it is item with the description LCC2000-V). Archaeological site data were provided in two ways. One, Milne’s (2007, 2012, 2013) recorded site, artifact, and feature coordinates were put into a spreadsheet and converted into shape-file points using QGIS. Second, the territorial archaeologist of Nunavut supplied a spreadsheet of all registered archaeological sites in the study area, accompanied with a confidentiality agreement that no products displaying the data would be greater than 1:2,000,000 meters in scale and the data must be terminated after one year. These too were converted into shape-file points and used.

Methods

Constructing the methods used in this analysis required in depth research into GIS and LCP used in fields other than archaeology. For this research, nearly all archaeologist-generated LCPs, created in the traditional connecting points in an A to B way, would have been impossibly time consuming and narrow-minded in its results. Figuring out how past populations moved from the coast to interior of the study area appeared daunting. While archaeological research on southern Baffin Island was initiated more than half a century ago (e.g. Collins 1950; Maxwell 1962), large areas remained un-surveyed, and only 453 sites are presently known. Therefore, connecting points of human occupation and land use in such an expansive geographic areas is no simple task (Figure 8, p.44). Running LCPs between two points was not an option, which, fortunately, prevented any results from being assumptive. Relating geographic areas on the coast with those of the interior by movement between them required the creation of networks incorporative of all human considerations and time periods. Thus, Llobera et al.’s (2011:845-

846) “mobility basin” inspired this analysis to undertake a methodological (and material) experiment of creating a study area-wide mobility network.

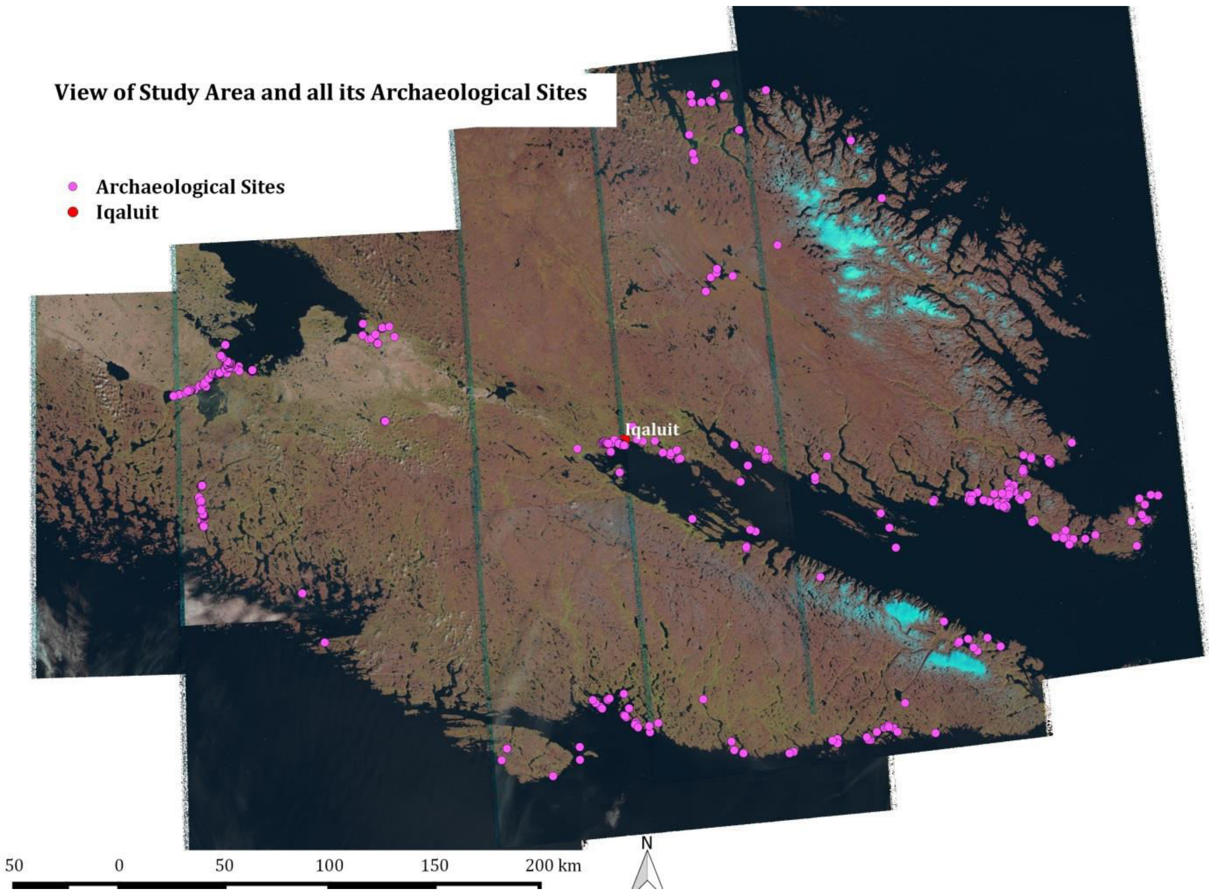

Figure 8. All archaeological sites recorded in the study area (pink).

Borrowing from biologic, ecologic, and environmental GIS (Atkinson et al. 2005; Boroushaki & Malczewski 2008; Chan 2012; Jones et al. 2014; LaRue & Nielson 2008; Leonak et al. 2012; Li et al. 2010; Malczewski 2006; Rees 2004; Riley et al. 1999; Tobler 1993; Wang et al. 2009; Wood & Schmidtlein 2012), the methods devised in this research use a two-step process to create these mobility networks. The first step involves creating a cost surface through a hierarchical compilation of environmental and human factors. This is known as an analytical hierarchy process (AHP), where criteria are weighted in importance and combined to create an overall output value representative of human likelihood to move across any given space. The second step, the cost surface/LCPs generation, required two sub-steps. Initially, the output likelihood as a cost value is run through a "hiking function" (Tobler 1993). Then that likelihood/walkability surface undergoes a "watershed" function in GIS, which, with some refinement, outputs a humanistic yet statistically sound network of paths across a geographic expanse (Fábrega-Álvarez 2006; GRASS tutorial n.d; Llobera et al. 2011). Once a final geospatial output was created, it became possible to select routes or pathways from the study area's coasts to the interior based upon any number social-theoretical variables.

A major goal of the methodology was to make a significant contribution to the Southern Baffin Island Chert Provenance Project. This has been accomplished in two ways. The analysis resulting from this study has created a strong foundation for future research by putting forth opportunities for field investigation in "ground-truthing" (McCoy & Ladefoged 2009) and in refinement by laboratory geospatial studies, like an aforementioned remotely-sensed feature extraction. Additionally, the opportunities and information created by the analysis monetarily cost nothing to the project's funding because all materials used were free and open-source.

The Process

This analysis consists of two major components. This included the formulation of an analytical hierarchy process (AHP) and the subsequent generation of the cost surface/LCPs. These methods were devised by using methods outside of archaeology. Saatay (1980) developed the AHP to incorporate human choice and feedback into statistical analyses. Direct applications of the AHP in an LCP analysis guided this research through examples in animal ecology (Atkinson et al. 2005; LaRue & Nielson 2008; Leonak et al. 2012; Li et al. 2010; Wang et al. 2009). Details of how create the components required for an AHP and to generate cost surface/LCPs can be extracted from literature in environmental impact modeling (Chan 2012; Jones et al. 2014; Rees 2004; Wood & Schmidtlein 2012) and geospatial statistics (Boroushaki & Malczewski 2008; Malczewski 2006; Riley et al. 1999; Soule & Goldman 1972; Tobler 1993). Computation of the two components of this analysis require a process consisting of criterion creation, criteria weighting, calculating an AHP, calculating the cost surface, running the cost surface through a walk-algorithm, calculating a watershed basin from the walk-algorithm cost surface, and refining to generate LCPs.

To generate a cost surface, one must compile criteria that assign a cost value (Howey 2006; Howey 2011). Naturally, there will be a hierarchy of importance for each criterion (Bhushan & Raj 2004; Malczewski 2006). A statistical means of generating the weighting system of criterion does exist, and that is called an analytical hierarchy process (AHP). Bhushan & Raj (2004:13) refer to this weighting system as a "multi-objective decision making" formula that helps reduce the subjectivity of randomly assigning a value of one criterion over another. Although one can calculate these weights on their own, there are free online AHP calculators (Goepel 2014). This analysis used Goepel's (2014, http://bpmsg.com/academic/ahp_calc.php) AHP calculator to weigh the cost criteria before using GIS to generate a cost surface. As the results chapter will show, changing the hierarchy of criterion weights greatly alters the subsequent calculations. My criteria consist of ruggedness, land cover traverse-ability, and proximity to water. Two separate AHPs were calculated, and two extremely different subsequent cost surfaces were produced.

According to Bhushan & Raj (2004:15-17), the construction of an AHP begins with establishing a goal followed by placing a hierarchy of criteria in the manner of criterion one is "x" times more important than criterion two and three. The goal of this AHP is to produce a weighted cost surface. In one AHP, the hierarchy was land cover traverse-ability, ruggedness, and proximity to water. With estimated "x" times of importance, this hierarchy was entered in Goepel's (2014) AHP calculator as importance of one being x3 that of two, x9 that of three, and two being x5 that of three. Geopel's (2014) calculator produced a weighting of 62.6% for land cover traverse-ability, 30.1% for ruggedness, and 7.2% for proximity to water. In the other AHP, ruggedness ranked one, followed by land cover traverse-ability and proximity to water with importance entered into Goepel's (2014) calculator as one being x2 of two, x6 of three, and two x4 of three. This resulted in weighting of ruggedness at 58.2%, land cover traverse-ability at 30.9%, and proximity to water at 10.9%. Selecting and weighing the criteria ultimately create the cost surface.

The first criterion selected was ruggedness. Calculating a ruggedness index on a DEM determines rapidity of change for one pixel's elevation to each of its neighboring pixels (Riley et al. 1999). Ruggedness index is often taken into consideration during environmental impact assessments (Chan 2012; Jones et al. 2014; Rees 2004; Wood & Schmidtlein 2012). Additionally, some variation of it is used in ecological research tracing animal movements (Atkinson et al. 2005; LaRue & Nielson 2008; Leonak et al. 2012; Li et al. 2010; Wang et al. 2009). This algorithm categorizes clusters of these values into seven tiers: level, nearly level, slightly rugged, intermediately rugged, moderately rugged, highly rugged, and extremely rugged

(Riley et al. 1999:24). This more finite calculation of slope vivifies the step-by-step lateral changes of a terrain. For this analysis, Riley et al.'s (1999) ruggedness index was calculated in by entering a raw DEM into QGIS's raster tool terrain analysis >> ruggedness.

