A beetle-based palaeoecological reconstruction of human-environment interactions in Kivalekh, northern Labrador

By, Pier-Ann Milliard

Department of Archaeology
Memorial University of Newfoundland
December 2022

ABSTRACT & RÉSUMÉ

This research attempts to capture and document the "ecological footprint" of past Inuit groups who lived in Kivalekh in northern Labrador over the last thousand years. Using methods from both archaeology and palaeoecology, this work aims to examine and document how human activities affected the local landscape and ecosystems processes. This is achieved by reconstructing environmental change in the vicinity of Kivalekh over the last thousand years or so through a multi-proxy analysis (with archaeoentomology – the study of insect remains – as the main focus, complemented with biostratigraphy and charcoal analysis) applied on one peat monolith collected within a 30-meters distance of the archaeological site itself. This thesis first reviews published research that has examined how hunter-fisher-gatherers affected local environments through their activities within the landscape and discusses methodological considerations relevant to this scholarly literature. This review informed the design of the methods employed to achieve the research conducted in this thesis, which also led to a better understanding of the chronology of human occupation at Kivalekh.

* * *

Cette recherche tente de capturer et documenter « l'empreinte écologique » des groupes Inuit qui ont vécu à Kivalekh, au nord du Labrador sur une période de 1000 ans. En combinant des méthodes provenant de l'archéologie environnementale et de la paléoécologie, ce travail tente de documenter les différentes façons dont ces groupes humains ont modifié le paysage local du nord du Labrador, et par le fait même, affecté les dynamiques des écosystèmes. Ceci est réalisé en reconstruisant les changements environnementaux locaux en périphérie du site archéologique de Kivalekh, sur une période approximative de 1000 ans. Je combine plusieurs méthodes d'analyse (soit l'archéoentomologie étant la méthode principale, complémentée avec des analyses biostratigraphiques et anthracologiques) sur un échantillon de tourbière provenant d'un monolithe prélevé en périphérie du site (<30 mètres à l'extérieur du site). Cette thèse passe d'abord en revue la littérature associée aux recherches menées sur les impacts écologiques des groupes chasseurs-cueilleurs-pêcheurs au sein des paysages arctiques et subarctiques afin d'élaborer la méthodologie proposée ici et par le fait même proposer une chronologie à résolution élevée pour le contexte étudié.

GENERAL SUMMARY

The archaeological site of Kivalekh is reported to be the largest Inuit winter settlement in Labrador and is located near other well-documented sites (such as Uivak Point, Oakes Bay and Okak Mission). It therefore has the potential to offer insights into past Inuit-environment interactions, in addition to providing a high-resolution chronology for the human occupation of the site. To do so, this research aims to capture and document the ecological footprint (i.e., the beetle taxa associated with human activity) of ancestral Labrador Inuit, and to examine how their activities affected the local landscape and biodiversity. By conducting a multi-proxy analysis (biostratigraphy, charcoal, and beetles) on samples of peat collected in the vicinity of the winter camp, we can reconstruct local environmental change in Kivalekh over the last thousand years or so.

ACKNOWLEDGEMENTS

First and foremost, I would like to start by acknowledging the territory of the ancestral homelands of the Beothuk in which this thesis has been produced. As my research concerns past Labrador Inuit, I would also like to recognize the Inuit of Nunatsiavut and their ancestors, as well as the Innu of Nitassinan and the peoples of NunatuKavut, who share the land with the Inuit. I am grateful that I got the chance to engage with their environmental histories, using many available sources of knowledge (scientific literature, archives, and various ethnographic exhibits and documents) that helped me produce the work herein.

I also wish to send my gratitude to my supervisor Dr. Véronique Forbes for her inspiration, guidance, and constant support. I am extremely grateful that you picked me as one of your students in the first place and passed on to me your passion for beetles – it is fair to say that it made me see the world differently today. I look forward to continuing to work with you in the coming years. Lots of fun projects await! Thanks to Dr. Paul Ledger for teaching me in the lab how to combine proxies in my research and for your patience in explaining to me (over and over again) chronological modelling and many of the technicalities with radiocarbon dating (it is still a work in progress…) I also wish to thank Dr. Peter Whitridge for his help finding publications about Kivalekh that are not readily accessible, and for sharing many pictures from the fieldwork that I used in my thesis. On that note, thank you to Ph.D. student James Williamson for producing and sharing GIS maps of the site. I used a few of them in my work, and they were absolutely helpful in locating all the features of the site. Of course, a special thanks to the members (and friends) of the P.E.A.T. Laboratory as they helped me, in many ways, to achieve this project; in addition to all my peers from the department for your encouragements and friendship. Special cheers to Ivan Carlson, for collecting the samples I got the chance to analyze for my MA. Your help with transferring me

all your notes and knowledge of the site made all this possible. I hope this work will honor yours.