The seven ruggedness classes produced were manually reassigned, using the *reclassification* module in GRASS, to have analyst determined cost values more representative of a least cost to high cost surface. Original values ranged from 0 to 63, and this reclassification represents simple cost values 1-9 to emphasize both areas of deep depressions (value 1), likely water bodies, and near vertical interfaces (value 9), like cliffs (Figure 9, p.49). Reclassification rules were created in Notepad on the desktop to have 1 = (original values) "0.0 thru 7.8" (depressed), "2 = 7.9 thru 15.7" (level), "3 = 15.8 thru 23.5" (nearly level), "4 = 23.6 thru 31.4" (slightly rugged), "5 = 31.5 thru 39.2" (intermediately rugged), "6 = 39.3 thru 47.0" (moderately rugged), "7 = 47.1 thru 54.9" (highly rugged), "8 = 55.0 thru 62.0" (extremely rugged), and "9 = 62.0 thru 63.0" (near vertical). This document was entered as the rules in the reclassification module, and use simple values under ten to represent this criterion's cost values.

The second criterion selected was land cover traverse-ability. Thinking about what past peoples would have considered when walking through an environment would be selecting cover (i.e. marsh, grass, trees, boulders, etc.) less difficult to walk across. This thinking has only been applied in GIS to disaster evacuation plans, where walking speeds of individuals across the type of ground proves essential (Jones et al. 2014; Wood & Schmidtlein 2012). In 2014, the USGS cooperated with ESRI to create a "tool" that does this automatically in ArcGIS (Jones et al. 2014). Both the USGS (Jones et al 2014) and Wood & Schmidtlein's (2012) tsunami evacuation plan were based on a study of walking speed and cover type conducted by Soule & Goldman (1972). This study categorized a walking "cost" on a scale of ideal cover from "blacktop road", with four categories between, and ending with "loose sand" (Soule & Goldman 1972). In light of this work, the land cover shape-file of the study area was converted into a raster based on the cover type number using the *vector to raster* module in GRASS. Each cover type number was then reclassified, again using the GRASS *reclassification* module, to fall into seven cost values with 1-6 paralleling those defined by Soule & Goldman (1972) and by adding the additional value 7 to represent water, which is not possible to walk on (Table 1, p.51).

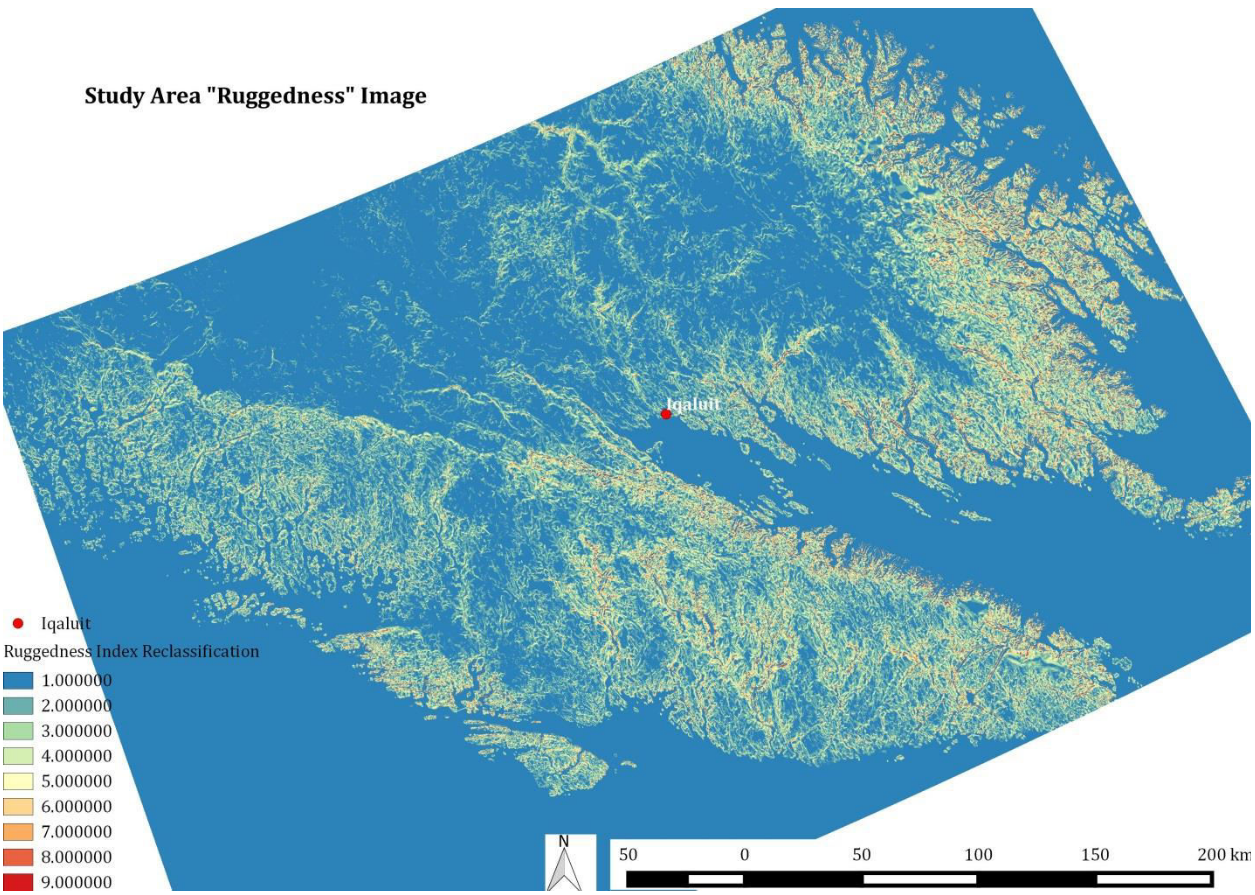

Figure 9. Nine-Category ruggedness reclassification, clearly highlighting the rocky, likely steep, interfaces from flat, likely saturated, areas.

The third criterion selected was proximity to water. Drinking water is essential for humans and all terrestrial animals. However, research for the present study found just one ecological study that took it into consideration during construction of a predictive model for southern Great Plains cougar migrations (LaRue & Nielson 2008). LaRue & Nielson (2008:376) created a proximity to water criterion in their AHP with distance categories of <1 kilometer (km), 1-5 km, and 5< km. Inspired by this, the water body (polygons) and ways (lines) shape-files from Geogratis were merged into a single "lines" shape-file, and any water bodies not intersecting with lines were clipped. This step produced the moving water systems in the study area, which will be the potable sources. Then, a series of buffers were created around them using the *raster buffer* module in GRASS at intervals of <250 meters (m), 250-500m, 500m-1km, 1-5km, and 5< km. These intervals created a raster image covering the entire study area. Again using the GRASS *reclassification* module, costs 1-5 were assigned in ascending order to each of those intervals.

With three cost containing criteria selected and weighted with an AHP, a cost surface can be generated (Atkinson et al. 2005; Rees 2004). The raster calculator module in GRASS was used to make a single cost surface using the cost values within the pixels of criteria ruggedness (A), land cover's traverse-ability (B), and proximity to water (C). These equations, with the AHP weights, were entered as:

1. (A*0.301)+(B*0.626)+(C*0.072)

And

2. (A*0.582)+(B*0.309)+(C*0.109)

Table 1. Cost classification based on study area land cover and types identified by Soule & Goldman (1972)

Code Number	Land Cover Type	Cost	Category	Land Cover (Soule & Goldman 1972)
20	Water	7	Water	N/A
30	Barren/non-vegetated	1	Bare Ground	Blacktop
31	Snow/ice	6	Wetland/Snow/Ice	Loose Sand
35	Sparsely vegetated bedrock	5	Rocky	Swampy Bog
36	Sparsely vegetated till-colluvium	5	Rocky	Swampy Bog
37	Bare soil with cryptogam crust- frost boils	1	Bare Ground	Blacktop
51	Shrub tall	3	Shrubland	Light Brush
52	Shrub low	3	Shrubland	Light Brush
53	Prostrate dwarf shrub	2	Tundra	Dirt Road
80	Wetland	6	Wetland/Snow/Ice	Loose Sand
101	Tussock graminoid tundra	2	Tundra	Dirt Road
102	Wet sedge	4	Sedge	Heavy Brush
103	Moist to dry non tussock graminoid/dwarf shrub tundra	2	Tundra	Dirt Road
104	Dry graminoid/prostrate dwarf shrub tundra	2	Tundra	Dirt Road

The products of these equations were two distinct cost surfaces using values of cost derived from conditions most suitable for physical movement across the entire study area. As a unified image, the new pixel values are averages of lowest cost equating to most likely to be moved across while higher values mean a decreasing likelihood.

Once a cost surface has been generated, one can create LCPs. First, these cost surfaces needed to be refined so that they represent human walking. Thus, a hiking function was applied to the cost surfaces, because it inserts factors such as walking speed and energy expenditure (Tobler 1993). This was accomplished using GRASS module *r.walk* on both cost surfaces. Keeping Llobera et al.'s (2011) and Fábrega-Álvarez's (2006) fluid mobility networks in mind, both r.walk-ed cost surfaces were run through the GRASS module *r.watershed* with a "drain cell" output and minimum size of "1000" (GRASS tutorial n.d.). The products were two raster images of pathway networks indicative of least cost over the whole study area. In essence, it is a water drainage map, except the values are least resistance to human movement, thus most favorable.

Unfortunately, the LCP network products are sloppy and require refinement (GRASS tutorial n.d.). The function created values in the thousands of mirroring positive/negative values, which was corrected and simplified to values fewer than ten like those of the cost criteria by taking the *logarithm* of the *absolute value* for both LCP network images. This can be accomplished by using the formula for both r.watershed created images (GRASS tutorial n.d.):

log (abs(x) +1)

The raster image produced shows more legible values, but there is a myriad of colorized categories that only slightly resemble a network of pathways. Changing this requires an observation of a threshold value where all values above it are distinguished as the network and all values below it become a flat background. Accomplishing this can be done through GRASS's graphical calculator module *r.mapcalculator* and entering:

input raster > threshold value x = new output raster

The output is, quite literally, black and white. This is finally an image that displays the network of pathways and only the network of pathways. Creating the LCP lines requires two more simple steps. Run the outputs through GRASS module *r.thin* to make them cleaner and less blocky (large pixel-ed). Finally, insert the "thinned" raster into the GRASS *raster to vector* module and render zero values as null (GRASS tutorial n.d.). Now, this is the final LCP network, the 'pathways', in a line shape-file that can be used to conduct further analyses, make assertions about human movement, insert perception, indigenous knowledge, and social theory.

Hypothesis

The present research aims to test the following hypothesis: is it possible to generate a model that can demonstrate human mobility using open-source GIS? The use of AHP to generate a cost surface, and the use of a watershed function seems like a plausible way to not only create paths to the interior of southern Baffin Island but also to create networks of human-landscape interaction within this expansive geographic region. Open-source data is robust enough to provide the information necessary for creating a cost-saving predictive model. I believe the accuracy of the model has much to do with how the criteria will be weighted in the AHP. The model can be evaluated by comparing existing (and undiscovered) archaeological sites, Inuit cultural sites, Inuit place names, and Inuit oral histories of inland travel routes to the generate pathway networks.