I would like to thank the faculty of the Department of Archaeology at Memorial University for offering me the opportunity to complete this degree and continue my doctoral studies at your institution. Sincere gratitude to the funding bodies that helped me achieve this research in time: the School of Graduate Studies at Memorial University, and the Canada Graduate Scholarships-Master's (Social Sciences and Humanities Research Council) Joseph Armand Bombardier award for their financial support. I also wish to thank the SSHRC-Storytellers 2022 jury for choosing to give my project an award. And lastly, thanks to Dean's Excellence Award for your recognition.

Finally, I wish to send my gratitude to my family. Many thanks to my partner, Eric, who always supported me throughout the realization of this project. Your resources, skills, and moral support helped me to achieve this thesis. Thanks to my family for always believing that I was in the right place. On that note, cheers to my dad, Jean, for supporting me all along.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

purposes: cooking, heating, building tools and dwellings; (c) the presence of charcoal indicate hunter-fisher-gatherers' use of woodland resources, leaving traces in the soil matrix; (d) harvesting *Picea* (spruce) and using it for insulating dwellings, beddings, and as a flooring material offers opportunities for specific beetles to occupy niches inside the homes; (e) the presence of abundant discarded bones is responsible for increasing the presence of certain nutrients in the soil composition, resulting in the emergence of rich and diversified vegetation compared to occupation sites' 'natural' surroundings; (f) certain kinds of human activities, when undertaken near the edge of a body of water (such as here, skinning or processing a seal or its skin) affect the level of eutrophication in ponds and lakes through nitrogen inputs; (g) foot traffic (or trampling) can result in decreasing the presence of certain native plants that are sensitive to disturbance, and increasing those who thrive in such disturbed context; and finally (h) the transportation of specific resources (spruce, down, fur, feathers, wood, etc.) creates niches for beetles associated with organic matter, that can be transported or attracted to human homes. Figure made by the author in collaboration with Eric Aylward, using Adobe Illustrator.

Figure 3.1 – Simplified map showing the archaeological site of Kivalekh with principal geographical features and important archaeological sites nearby as described herein. Figure made by the author.

Figure 3.2 – Example of a large sod house visible on the surface of the site, found at western end of the archaeological site of Kivalekh, facing North. This photo is a courtesy of Dr. Peter Whitridge (2018).

Figure 3.3 a – Orthophoto mosaic of the archaeological site of Kivalekh generated from RPAS imagery. The agglomeration of sod-houses (red circles) like the one seen from the ground as shown in Figure 8, is easily observable using drone technologies. **b –** Contour map of the archaeological site of Kivalekh (same picture as in Figure 9a), generated in QGIS. Red circles highlight the two agglomerations of sod-houses**.** **c –** Orthophoto mosaic of the same area presenting the sod-houses (underlined). All these are a courtesy of James Williamson.

Figure 3.4 – Archaeological features surveyed and recorded, located north of the winter houses at Kivalekh. Courtesy of James Williamson. The large red circle shows the agglomeration of winter sod houses of Kivalekh, as depicted in Figure 3.3.

Figure 4.1 a – Locations of the trenches (P.E.T.) #1,2,3. **b –** Locations of the trench P.E.T #3 measuring 1m x 1m, from which the monolith studied herein come from. Courtesy of James Williamson for producing these maps, although modified by the author.

Figure 4.2 a – Photo of Kivalekh's P.E.T #3 profile North before tin insertion.
b – Photo of the monolith inserted into Kivalekh's P.E.T #3 profile North. The scale is provided to help read the measures from the tape. Photos are a courtesy of Ivan Carlson (2019). Figure made by the author.

Figure 4.3 –Stratigraphy of Kivalekh's P.E.T. #3 North' Profile with matrix descriptions. Initially drew on the field by Ivan Carlson and Véronique Forbes, but transcribed by the author, using Adobe Illustrator.

Figure 4.4 – Forbes, Carlson, and Winters are subsampling small volumes for pollen analysis. Photo is a courtesy of Ivan Carlson (2019).

Figure 4.5 – The loss-on-ignition (LOI) test was undertaken by weighing a small amount of soil from the monolith's samples, placing them in crucibles, and weighing them again after laboratory ignition in a furnace at 550- degrees Celsius for a duration of 4 hours. Photo taken by the author.

Figure 4.6 a – Example of what we see under the binocular microscope during the process of sorting for Coleoptera remains. Depicted in the picture is mainly what dominates the peat matrix (*Sphagnum* spp. moss), wood, and a head of an *Aleocharinae* indet. **b –** Example of specimens (heads of *Holoboreaphilus nordenskioeldi*) glued on entomological cards prior to proceed to the identification. **c –** The dataset generated throughout this thesis is now part of the Entomological collection in the P.E.A.T. Laboratory at Memorial University, alongside with other fossil specimens from other contexts. Photos taken by the author.

Figure 4.7 – Minimum Number of Individual (MNI) is easily calculated as Coleoptera have the same number of body parts (1 head, 1 pronotum, and 1 right and left elytron). Photo of a *Holoboreaphilus nordenskioeldi* (Mäklin). Photo taken by the author and figure made in collaboration with Eric Aylward, using Adobe Illustrator.

Figure 5.1 – Loss-on-ignition (LOI) % on Kivalekh's monolith (whole sequence).

Figure 5.2 – Groupings of identified taxa according to their ecology and habitat. Taxa in bold red font are those that belongs to mesic and riparian (macro-) habitat groups, but which are known to be associated with microhabitats in decomposing organic matter (such as leaf litter and debris on house floors) that are common on archaeological sites (Bousquet et al. 2013; Forbes & Sikes 2018).

Figure 5.3 – Pie chart illustrating the proportion of beetles (MNI) associated with each ecological grouping identified from Kivalekh. Taxa associated with "In decomposing matter" are the most represented in this study.

Figure 5.4 – Pie chart illustrating the proportion of beetles (MNI) associated with each ecological grouping identified from Kivalekh, but using an alternate classification, where all taxa which can be considered as having decomposing matter as their microhabitat (e.g., those in red font in Figure 19) are grouped together.

Figure 5.5 – New locality records for Labrador: a) the Omaliinae *Holoboreaphilus nordenskioeldi* (Mäklin), for which heads, pronota, and elytra have been identified in the Kivalekh fossil assemblage (drawing underneath by Campbell 1978); and b) *Olophrum boreale* (Paykull) photograph of a complete specimen from Staphyliniformia world catalog database (GBIF 2022), with a photograph from one of the pronota identified by the author.

Figure 5.6 – Graph illustrating posterior density estimates of the age of the events and their various depths for the Kivalekh profile using Bacon v2.2. The shaded grey area in the model (f) indicates the age-depth model based on the two radiocarbon dates with a smoothed spline fitted to the data. Dates in bold on the *x* axis indicate Kivalekh's important events recorded

in the archives, respectively, the establishment of Okak Mission site by the Moravian missionaries, and its abandonment (Curtis et al. 2006; Taylor 1974). Their incorporation in the chronology shows that they occurred *after* the ecological footprint (or KIV-1) obtained in Kivalekh's sample, further demonstrated).

Figure 5.7 – Frequency diagram (or summary stratigraphic diagram) for the Kivalekh profile displaying loss-on-ignition (LOI), identified Coleoptera classified in taxonomic order, and charcoal data displayed as macroscopic charcoal concentrations and counts of macroscopic charcoal fragments per size class. Also displayed are the beetle assemblage zones (KIV-1 and KIV-2). This biostratigraphic diagram was undertaken using CONISS following square root transformation of percentage data to define different zones of activity. This was made by Dr. Paul Ledger. * Note that the data illustrated into the diagram was adjusted to account for different volumes analyzed.

APPENDICES

Appendix 1 – Cores samples and matrix descriptions for each location tested (Coffin Island, Green Island, and Okak Islands [Kivalekh]). In order to find a suitable sampling location, the matrix had to be organic (peat, silt) with enough depth to allow the insertion of the monolith tin. These descriptions were found in the field notebook from 2019 (Carlson 2019) and transcribed herein.

Appendix 2 – Loss-on-ignition (LOI) results presented in percentages (%). Samples from #22 (28-29 cm) to #33 (38-39 cm) [**bold numbers**] varies between 70.98% and 86.38%. This does not result in a sharp lithological change, and globally the soil matrix from the monolith is highly organic in nature.

Appendix 3 – Table of the Minimum Number of Individuals (MNI) of the specimens recovered and identified from Kivalekh's samples (depth range in cm per volume (ml) analyzed).