Before conducting the geospatial analyses, I decided not use archaeological site data through any step of the process. The justification for this decision is two-fold. This research aims to find archaeological sites in locations that have not been previously surveyed. If the existing site data were inserted, the LCPs would have favored the spaces where archaeological sites have already been found! Second, by electing to ignore archaeological site data, the chance of *a priori* testing is eliminated. Therefore, archaeological data provide an interpretative tool that can validate or refute claims potentially made with the generated and selected pathways.

An interview with Southern Baffin Island Chert Provenance Project Principal Investigator, Dr. Milne, conveyed the belief that ground cover would make movement to the interior extremely challenging. She expressed how brutal her own field experiences had been, especially on the jagged and sharp igneous rock zones that serve as a boundary between the coast and less hazardous interior lakes region (see St. Onge et al. 2006, Figure 2, p.5). Backed by the evacuation plan of USGS, the first impression was that land cover traverse-ability would be the most significant factor in the movement to southern Baffin Island's interior. Then I realized that all of the archaeological and non-archaeological cost surface/LCP analyses used some DEM-slope-ruggedness calculation as sole or, at least, most important criterion. Consequently, two separate analyses were run: one with land cover traverse-ability as the most significant and the other ruggedness. Despite conversations with Dr. Milne and persuaded by the overwhelming preference in the literature, I predicted that ruggedness would most convincingly demonstrate population mobility of southern Baffin Island's past.

Chapter 4- Results

Going Inland and Back

This analysis found possible pathways from southern Baffin Island's coast to the interior lakes region, specifically around Mingo Lake and the southern coast of Amadjuak Lake. First, LCP networks, or mobility-sheds, had to be generated using the cost surface and the watershed function in GRASS (Fábrega-Álvarez 2006; Llobera et al. 2011). Second, the Land Cover Traverse-Ability network was selected to extract pathways. Third, gaps in the generated pathways had to be connected. This was accomplished using a technique familiar to any 'trail-blazer' with a topographic map—topographic inference. Ultimately, 14 continuous pathways going from coast to inland and back have been created in this analysis.

Results of Geospatial Analysis

The products of this analysis were two LCP networks similar to the "mobility basins" created by Llobera et al. (2011:845-846). LCP networks generated here are representative of all of the easiest pathways to move throughout the entire study area on southern Baffin Island. First, land cover traverse-ability was used as most influential in its effect on population mobility. Second, ruggedness was used as the most influential factor shaping how peoples moved. Altering the weight for either land cover traverse-ability or ruggedness produced radically looking LCP networks that show far different manners in which past peoples moved.

Land Cover Traverse-Ability

Using the AHP weights described previously, a majority weight given to land cover shows much more lateral movement in the study area. There are few LCPs that penetrate deeply from the coast to the interior, but the ones that do are very close to those LCPs that start from the interior and branch out towards the coast (see Figure 10).

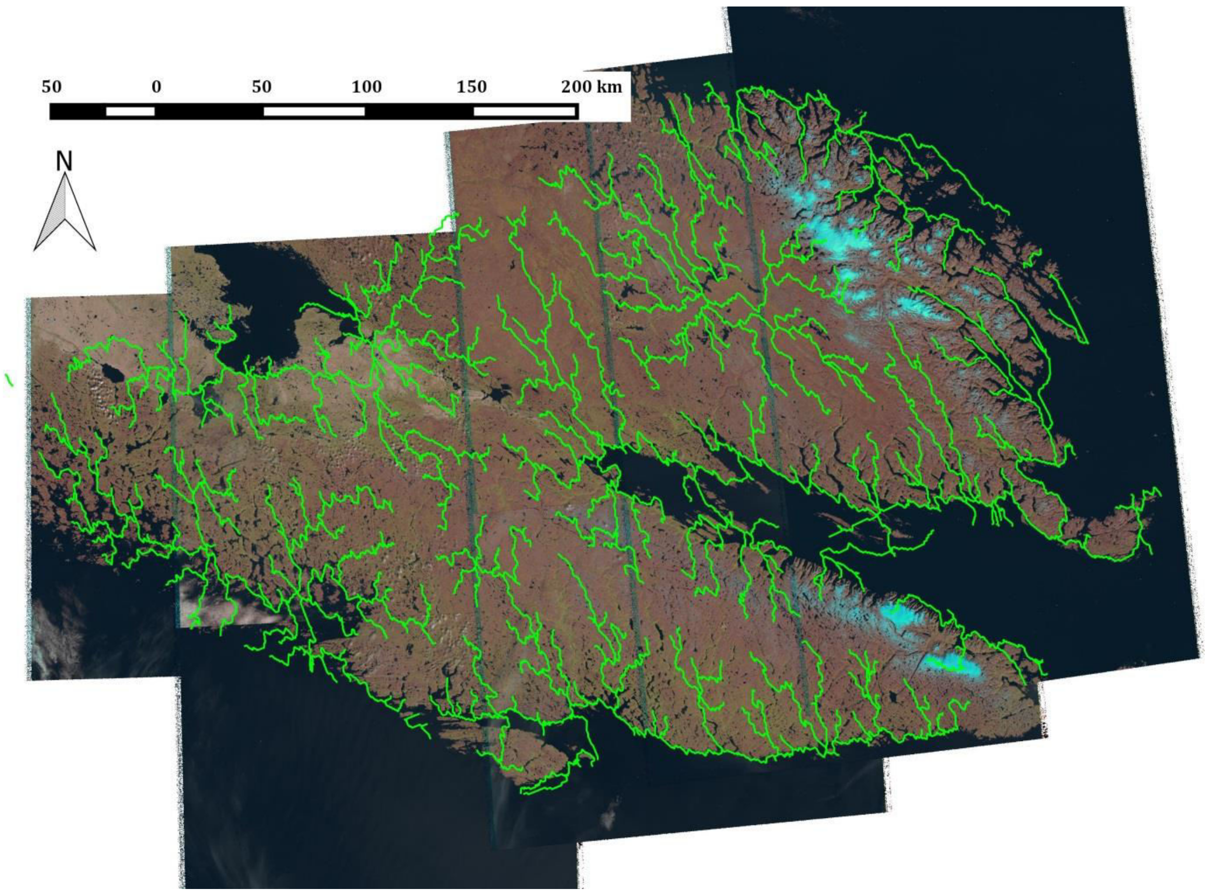

Figure 10. Land Cover Traverse-ability LCP network (green). These routes highlight major coastal intersections and just a few deep inland penetrations.

Ruggedness

Using the AHP weights described previously, a majority weight given to ruggedness show much more vertical movement in the study area. By making micro-topography and ruggedness the most significantly weighted criteria, many more LCPs penetrating from the coast inward were generated. Despite this, most only go a short distance before termination. Likewise, the LCPs starting from the interior fall far short from intersecting with those of coastal origins (see Figure 11).

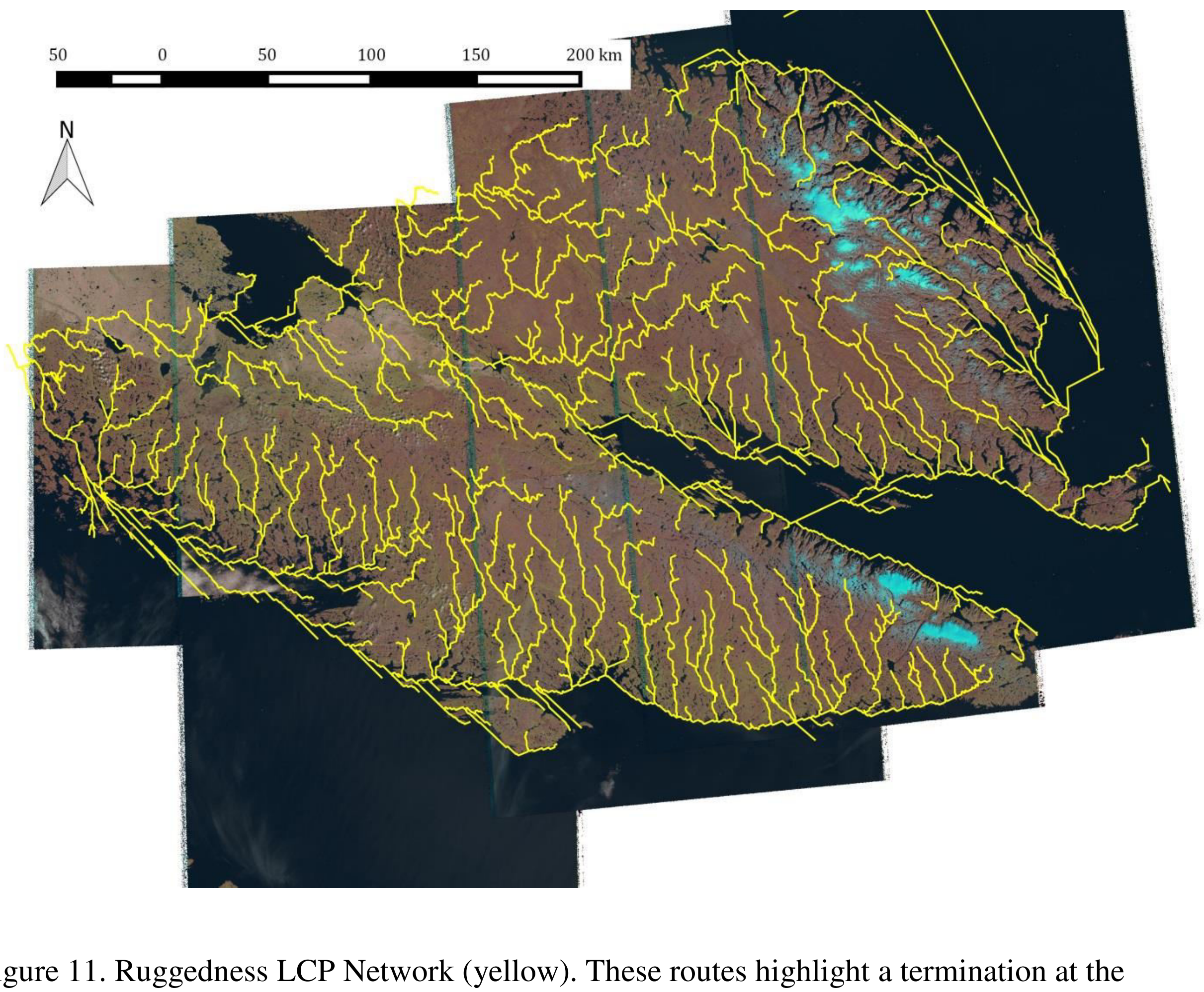

Figure 11. Ruggedness LCP Network (yellow). These routes highlight a termination at the geologic interfaces (see Figure 2, p.5) and a bias towards following water.