Appendix 4 – Histogram of the Minimum Number of Individuals (MNI) of the specimens recovered and identified from Kivalekh's samples (depth range in cm per volume).

Chapter 1 – Introduction

"[…] Man is everywhere as a disturbing agent. Wherever he plants his foot, the harmonies of nature are turned to discord" (Marsh 1864).

Humans inhabiting a landscape affect, in many ways, the ecosystems dynamics as their activities leave traces in the environment. Redefining the place humans occupy in nature started with re-examining old paradigms in the humanities and deconstructing popular thinking (Billington 1981; Bottema et al. 1990; Dickason 1997; Mann 2005; Redman 1999), such as the one captured in the citation above (Marsh 1864). For a long time, scholars associated the beginnings of human impacts on nature with the emergence of agricultural societies and centralized economies (e.g., Lozny 2006; Moran 2010), and their acceleration with the Industrial Revolution in the 18th century (Moran 2010). Indigenous people have thus long been assumed to have minimal or no impact within their environment (Billington 1981; Dickason 1997) – something primarily depicted through the Pristine Myth (Denevan 1992) and the Noble Savage trope (Briggs et al. 2006; Mann 2005; Redman 1999, 2005). It is only recently that debates within both ecology and archaeology have started to shift this paradigm, dismantling these two theoretical constructs. As a number of studies have since proved that environmental changes associated with mobile groups were also detectable and accessible in the palaeoecological record (e.g., Aronsson 1994; Barbel et al. 2020; Barry et al. 1997; Bhiry et al. 2016; Butler & Dawson 2013; Butler et al. 2018; Derry et al. 1999; Dussault et al. 2016; Forbes et al. 2015, 2020; Kamerling et al. 2017; Kaplan & Woollett 2016; Ledger 2018; Ledger & Forbes 2020; Michelutti et al. 2013; Oberndorfer et al. 2020; Panagiotakopulu et al. 2020; Renouf et al. 2009; Roy et al. 2015, 2021; Zutter 2012), ideas about Indigenous peoples living in harmony with nature have been abandoned. Nowadays, ecosystems are understood as the product of interactions between ongoing natural processes and the results of human actions (Briggs et al. 2006; Wu & Loucks 1995; Scheffer et al. 2001). However, since this paradigm shift first occurred, the continued use of words such as 'destructive effects', 'degraded', or even 'impact/impacted' (e.g., Bottema et al. 1990; Briggs et al. 2006) when referring to all or most human action within the natural environment continue to endorse somewhat a pejorative meaning (as figuratively shown with the Marsh quote above). Today, as an increasing number of studies have looked into the possibility that humans could also be a force for positive changes in the environment (e.g., by increasing biodiversity or ecosystem productivity, see for example Butler et al. 2018; Thomas 2020), we are moving towards a more nuanced understanding of the role humans play in shaping the landscapes around them. In this thesis, words such as 'modifications/modified' and 'disturbances/disturbed' will be preferred to others such as 'impacts/impacted', in an effort to avoid tacitly endorsing and perpetuating a pejorative meaning for all humans influences in the environment.

A recent review of palaeoecological and environmental-archaeological studies conducted in Labrador has drawn a picture of the general patterns that emerge as a result of Inuit-influenced environmental interactions (Carlson 2022). Evidence shows that the northern Labrador landscape was shaped by the long history of engagement between Inuit (and Palaeo-Inuit) and their environment. For example, it is now known that hunter-fisher-gatherers' everyday activities cause environmental disturbances by adding nutrients into the soil, leading to changes in local biotic communities, due to the fact that this leaves detectable traces in the palaeocological record, in the form of remains of plants, insects, or biochemical signatures (Couture 2014; Couture et al. 2016; Derry et al. 1999; Dussault et al. 2016; Fenger-Nielsen et al. 2019; Forbes 1996; Frink & Knudson 2010; Hicks 1993; Kamerling et al. 2017; Knudson & Frink 2010; Ledger 2018; Ledger & Forbes 2020; Lutz 1951; Michelutti et al. 2013; Renouf et al. 2009; Roy et al. 2012; 2015; 2021; Zutter 2009, 2012). Following these premises, this thesis will examine environmental change and human activity within Labrador's northern coastal landscape by attempting to capture and define an 'ecological footprint' for the groups of hunter-fisher-gatherers' groups who lived there. It then considers the human agent as part of the global environmental system. Since insects have proven to be an excellent proxy to study both lifeways and environmental changes, archaeoentomological analysis was performed on samples of peat collected near the archaeological site of Kivalekh.