‘Paths’ of Highest Archaeological Potential

Filling in the gaps of the nearest LCP segments led to the isolation of 14 pathways connecting the coast to interior regions. They can be referred to as paths 1 through 14 from west to east (left to right; Figure 12, p.59). Of these 14 pathways, there are five differentiated zones named for either their origin or, in one case, by a single destination. These zones, from west to east, include the Keltie Inlet, Mingo, Ava Inlet, Tikkuut, and Frobisher Bay pathways. The Keltie Inlet and Mingo pathways lead to the Mingo Lake/River areas to the southwest of Amadjuak Lake. Ava Inlet pathways’ destination is either the southwestern shore of Amadjuak Lake or the Hone River’s headwaters on Amadjuak Lake’s southeastern shore. Named after its origin at the Tikkuut peninsula near Kimmirut, Nunavut, the Tikkuut pathways’ destination is the headwaters of the Hone River on Amadjuak Lake’s southeastern shore. Finally, the Frobisher Bay pathways vary in direction and have two destinations: (1) the Hone River’s headwaters or the headwaters of the Nuvungmuit River, and (2) to the northeast of the Hone River’s, on the southeast shore of Amadjuak Lake. Obviously, the lengths of these pathways vary greatly, as do any potential perceptions as to who may have used them.

Understanding the Results

Archaeological sites were used to determine which LCP network was more reflective of human movement to assess a subjective ‘accuracy.’ By calculating nearest distance from the LCPs (lines) to archaeological sites (points) using GRASS module *v.distance*, a reasonable comparison of archaeology-to-LCP network could be made (Table 2, p.59).

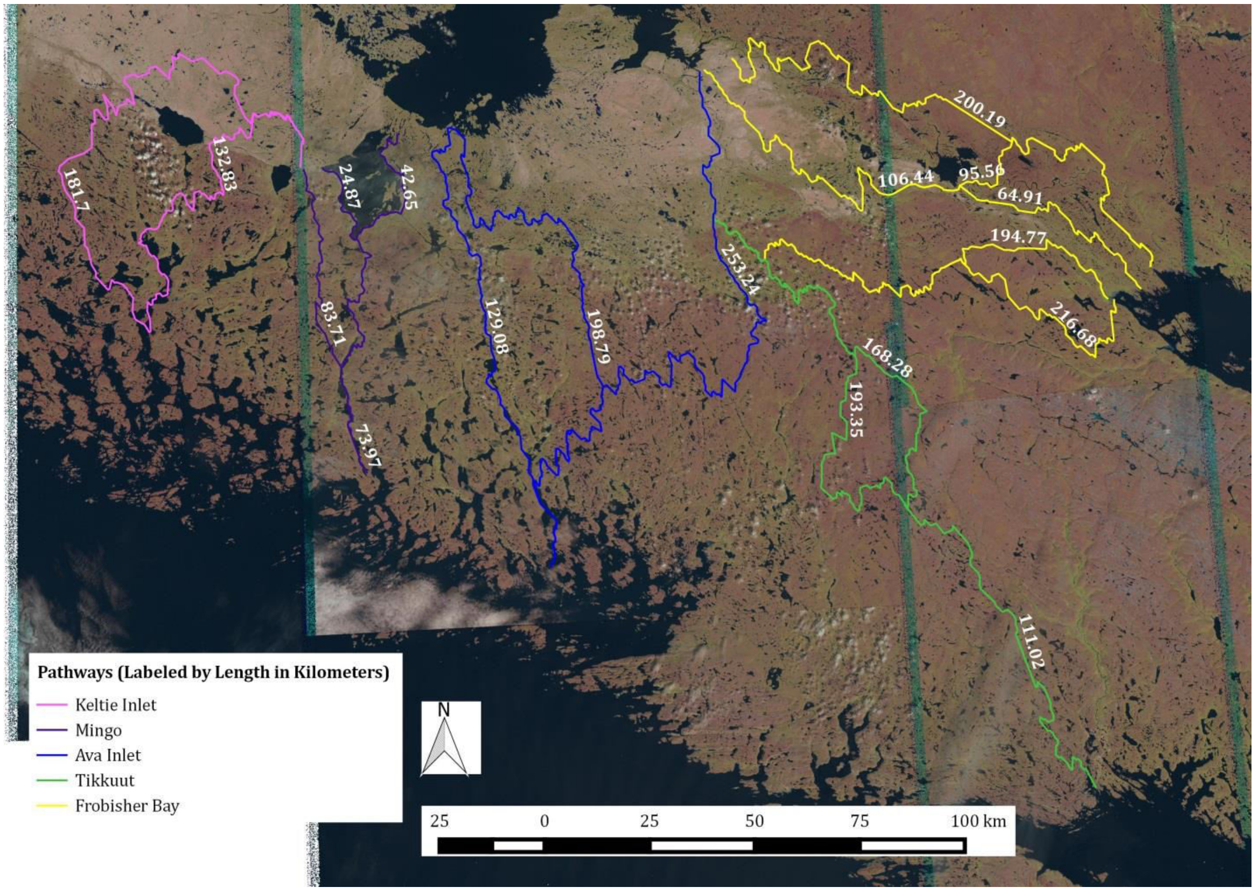

Figure 12. Map of individual pathways, their length in kilometers labeled (white), and differentiated by 'zones'.

Table 2. Relationship of LCP networks to Archaeological Sites

Distance to Sites (meters)	Land Cover Traverse-Ability	Ruggedness
Mean	647.71	2,676.49
Minimum	0.0	0.0
Maximum	8,272.0	9,894.0
Median	289.0	1814.0

Both LCP networks had archaeological sites fall directly on them, with minimum distance zero meters (m), and resting extremely far away, with maximums nearing ten kilometers (km). However, the land cover traverse-ability LCP network proves far more accurate in its relationship to existing archaeological sites. Mean and median distances are convincing of this. The land cover LCPs averaged 647.71 m while the ruggedness LCPs averaged over 2.5 km, more than four-times the distance. Second, more than half of the sites were within 289 m of the land cover LCPs whereas half of the sites were nearly 2 km away from the ruggedness LCPs, more than six-times the distance.

With these statistics in mind it was easy to proceed with individual pathway selections to create the 14 pathways revealed above. From these 14 pathways, one can insert perceptions about human-landscape interaction and past population mobility from Baffin Island's coast to the interior lakes regions. For the remainder of the pathway selection and interpretations, the land cover traverse-ability LCP network was used exclusively. The LCP segments closest together needed to be connected to create continuous pathways linking the coast and interior. After these locations were selected, I used the contour lines provided by Geogratis to 'topographically infer' the connections. Essentially, the dots were connected by judgment like if one were to navigate their own paths with a topographic map (see Figure 13, p.61).

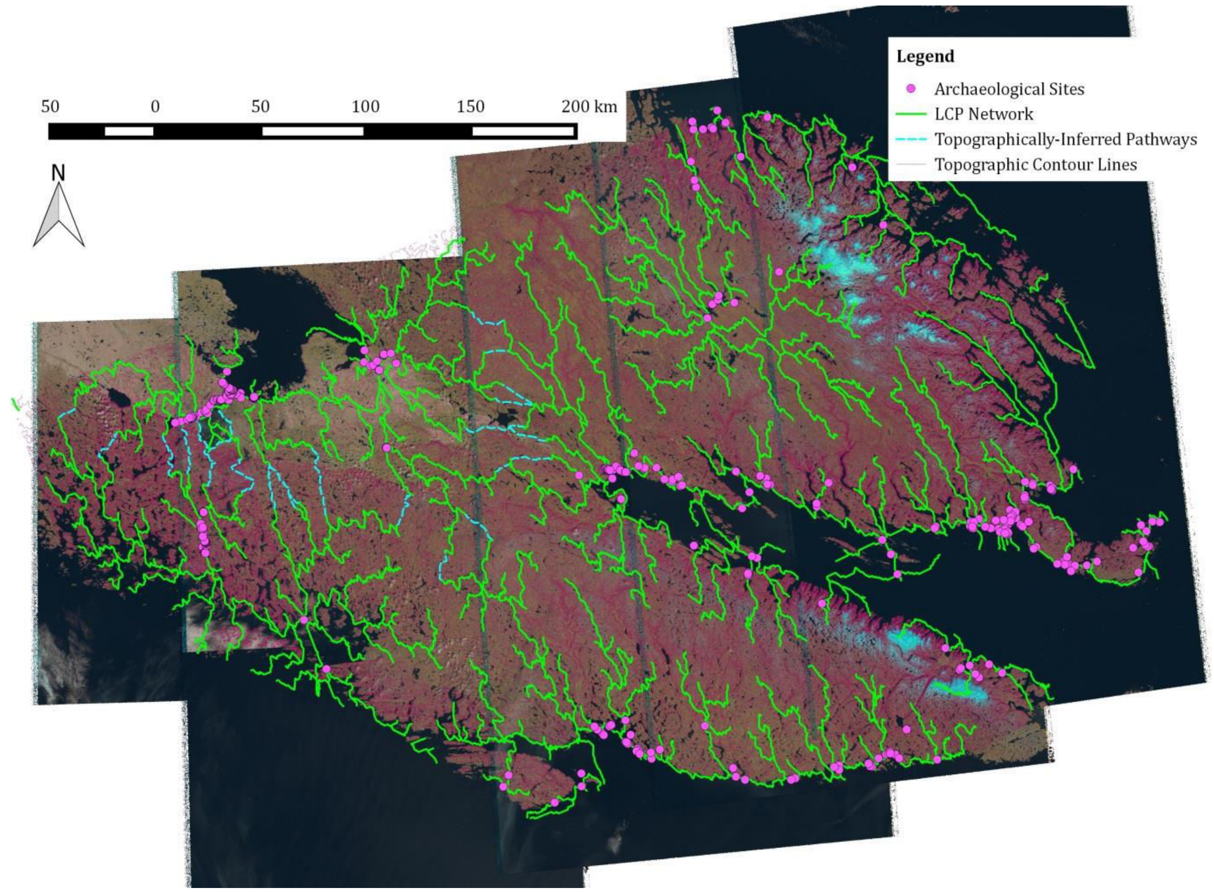

Figure 13. LCP network's (green) gaps filled in by the 'topographically-inferred pathways' (dashed sky blue) shown in relationship to archaeological sites and topographic contours.

Chapter 5- Discussion

The 14 pathways extracted from the LCP network provide a unique look into what factors may or may not have attracted humans to move across these places. Just because these routes were generated with ideal human conditions in mind does not mean that any person at any given time did, for certain, move along them. Additionally, these pathways are not perfect. There are segments that are found in water and parts with peculiarly random right/left-face turns. Both of these are not typical of humans walking. However, this shows the inherent error in using digital methods. Despite my efforts to make the analysis demonstrate human behavior, a computer does not think like a person. Those bends and water paths are a 'lost in translation' kind of phenomena occurring in consequence of reducing raster pixel sizes and converting them into geometrically smooth lines. Although the direct results cannot tell about past population mobility, Inuit knowledge about trails inland, language and landmarks, and chert accessibility in archaeological site formation can.

Experience the Landscapes as they did

Recordation of oral histories describes numerous journeys to southern Baffin Island's interior along paths convincingly similar to some of those generated in this analysis. In Stenton's (1991c) Amadjuak Trail project, he interviewed two Inuit elders and learned of two separate trails going towards Amadjuak Lake. One trail starts at the old fur trading hamlet of Amadjuak, runs along a chain of lakes, and travels along the Mingo Lake's shoreline to the Mingo River's confluence with Amadjuak Lake (Stenton 1991; 4-5c). The other starts at the apex of an inlet around White Bear Bay, trekking straight through rugged terrain, and bowing east then back west, approximately due north to the southern shore of Amadjuak Lake (Stenton 1991c:4-5).

Fascinatingly, these route descriptions almost mirror two of those generated in this research. Pathway 4 follows an identical route to Stenton's (1991c) first trail description, as does Pathway 5 to the second (see Figure 14).

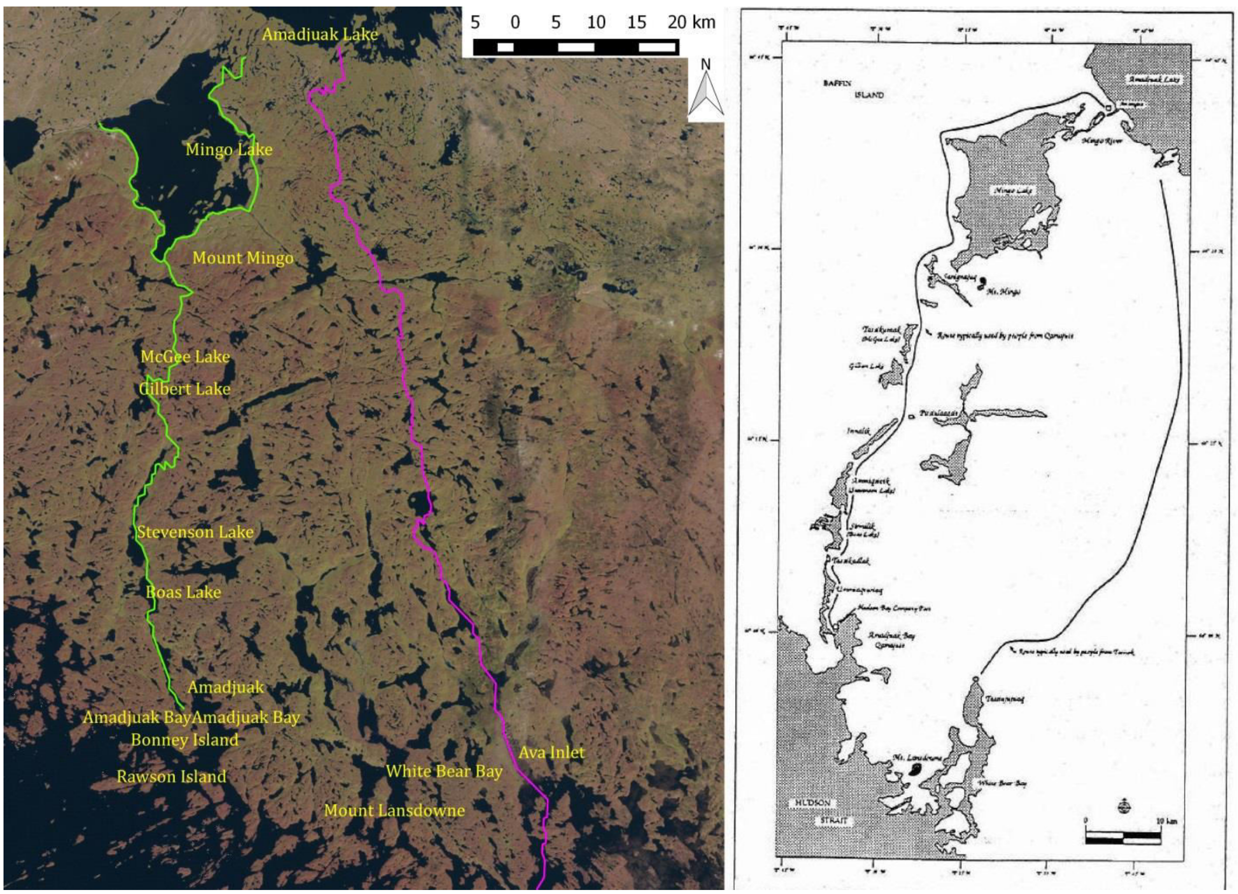

Figure 14. Side-by-side of pathways 4 (green) and 5 (pink) with the trails illustrated by Stenton (1991c: Figure 1, p.5) showing a near identical match of landmarks

Language and Landmarks

Inuit toponyms have ascribed meaning on a physical environment, and this meaning is the purest example of cultural landscape. Language is a descriptive art form of countless generations. Two place names pertaining to the study area illustrate this point. Amadjuak Lake is one of these places. Numerous archaeologists have revealed a translation as *amaaq* meaning "chert" and representing "the place where chert comes from" (Milne 2005; Milne et al. 2013; Park et al. 2014; Stenton 1991c). By itself, this descriptive toponym reveals a far reaching history, because the Inuit very rarely utilized chert for toolmaking purposes (Milne 2005; Stenton & Park 1998). In addition to *amaaq*, Franz Boas includes a geographic place called *Amaqdjuaq* meaning "the large place where children are carried in the hood" (1888:662). Boas' (1888) definition highlights the meaning Amadjuak held for the Inuit, as a destination of a journey in addition to the place where chert can be found. The second place name is *Tikkuut*, as in the Tikkuut Peninsula, where the modern hamlet of Kimmirut, Nunavut is located. According to a free online dictionary (http://www.livingdictionary.com/), *tikkuut* served as a root in the words *arqutikkuutuq* meaning "follow marked road" and *nuvvitikkuutuq* meaning "central rope" (Inuktitut n.d.). Therefore, the Tikkuut Peninsula may have earned its name by being a navigational beacon for an inland route with the reputation of an anchored central fixture marking the beginning of a road to be followed.

Along the pathways, there are many significant landmarks. An in-depth study of Inuit toponyms and their meaning-history would further enhance a pathway study. Although no direct Inuit translation was found, at least six commonly recognized landmarks have Inuktitut based names including the aforementioned Tikkuut Peninsula, Kimmirut, Amadjuak (lake and old hamlet), Katannilik (Territorial Park, though parks are a modern not Inuit construct), Qasitujuak Lake, Anakudluk Lake, Lake Ammatuk, Mount Mingo, Mingo Lake, and the Nuvungmiut River. Further landmarks with non-Inuktitut names include Boas Lake, Stevenson Lake, McGee Lake, Pleasant Inlet, Fair Ness, Murray Point, Ava Inlet, Keltie Inlet, Tinitonito Bay, Foul Inlet, the

Jordan River, Kynersley Lake, Peterhead Inlet, the Sylvia Grinnell Lake/River, Peale Point, and the Hone River. Surely, the Inuit have place names for these landmarks and many more (Bennet & Rowley 2004). I believe an in-depth Inuit place name research project could further current knowledge of land-use on southern Baffin Island through a landmark study.

Landmarks provide the blazes on the trail that may have been necessary to make these hundreds-of-kilometers long journeys to the interior from neighboring coastal locations. These blazes are most often highly noticeable, naturally occurring landscape features that alert an individual's perceptions by acting as a centripetal (drawing in) or centrifugal (pushing away) force (Molyneaux 2002). There are an abundance of these features along the pathways generated in this analysis, and may have signaled actions or movement from Baffin Island's past peoples. In facilitation of their own mobility, human-made stone features called *inuksuit* (*inuksuk* singular) were constructed to represent caches, campsites, or serve as a marker that a destination has been reached (Inuksuk n.d.; see Figure 15, p.66). These landmarks can be found all over the study area, and though they are usually attributed to the Inuit (Inuksuk n.d.), there is an ancient 3,000 year old inuksuk on the northwestern edge of Mingo Lake, which would have been constructed by an earlier Palaeo-Eskimo, probably Pre-Dorset, group (Inuksuk n.d.) Utilization or construction of landmarks physically, by remembering a feature or building stone markers, or mentally, through artistic/historic expressions in toponyms, transform a physical environment into a cultural landscape (see Figure 16, p.66).

Figure 15. Example of a large Inuksuk and meat cache overlooking the Mingo River, approximately two kilometers from where it drains into south Amadjuak Lake. A large multi-component Palaeo-Eskimo sites—LdDx-42—is situated just across the river from this Inuksuk (photo credit: Milne 2004).

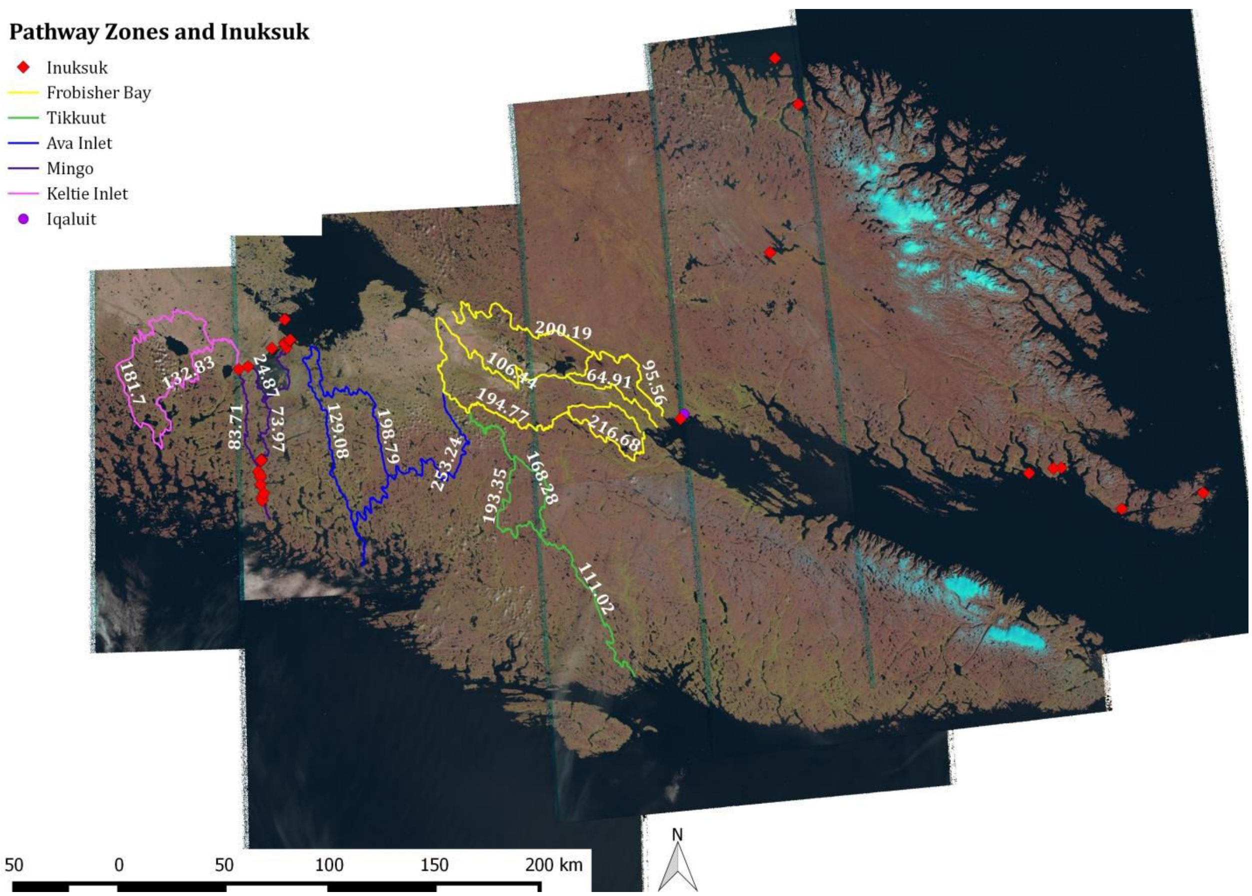

Figure 16. Image showing all Inuksuk throughout study area and compared with computed pathway zones