1.1 Research objectives

This research attempts to capture and document the ecological footprint of past Inuit groups who lived at Kivalekh, northern Labrador, and by extension, examine how their activities affected the local landscape and biodiversity. This will be achieved by reconstructing local environmental change in the vicinity of Kivalekh over the last thousand years or so by conducting a multi-proxy analysis (beetle remains, biostratigraphy, charcoal) on samples of peat collected close to the archaeological site. More specifically, my project aims to:

1. Improve our understanding of the ecological processes resulting from human activities at Kivalekh and attempt to define an "ecological footprint" for Labrador Inuit over the last thousand years or so.
2. Test whether palaeoecological data recovered from a peat profile may help improve our understanding of the chronology of occupation at Kivalekh by integrating the results of the multi-proxy analysis with radiocarbon dates.
3. Extend the temporal and spatial record of beetle biodiversity by identifying subfossil specimens from this understudied area of northern Labrador.

Studying beetle fossils extracted from a carefully selected sampling location within a peat bog close to Inuit habitations sites will allow me to assess and document local ecological change over time, including the archaeological footprint (the beetle taxa and associated ecological information) of Inuit groups. In order to achieve a detailed, high-resolution chronology for different occupations, the archaeoentomological data produced will be integrated into a Frequency diagram with radiocarbon dates, alongside microscopic charcoal analysis and loss-on-ignition (LOI) results. Contributions from palynology are then integrated into the Frequency diagram. The data generated, combined with a thorough review of the literature about past Indigenous lifeways in the Arctic and the history of the chronology of human occupation in Labrador, will help interpret the palaeoecological datasets and relate them to occupation and human activity potentially captured in the peat. In Labrador, where the mosaic of cultures is sparse, complex, and dynamic, it is hoped that this thesis will also contribute to ongoing conversations about the role of humans as ecological agents (e.g., Crumley 2021; Kareiva et al. 2011; Lozny 2006; Lozny & McGovern 2019; McGovern 2018a, b; Moran 2010; Nelson et al. 2016; Ojala et al. 2021; Thomas 2020; Walker et al. 2004).

1.2 Theoretical framework

When examining past Arctic hunter-gatherers in the environment, questions arise regarding the interactions between biotic (living) and abiotic (non-living) agents and how these manifest and change through time. Resilience strategies, ecosystem dynamics, and environmental and landscape history all constitute key elements deriving from these interactions (Arnold 1996; Butzer 1982, 1996; Crumley 2021; D’Antonio & Thomsen 2004; Sassaman 2004). The main theoretical framework for this research is Historical Ecology, which allows various tools and methods from different disciplines to be integrated in order to achieve a narrative of the evolution and modification of a specific environment (Crumley 2021). As previously mentioned, the work herein views humans as a component of ecosystems' evolution and simply part of nature. The growing corpus of anthropological and archaeological work on human-animal and non-human (non-living things) relations enriches this discussion, primarily through Indigenous contributions that incorporate different epistemologies and ontologies under the Historical Ecology umbrella (Alberti 2016; Alberti et al. 2011; Atalay 2006, 2012; Braje et al. 2017; Echo-Hawk 2000; Nyyssönen et al. 2013; Todd 2014, 2016; Todd et al. 2014; Viveiros de Castro 1998). Indigenous thinkers challenge the accepted anthropocentrism in academic discourse by offering an alternative point of view in which relationships between humans, animals, plants, and non-living things transcend the dualistic notion of nature/culture and human/animal (Viveiros de Castro 1998; Todd 2014, 2016; Todd et al. 2014).

Coherent with the core idea of Historical Ecology's agenda, multi-proxy analyses employed in this research are integrated with other sources of knowledge (such as scientific literature and archives) to help understand when and how past humans lived (Crumley 2021). It is because once humans are conceived as part of ecological systems, understanding their roles in shaping ecosystems requires us to first reach an understanding of their social and political organization as well as their economy. These are crucial elements that could potentially help define an 'ecological footprint' for a cultural group (Figure 1.1). Furthermore, using different types of historical data could provide information on resources and land use. Applying archaeoentomology (i.e., the scientific study of insect fossils recovered from archaeological contexts) through an Historical Ecology lens will hopefully contribute to extending the knowledge about how humans influenced species, habitats, and landscapes (Balée 1999, 2006; Crumley 1994, 2021; Mihoub et al. 2017; Lennartsson et al. 2017).