Human Interactions with Lands between Frobisher Bay and the southern Interior Lakes

A second instance of Inuit trail oral history and corroboration with this analysis occurs in Boas' (1964 [1888]) description of routes to the interior that were used by various Inuit groups (Müller-Barr & Wille 1998; Stenton 1991c). During spring, peoples moved up to the peak of Frobisher Bay (Stenton 1991c:102). When summer came, the men took a long journey to the interior that loosely followed the Sylvia Grinnell River. Then starting at Lake Ammatok the men followed a "a series of small lakes and rivers to the southeast corner of Amadjuak Lake where the Nuvungmiut River empties" (Stenton 1991c:104). After, the women took a different trail called *aqbeniling*, meaning it took six days to reach, to establish the summer's settlement (Stenton 1991c:104). Again, this analysis generated pathways that fit these descriptions to-a-'t'. Pathway 14 follows an over 200 km route reminiscent of Stenton's (1991c) description of the men's summer route. Further, pathway 12 is just 106 km long and ends at Miterk Bay at Amadjuak Lake between the headwaters of the Nuvungmiut and Hone Rivers, convincingly similar to the women's six day route (see Figure 17, p.68).

Landscape Archaeology and Palaeo-Eskimo Behavior Reconstruction

Baffin Island's interior is the only place in the study area where a reliable and easily accessible amount of toolstone quality chert can be acquired. Descriptions of the landscape features where chert can be accessed in higher quantities can be categorized as either exposed by eskers or as nodules in till cobbles (Hamilton 2008; Milne 2007; 2013; Stenton 1991c). These areas where chert may be exposed and accessible could prove informative in locating archaeological sites in reasonable proximity to this analysis' generated pathways. The discovery of site LbDt-1 in 2013 validates this supposition. LbDt-1 falls along a pivotal intersection for five pathways—7 through 11.

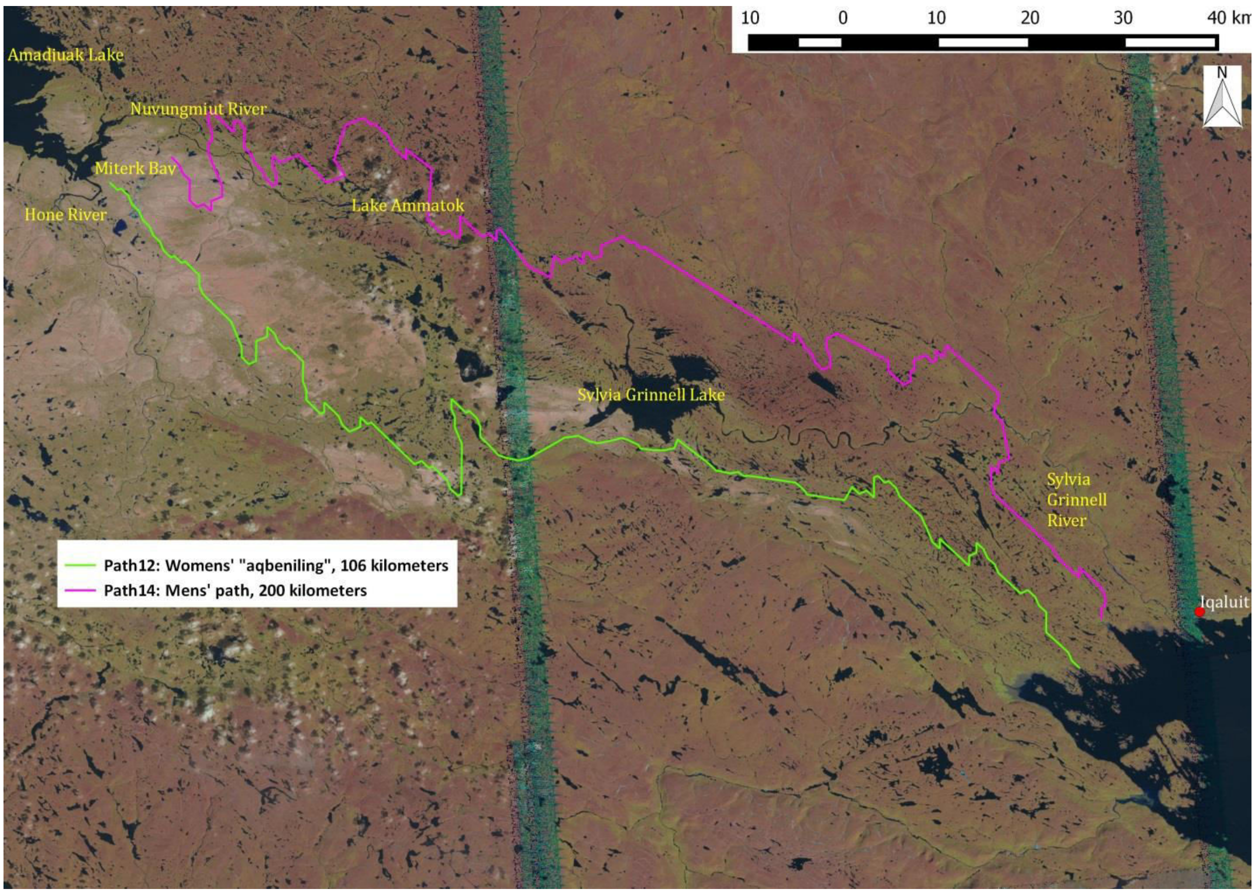

Figure 17. Paths 12 (green) and 14 (pink) possibly resembling the male vs. female pathways with landmarks mentioned by Stenton (1991c:104)

The location of LbDt-1 presents an ideal model for acquiring chert toolstone because there is much till-cobble nearby as well as *in situ* chert nodules exposed in a large limestone outcrop at the site. The site rests within a kilometer, downstream, from an esker formation. A simple vector query with pathways, till, and eskers highlight places with similar ideal conditions. This was accomplished here (see Figure 18) by making a 650 m buffer around the pathways (1,300 m in diameter and the mean distance of archaeological sites from the pathways) and finding intersections of this, 'till-colluvium' as a land cover type (Geobase 2009), and being within 1 km of an esker feature. The product is a predictive model of locations where chert should be located and easily accessible. This emphasizes the pathways that may have proved more alluring to chipped stone tool-using Palaeo-Eskimo groups, and narrows considerably areas of interest for future site investigations related to the Southern Baffin Island Chert Provenance Project.

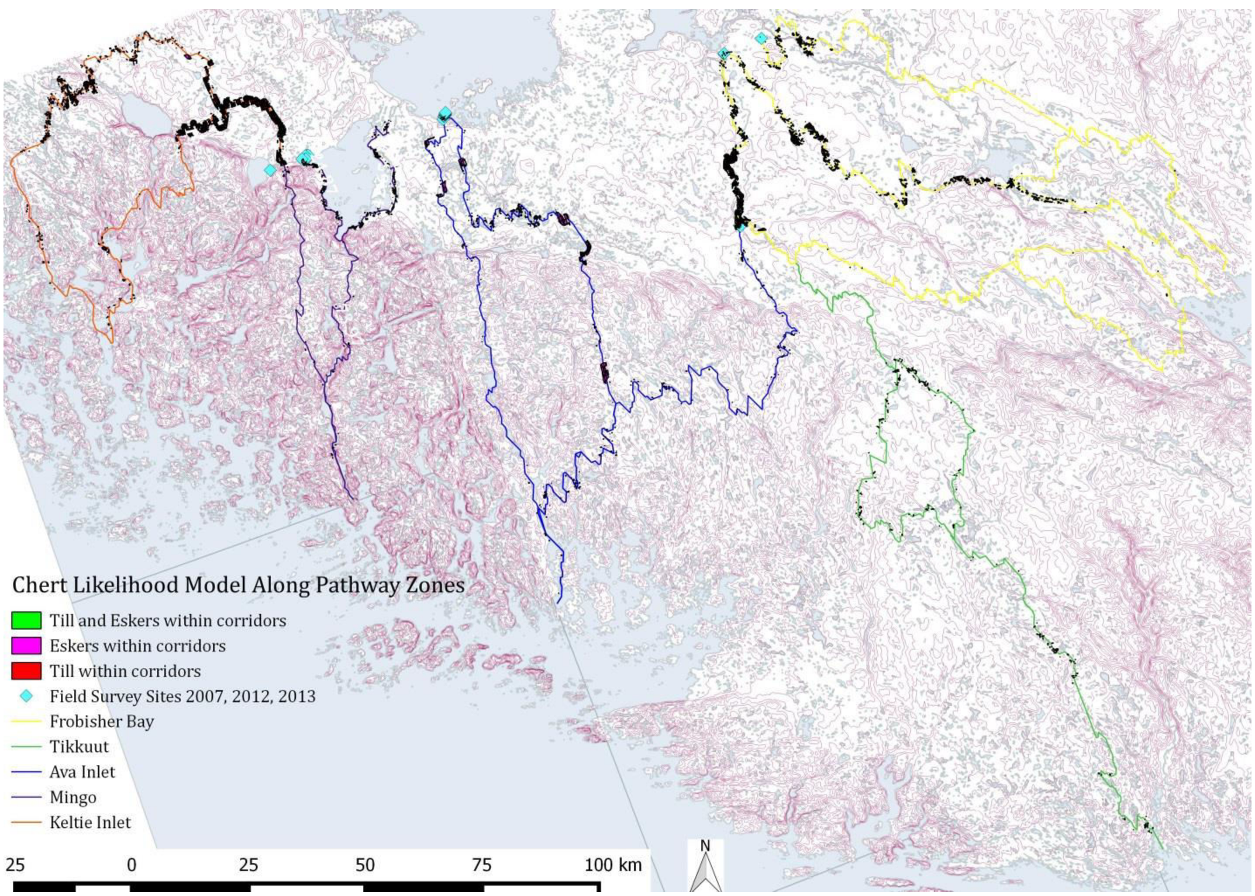

Figure 18. Likelihood of chert higher in the 'darker' areas along the pathway zones, field survey data shown 'under' chert model to show overlap of chert and sites

‘Landscapes’ and Site Formation

Inuit Land Use Patterns and Interactions with Natural Landscapes

Southern Baffin Island’s natural environments have a great advantage regarding the analysis of landscapes. Recollections of uses and feelings about different places from contemporary archaeological and Inuit experiences could mirror those of past peoples (Aporta 2009). Both the continued undisturbed-by-human condition of many locations and challenges posed by southern Baffin Island’s environments make the indigenous experience incredibly informative. These experiences combined with geospatial analyses can recount centuries of cultural interaction with the environment and on the formation of cultural landscapes. Both experiences, and digital models are essential to find particular areas of significance in such a vast area. This is especially true for understanding movement across such an expanse. Prior to today’s permanent settlements, most Inuit viewed life as being on the trail and moving across their landscapes (Aporta 2009; Bennett & Rowley 2004). This research serves as an “archaeology of place” (Wheatley n.d.) to find those trails that were home to generations of the area’s Inuit and their predecessors. Throughout history, understanding life as a ‘Baffin Islander’ is to understand movement, because if they stayed in one place too long the land tells them, “For the health of the land and the animals, they need[ed] to move” (Bennett & Rowley 2004:121). In a place with limited and seasonally restricted resources, routes had to be “lived rather than travelled” (Aporta 2009:135).

Navigation is essential in a life on the trail. To the Inuit, “Essential to navigation was the system of place names” (Bennett & Rowley 2004:113). Each place has meaning based upon its traits or the resources it provides, and giving names socializes the land and turns it into a cultural landscape (Tacon 1994). According to the Inuit, one’s personal actions reflect consequences on the landscape, because respect for what the land could give or take is essential for survival (Bennett & Rowley 2004:118-119). Life is a constant learning relationship with the landscape. In this relationship landmarks and their names are like members of a family, thus, "There is never an unrecognizable place" (Bennett & Rowley 2004:120). For the Inuit, landscapes are more than the places where tasks are performed in accordance to temporality, *i.e.* 'task-scape' (Ingold 1993). Landscapes are life, they are family, and they are lived for. Describing his memory of travelling to a particular lake, an Inuit elder said, "Every day I long to drink it. I yearn for its landscape" (Bennett & Rowley 2004:119).

Archaeological Evidence for Long Term Human-Landscape Interactions

Yearning for those landscapes may have motivated many generations of Palaeo-Eskimo and Thule-Inuit groups throughout the entirety of human history on southern Baffin Island. Milne et al. (2013) provide an enlightening view of an archaeologically unverifiable reason for the seasonal mobility of Palaeo-Eskimo populations to the island's interior: to socialize. Certainly new faces can be uplifting and diversifying mates are healthy for sustaining viable populations (Milne 2008a; Milne et al. 2013:58), but so too may socializing with the landscape have been essential for emotional and spiritual survival. The essentialness of socialization is clearly demonstrated in the archaeology of southern Baffin Island's interior. Archaeological sites LdFa-1 (northwest shore of Mingo Lake) and LeDx-42 (south side of Mingo River to southwest of Amadjuak Lake) highlight the importance of the interior throughout the entirety of the Palaeo-Eskimo Period between 4,500 years and 1,000 years ago (Milne et al. 2013). Throughout this time, people used these two sites for intensive lithic tool reduction and for mass caribou processing, which "contradicts assertions that the importance of terrestrial resources declined in favor of sea mammals" (Milne et al. 2013:55). Although tools, structure, and practices may have differed between groups of the early, middle, and late Palaeo-Eskimo periods, it seems that there was a "mobility-continuity" (Milne et al. 2013:53). To the Palaeo-Eskimo like the Thule-Inuit, moving to Baffin Island's interior was essential for survival. Survival required taking advantage of seasonally optimal resources and, in so doing, interacting with those places that provide senses of comfort, familiarity, and renewal.

Chapter 6- Conclusions

This research has contributed to resolving spatial problems and questions of scale (Molyneaux 2006) for an in-depth case study on southern Baffin Island by using GIS and landscape archaeology. The attempt to locate how and where past peoples may have moved between archaeologically dense coastal and inland areas was successful. Further, the significance of the possible coastal-interior pathways can be surmised based on what resources may have been available and who may have travelled on them (i.e. Palaeo-Eskimo or Thule-Inuit groups; men or women). Since GIS has become more frequently used in archaeological work (McCoy & Ladefoged 2009), the possibilities of answering questions of cultural use of space and its significance are abundant. The products of these works will grow in complexity and sophistication with the ever increasing accessibility and advancement of spatial technologies. Discoveries of archaeological phenomena will expand greatly as it has with remote sensing (satellite imagery) in even the most forbidding of landscapes (Gietl et al. 2007; Rajani & Rajawat 2011; Saturno et al. 2006; Siart et al. 2008). So too will the connections of those scattered archaeological phenomena become clearer, whether it be perceptual like understanding colonization from similarity of technological construction (Ellis 2008, 2011) or physical like stone geochemical signatures and discovering lithic sources through GIS interpolation (Clarkson & Bellas 2014). The analysis and product of this research highlights these positive strides for archaeology through the use of GIS.

Summary- Landscape and Baffin Island Identity

In line with the aforementioned positive futuristic outlooks, this research has produced a methodology for reconstructing population mobility through the use of GIS. Creating an AHP to generate an LCP network conveys a promising method for showing the contingency-based and fluidity of human physical movement. Therefore, objective one (see p.8) was successfully completed. Further, placing oral histories, toponyms, and landmarks over those digitally reconstructed pathways related something geo-statistically empirical and converted it into a potentially realistic portrayal of how past Baffin Islander's may have moved across their landscapes. Thus, objective two (see p.8) was also successfully completed. More important than the methodological achievements, this research sheds light onto what life may have been like in any of Baffin Island's past societies in addition to being a foundation upon which new hypotheses can be created and tested for future research in the study area. Free open-source geographic data sets, digital elevation models, and GIS programs have produced information about population movement, cultural use of space, and potential testing for gendered use of landscapes. With an AHP and watershed function, a more complex method for creating LCPs resulted in very humanistic pathways in which past peoples may have travelled from southern Baffin Island's coast to its interior and back. These pathways appear to closely correlate with Inuit oral-historical accounts of inland routes, and they seem to be in reasonably close proximity to both known archaeological sites and potential sources of chert.

Seeing the wide possibilities for moving from coast to interior provides a number of new ideas about what life may have been like for those that lived it. The pathways constructed in this study show the difficulties and contingencies of geography for each specific area's inland routes. Inspiration for this movement was either resource or socially based, or both. Caribou, Arctic char, and tradition definitely lasted as an inspiration from Baffin Island's earliest inhabitants to today's Inuit. In addition to these phenomena, chert once proved equally important. Chert shaped how Palaeo-Eskimo groups moved inland, and understanding how this movement occurred was my contribution to the ongoing Southern Baffin Island Chert Provenance Project. Preliminarily, objective three (see p.8) was achieved. With open source geospatial data, areas of likelihood for chert were highlighted and correlated with archaeological sites.

The landscape is Baffin Island identity. Being a Baffin Islander requires knowing how to survive in this remote and challenging environment (Aporta 2009; Bennett & Rowley 2004). Traditions, including language, have preserved the identity of the Inuit (Patrick 2013). This recognition of traditions' importance for identity helps create a cross-cultural understanding of differences, like the beliefs of "western" concepts such as archaeology versus the indigenous retelling of history through oral knowledge (Forte 2013). The archaeology and ethnography of southern Baffin Island has demonstrated these points. Landscapes, both physical and cultural, of southern Baffin Island have elucidated the productivity of structured technology-based analyses (GIS) and illustrated the value of traditional knowledge.

Future Directions

In Chapter 5, the potential for doing an expansive Inuit place names project to emphasize greater places of significance regarding movement across the study area was mentioned. This is just one possibility for future research created by this project. An unexpected product of this research was the breadth of research possibilities it has created. The scale of this research was so large that it has generated field and lab (geospatial) opportunities to test the results through ground truthing or more advanced GIS/remote sensing techniques. Research opportunities stretch to testing of Palaeo-Eskimo or Thule-Inuit lifeways such as longevity of seasonal settlement patterns/strategies. The terrestrial environment is incredibly challenging, especially to move across. For example, many of the paths generated in this analysis would have required much less energy for travel if using frozen bodies of water. This could suggest people may have been spending the majority of the year moving to, being in, and coming back from the interior as opposed to the movement being part of more strictly defined seasonal round (Hamilton 2008; Milne 2005, 2007, 2008a/b, 2012, 2013, Milne et al. 2009; Milne et al. 2011; Milne et al. 2012; Milne et al. 2013; Stenton 1989, 1991c). Clearly, thinking about the challenges and variability of Baffin Island's natural environments can greatly impact research questions in regards to human agency in these landscapes.

Another avenue of research generated by this project could be testing for gendered uses of space on southern Baffin Island. Chapter 6 presents a potential correlation between pathway 12 and a traditional Inuit women's inland travel route in addition to pathway 14 and a traditional Inuit men's route. This possible correlation raises the opportunity to test these travel routes directly, and would allow a rare opportunity to conduct archaeological field research that would be explicitly testing models of gendered land use. Further, if land use was engendered in this portion of southern Baffin Island, could it be possible that this was a custom across southern Baffin Island, and could it be something that Palaeo-Eskimo groups may have done as well? Justification for the latter portion of the previous question rose with the observation that pathway 12 should also contain more areas likely to have chert (see Figure 17). Thus, this research has unveiled numerous questions about gendered uses of cultural landscapes. What if Palaeo-Eskimo men and women similarly followed these separate routes? If so, and knowing the women's route has higher access to chert, it intriguingly raises the question about women being directly involved in the procurement and transport of lithic raw material from source locations to larger tool making sites like LdFa-1 and LeDx-42 near the large lakes.

Testing of the chert locations in correlation to this research's pathways could prove useful to future research in the area. Access to chert could prove incredibly important to inland travel routes and Palaeo-Eskimo archaeological site formation. This is highlighted by the fact that fieldwork conducted in 2013 led to the discovery of the LbDt-1 site, which rests at an intersection of five of the generated pathways leading from the coast to the interior. LdDt-1 is the first large lithic quarry site of its kind ever identified on southern Baffin Island. Therefore, there appears to be a strong connection between chert accessibility and Palaeo-Eskimo population mobility. More in-depth geospatial testing and field-based ground truthing of the generated pathways could reveal many more places where chert toolstone was acquired and where archaeological sites were formed. There seems to be innumerable research possibilities when combining this kind of testing with questions of cultural place names, seasonality of movement, and gendered use of space in the archaeology of southern Baffin Island's landscapes.