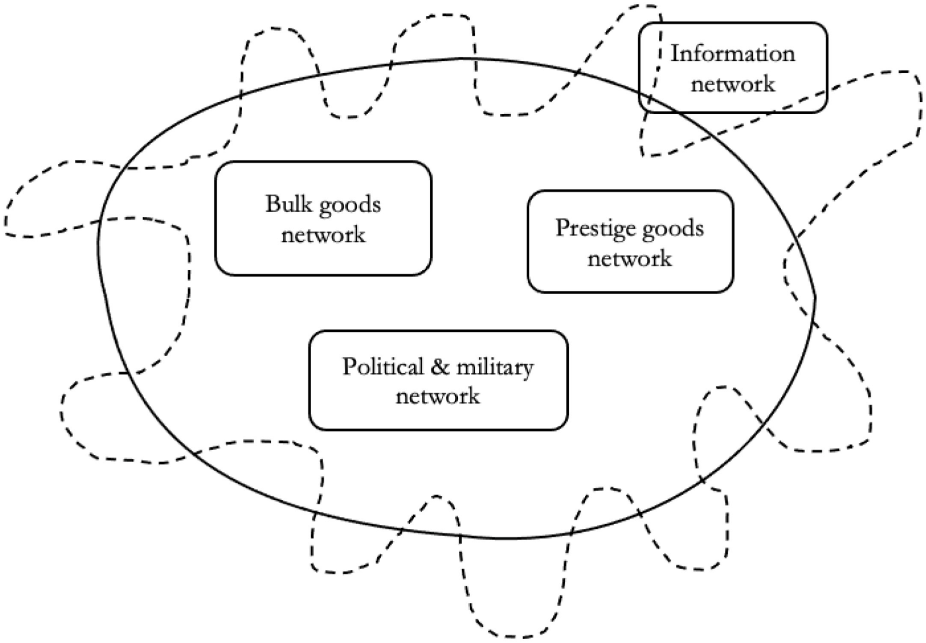


Figure 1.1 – Simplified nesting of boundaries from the theory of 'world-system exchange networks' as described initially by Chase-Dunn (1997) and Chase-Dunn et al. (1998, 2011). The four categories of network, such as (1) bulk goods, (2) political and military, (3) prestige goods, and (4) information, are suggested (abstractly represented by the oval and continued shape). This schematically illustrates the crucial elements that could help defining an ecological footprint for a cultural group. This schematic representation could help illustrating the boundary of a site and by extension to help defining specific methods of sampling for specific research objectives. Figure made by author, though inspired from Chase-Dunn, C. (1997): 54.

Additionally, insights from Niche Construction Theory (NCT) will be integrated into this theoretical framework. The concept of 'niche' is critical in almost every aspect of ecological thinking (Chase & Leibold 2003), although it seems to be understood in different ways that can sometimes seem contradictory (Brown 1995; Hariston 1995; Hubbell 2001; Root 1967; Williamson 1972; Schoener 1989; Real & Levin 1991). For this thesis, the term 'niche' is understood as the combination of physical elements (e.g., geography, climate, hydrology, etc.) that allow a species to satisfy minimum requirements so that the birth rate of a local population is equal to or greater than its death rate (Chase & Leibold 2003). 'Niche construction', is "the process whereby organisms, through their metabolism, activities, and choices, modify their own and/or each other's niches" (Odling-Smee et al. 2013; Laland & O'Brien 2010). NCT encompasses contemporary evolutionary theory, which implicitly assumes that the processes of natural selection pose pressure on the environment that are decoupled from the adaptation strategies of the organisms they select (Lewontin 1983; Laland & O'Brien 2010). To put it more simply, this suggests that organisms do not strictly adapt to their environment, but that instead, they build new ones from the external world (Lewontin 1983). That being said, it is no surprise to learn that every organism – humans in particular – modifies their environment to various degrees. Each organism or species here is an active participant in the global feedback system between natural selection pressures in the environment and the characteristics of the organisms themselves (Laland & O'Brien 2010). Therefore, this thesis proposes to focus on humans' role as 'ecosystem engineers' (Smith 2007).