Community involvement and the integration of higher resolution raster imagery would enhance the results of this study going forward in the future. I believe using Inuit traditional knowledge and contemporary land use strategies would add significant detail to the model thereby increasing the likelihood of identifying past travel routes between the coast and interior regions. This would also facilitate comparisons between my digitally created trails to ones people know about and/or that are still being used today. Further, personal anecdotes about travel routes from local elders groups and hunters would help to identify significant landmarks they encounter in their travels within the region. This knowledge would help increase the resolution of the identified pathways, making them more representative of human movement since those who live on southern Baffin Island could directly influence coastal-interior path projection.

I believe the model as it is can be immediately applied to field survey methods and planning in the study area. My model has generated movement networks that are within 650m of known archaeological sites, on average, with more than half of those being within 300m. Initially, low helicopter survey could be initiated using the coordinates of these pathways as a navigation route. It may be possible to spot surface features from the air, which is how LbDt-1 was located. Since my pathways represent easiest routes of human walking, these could be directly tested with ground surveys on foot or with all-terrain-vehicles. The pathway coordinates could be inserted into a global positioning system (GPS) unit and followed. This would directly test their plausibility as a travel route and allow the surveyors to map or test areas for archaeological remains. Although my pathways as they exist are not exact (nor should they be if you think about 4,500 years of human movement), my model significantly narrows down the search area in an otherwise overwhelmingly large geographic area.

Final Remarks- Landscape on Archaeology

Landscape emphasizes a shift in thinking to the significance of *where* the archaeological discoveries are made instead of *what* they are. By conducting an archaeology of place (Wheatley n.d.) one literally walks, or at least imagines being, in the shoes of someone from the past. Imagining and recreating the same feelings occurring because of a common landscape propels an archaeologist to consider many aspects of survival within a natural environment, and allows them to be a teller of a landscape's story (Ingold 1993). Realizing the complexities and contingencies that mean life and death allows an archaeologist to fathom the reasons why past societies constructed cultural landscapes to justify behaviors, rules, norms, and expectations as acceptable or unacceptable.

These mental constructs weigh on the minds of humans today as they did to those in the past. I believe accessibilities and limitations of our environments manipulate how we act in and perceive our world. In this way, landscape grants archaeologists an exclusive opportunity to reconstruct past human agency through empathy that is derived from either fieldwork, actually being in the places as a historical doppelganger, or through the use of GIS, realizing the importance of an environment through critical analysis of it. Reconstructing human behavior with empathetic agency is ascertainable, since humans have the ability to critically think about their own and each other's actions both now and in the past. All people are united by their senses and by our consequential existence in a common world. It is this sensory ecology (Molyneaux 2012) from which we can hope to extract greater understanding of each other through the study of landscapes.

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Appendix

The appendix outlines the access to data sets and GIS programs that were used to complete this research. Access of the geographic and geologic data used was completely free and open source. So too were the GIS programs used. The locations both in name and web address will be provided to help those who may be interested in this information for future work. Archaeological site/feature data were provided in two ways. Milne's 2007, 2012, and 2013 site reports include tables with coordinates of the archaeological sites and/or features for those field seasons. This data was used with oral consent from Dr. Milne and is otherwise not free to the public. Additionally, the territory of Nunavut's Department of Culture, Language, Elder's and Youth provided the locational data for all known archaeological sites in the study area. This access required permission from the territorial government and fulfillment of licensed agreement. The terms and conditions of that agreement were followed, and the Site Data License is included herein.

I. Open-Source Geospatial Foundation at http://www.osgeo.org/

A. GIS Programs: GRASS 6.4.4 and QGIS 2.4 Chugiak

1. http://www2.qgis.org/en/site/

II. Natural Resources Canada Geogratis at English page http://geogratis.cgdi.gc.ca/geogratis/Home?lang=en, simple searches:

A. Geographic data (vector; search in "Product Type: Data) by NTS sections

1. 025h
2. 025i
3. 025j
4. 025k
5. 025l
6. 025m
7. 025n
8. 025o
9. 025p
10. 026a
11. 026b
12. 026c
13. 026d
14. 035p
15. 036a

B. Geologic Information (vector and documents; no defined "Product Type")

C. Digital Elevation Models (raster; "Product Type: Elevation Data") by NTS Sections East and West:

1. 025h
2. 025i
3. 025j
4. 025k
5. 025l
6. 025m
7. 025n
8. 025o
9. 025p
10. 026a
11. 026b
12. 026c
13. 026d
14. 035p
15. 036a

III. United States Geologic Survey Global Visualization Viewer at http://glovis.usgs.gov/

A. Landsat 7 Enhanced Thematic Mapper Plus (ETM+) Scan Line Corrector (SLC-On)- Remotely Sensed Satellite Imagery (raster) sections:

1. LE70200152002236EDC00
2. LE70190162002229GNC00
3. LE70190152000224EDC00

4. LE70170162001196EDC00
5. LE70170152002215EDC00
6. LE70160162002208EDC00
7. LE70160152002224EDC00
8. LE70150161999257EDC00
9. LE70150151999257EDC00

IV. Archaeological Sites and Features: Milne Surveys

A. 2007 (see Milne 2007:49):

site_nm	LAT	LONG	Y	X
LdFa-1	64 39 24 N	072 20 09 W	64.65666700	-72.33583300
LdFa-12	64 39 51 N	072 19 37 W	64.66417000	-72.32694000
LdFa-13	64 39 48 N	072 18 92 W	64.66333000	-72.32556000
LdFa-14	64 39 49 N	072 18 97 W	64.66361000	-72.32694000
LdFa-15	64 39 50 N	072 19 10 W	64.66389000	-72.31944000
LdFa-16	64 39 48 N	072 19 54 W	64.66333000	-72.33167000
LdFa-17	64 39 52 N	072 19 55 W	64.66444000	-72.33194000
LdFb-3	64 39 28 N	072 20 25 W	64.65778000	-72.34028000
LdFb-4	64 39 29 N	072 20 16 W	64.65806000	-72.33778000
LdFb-5	64 39 30 N	072 20 06 W	64.65833000	-72.33500000
LdFb-9	64 39 39 N	072 20 66 W	64.66083000	-72.35167000

B. 2012 (see Milne 2012:13):

site	loc	LAT	LONG	Y	X	elev
KkDn-1	Quartz find 1	63 43 42.6 N	68 32 44.7 W	63.72850000	-68.54575000	19
KkDn-1	Hearth	63 43 43.2 N	68 32 43.9 W	63.72867000	-68.54553000	25.6
KkDn-1	Chert 2	63 43 41.8 N	68 32 44.5 W	63.72828000	-68.54569000	
KkDn-1	Chert 3	63 43 42.3 N	68 32 43.6 W	63.72842000	-68.54544000	19
KkDn-1	Chert 4	63 43 41.9 N	68 32 43.3 W	63.72831000	-68.54536000	21
KkDn-1	Chert 5	63 43 42.2 N	68 32 43.1 W	63.72839000	-68.54531000	24
KkDn-1	Chert 6	63 43 41.6 N	68 32 42.7 W	63.72822000	-68.54519000	21
KkDn-1	Chert 7	63 43 41.7 N	68 32 42.4 W	63.72825000	-68.54511000	23
KkDn-1	Chert 8	63 43 41.2 N	68 32 41 W	63.72811000	-68.54472000	23

C. 2013 (see Milne 2013:30):

Location	LAT N	LONG W	X	Y	ELEV
Cluster 6 tent rings	64 33 5.5	70 23 45.6	-70.396000	64.551528	117
Cluster 3 tent rings	64 33 4.1	70 23 50.4	-70.214000	64.551139	115
Cache	64 33 5.3	70 23 44.4	-70.395667	64.551472	118
Cluster 2 tent rings	64 33 4.5	70 23 50.3	-70.397306	64.551250	114
Tent Ring	64 33 5.8	70 23 44.2	-70.395611	64.551611	118
General site area	64 39 43.6	72 30 13.8	-72.503833	64.662111	117
General reading	64 38 5.5	71 41 19.7	-71.688806	64.634861	136
Area 1	64 38 23.3	71 40 48.2	-71.680056	64.639806	121
Area 2	64 38 24	71 40 43.4	-71.678722	64.640000	119
Area 3	64 38 27.8	71 40 25.5	-71.673750	64.641056	119
Area 5	64 38 28.6	71 40 23.3	-71.673139	64.641278	121
Area 6	64 38 32.3	71 40 20.3	-71.672306	64.642306	120
Area 7	64 38 34.9	71 40 15.6	-71.671000	64.643028	118
Area 8	64 38 36.2	71 40 15.4	-71.670944	64.643389	120
Area 9	64 38 39.7	71 40 8	-71.668889	64.644361	N/A
Area 10	64 38 44.4	71 40 2.8	-71.667444	64.645667	116
General reading	64 13 50.2	70 37 18.3	-70.621750	64.230611	199
Outcrop- lower	64 13 47.2	70 37 21.1	-70.622528	64.229778	191
Riverbank sump- lower	64 13 47.2	70 37 14.2	-70.620611	64.229778	186
Tent ring cluster- upper	64 13 51.7	70 37 19.1	-70.621972	64.231028	200
Debitage scatter- upper	64 13 50.1	70 37 26.2	-70.623944	64.230583	206
Test 1 Tent Ring 1	64 13 52	70 37 19.5	-70.622083	64.231111	197
Test 2 Tent Ring 2	64 13 51.7	70 37 19.2	-70.622000	64.231028	196
Test 3 lower site	64 13 43.2	70 37 14	-70.620556	64.228667	184
Test 4 lower site	64 13 42.6	70 37 13.8	-70.620500	64.228500	184

V. Archaeological Sites Territory of Nunavut

A. Locations not provided in accordance to license agreement

1. Site Data License:

Building Nunavut Together
Nunavutliuqatigiingniq
Bâtir le Nunavut ensemble
Nunavut

October 14, 2014

Jeffrey P. Stup
University of Manitoba

Site Data Licence: Modelling Population Mobility in Southern Baffin Island's Past Using GIS and Landscape Archaeology

Dear Mr. Stup:

As requested, enclosed please find a summary of the archaeological sites within your area of investigation. Please be reminded that this data is not to be shared with anyone other than those identified in the application you submitted on September 16, 2014 and that all copies of this data must be destroyed by October 3, 2015. Written confirmation of the destruction of this data must be sent to the Government of Nunavut.

Locate areas with archaeological potential in a defined study area for a Baffin Island lithic provenance study led by Dr. Brooke Milne. The study combines basic site locations, geographic names, remotely sensed imagery, and factors analytically designed in multiple spatial analysis being conducted in GIS.

25I, J, K, L, M,N,O and P
26A,B,C and D
35P

Sincerely,

[redacted]
Territorial Archaeologist