As this research seeks to understand how past people have interacted in their physical *milieu* and to capture an ecological signal for a particular cultural group, Resilience Theory is also relevant here, as it helps to understand what causes changes – particularly the ones associated with transformation or modification – in systems that are adaptive (Redman 2005). Resilience theory is based on three assumptions:

(1) *Change is not linear, continuous, gradual, or chaotic.*

Instead, change is episodic with a period of slow accumulation of 'natural capital' (i.e., stock of non-renewable and renewable natural resources such as animals, plants, water, air, mineral, and soil that, when they are combined, are beneficial to people (Kareiva et al. 2011; Redman 2005)). These episodes of change are constantly attested within a landscape, especially when humans' activities occur. By analyzing its soil composition, we can examine if the ecological signal of the hunter-fisher-gatherers' populations contributes to disturbing its natural ecosystem. If so, these episodic interactions would probably not be linear, continuous, gradual, or chaotic.

(2) *Spatial and temporal attributes are not uniform.*

The perception of space and time is primarily dominated by the western conception (i.e., linear, progressive, measured). Because landscapes are multi-layered (i.e., history of successive periods of anthropogenic activity on the surface of the earth) (Whyte 2002), many ecologists and environmental archaeologists assert that the prevailing condition of the landscapes we study and, more specifically, the dynamics that influence them, could not be fully understood without careful attention to the concept of temporality (Foster et al. 2003; Redman 2005). In Kivalekh, the 'catchment area' of the sampling location (the peat bogs surrounding the archaeological site itself) acts as an archive of long-term biocultural and biodiversity data – but to be able to make sense of this data, one must first be able to place them in space and time. Effectively, the monolith depth inherently captures a temporal dimension (e.g., the deeper the layer in the monolith, the older the palaeoecological data preserved within it), and the catchment area captures the spatial extent of the anthropic signal in the landscape. Both studied together, they allow an examination of the formation process of a specific and localized area of peat bogs, revealing how humans have socially constructed their environment.

(3) *Ecosystems do not operate under one single equilibrium state.*

Instead, ecosystems operate under multidimensional, nonlinear equilibria and processes. Humans contribute significantly to destabilizing equilibrium, changing diversity in the environment and affording flexibility and opportunities for specific species to thrive. Human presence in a landscape affects in complex and subtle ways the nutrients cycling into soils, creating niches for various species. An obvious example of this would be the acute presence of commensal mammals in cities, such as rodents that are benefitting from the presence of humans to feed themselves and find shelter, as well as cats and dogs (O'Connor 2013). This principle also applies to insect communities (e.g., Kenward & Allison 1994; Forbes et al. 2014, 2017; Panagiotakopulu & Buckland 2017; Smith 2012). Research in the Mediterranean area pointed out similar commensal patterns within the insect communities, thanks to the presence of ancient pests found in stored products as well as fleas and flies (Panagiotakopulu 2001b, 2004; Panagiotakopulu et al. 1995; 2010). By studying insect remains preserved in a peat sequence close to Kivalekh, we can attempt to document and explain changes in local biodiversity through time. Understanding these ecological dynamics allows us to reexamine old discourses and question ideas about nature's 'balance', or 'harmony', as previously pointed out, and the implications of conceptualizing humans as separate or outside of nature.

Following the assumptions of the theoretical framework applied herein (Historical Ecology, NCT, and Resilience theory), the site of Kivalekh could be seen as a "time capsule for land species" (Crumley 2021). Elsewhere, human activity has been shown to affect not only soil chemistry (e.g., level of organic matter, soil nutrients, and so forth), but also biotic communities (e.g., insects, animals, plants) and the landscape itself (e.g., dwelling, irrigation, selecting and gathering resources, etc.).

1.3 Thesis overview

This thesis is presented in seven chapters. Immediately following this one, Chapter 2 introduces different hunter-fisher-gatherer groups who occupied Labrador, and the research that has been done to begin documenting the ecological impacts of these cultural groups over time. This chapter also discusses challenges with establishing robust and precise chronologies in northern contexts. Chapter 3 presents this thesis's spatial and temporal scope by contextualizing the geography and climate of northern Labrador, as well as the archaeological and palaeoecological work conducted in the Okak area. Chapter 4 details the materials and methodology employed to conduct this research, from the fieldwork to the analysis in the laboratory. Following the presentation of the results (Chapter 5), Chapter 6 discusses the different ways this data could be interpreted and directly addresses the main objectives of this research project. Finally, Chapter 7 presents the concluding statements.

Chapter 2 – What do we know about the ecological footprint of hunter-fisher-gatherers' populations?

Until recently, research has rarely examined ecological changes associated with hunter-fisher-gatherers' populations in North America. In the North Atlantic region, the body of palaeoecological work generated mainly explored the cultural practices of Norse populations and other agro-pastoral occupations (e.g., Amorosi et al. 1997; Arneborg & Grønnow 2006; Bishop et al. 2013; Buckland et al. 2009; Dugmore et al. 2007a,b, 2009, 2013; Forbes et al. 2014, 2016; Fredskild 1988; Guillemot et al. 2016; Hartman et al. 2017; Hegmon et al. 2013; Jackson et al. 2018; Ledger et al. 2013, 2019; McGovern 2012, 2014, McGovern et al. 2007, 2014, Panagiotakopulu & Buchan 2015; Panagiotakopulu & Buckland 2017; Panagiotakopulu et al. 2007, 2018, 2020; Perdikaris & McGovern 2008; Smiarowski et al. 2017). Indigenous groups of North America (including First Nations, Métis, Palaeo-Inuit, and Inuit) have long been assumed to had minimal or no impact within their environment (Billington 1981; Dickason 1997). However, as previously discussed, their presence in a landscape and its related activities have significantly affected the ecosystems in and around occupation sites (see Carlson 2022 for a recent review of the literature). Recently, an increasing number of projects focusing on small-scale economies in different parts of the world allows us to appreciate better the varied (sometimes subtle, sometimes obvious) ways Indigenous peoples affected the landscapes and ecosystems in which they lived (e.g., Anderson & Freeburg 2014; Barbel et al. 2020; Butler 2011; Butler & Dawson 2013; Butler et al. 2018; Egelkrault et al. 2018; Fenger-Nielsen et al. 2019; Forbes et al. 2020; Harrault et al. 2019; Ledger 2018; Ledger & Forbes 2020; Ledger et al. 2019, 2020; Lemus-Lauzon et al. 2018; MacEachern & Turkel 2009;

Oberndorfer et al. 2017, 2020; Panagiotakopulu et al. 2018; Roy et al. 2015, 2021; Speller & Forbes 2022).

This chapter outlines hunter-fisher-gatherers' environmental and cultural histories from when the ancestral Inuit arrived in the Arctic around 2,500 cal. BC, to the present-day Inuit (Friesen & Mason 2016). Particular attention is given to Labrador Inuit as they are the primary concern of this research. This chapter serves to contextualize the current state of knowledge about hunter-fisher-gatherers' impacts on the environment, which is also presented here through an overview of palaeoecological and environmental-archaeological work conducted in the Arctic.

The objectives of this chapter are, therefore, as follows: (1) to present the current state of knowledge on hunter-fisher-gatherer environmental and cultural histories; (2) to establish the state of palaeoecological research on cultural groups from the Canadian Arctic, specifically in northern Labrador; and (3) to emphasize methodological challenges with establishing precise chronologies and discerning the ecological effects of human activity from those of other factors such as climate.

2.1 Hunter-fisher-gatherers: who are they?

The term 'hunter-fisher-gatherers' refers to populations who do not practice agriculture. It suggests a group of people who rely chiefly on harvesting local resources that are seasonally available. It incorporates traditional activities such as fishing, hunting, and harvesting various wild food resources (Ingold 1992).

There are two archaeological traditions in Eastern Arctic: (1) Palaeo-Inuit, and (2) Inuit, who represent several groups who migrated eastward from Alaska (Friesen 2007, 2013, 2015; Friesen & Mason 2016; McGhee 2000)

2.1.1 Palaeo-Inuit

Around 1,200 BC, the earliest groups of Palaeo-Inuit started extending throughout the Canadian Arctic, Labrador, and Greenland (Friesen 2016; Whitridge 2016). In archaeology and anthropology, Palaeo-Inuit is also referred to as Pre-Dorset, Independence I, Saqqaq, Groswater and Dorset, as these names derive from the sites where diagnostic artifacts associated with these cultures were found[1]. The earliest archaeological material remains seem to indicate the presence of a sparse and highly mobile population. Between 800 to 500 cal. BC, a transition in the material culture is attested archaeologically in the Arctic, through unique technologies and traditions, but most importantly, through novel settlement patterns that start appearing in the Arctic landscapes. Semi-subterranean houses characterize these new settlement patterns, and the size of settlements expanded, creating larger sites with middens accumulation in some regions. This new cultural entity is known as Dorset (Friesen 2007).

Despite disagreements regarding questions on 'where', 'when', and 'why' Dorset culture developed, arctic archeologists share a common understanding of what they represent in the record and how they constitute a distinct cultural entity (Ryan 2016). In order to be concise, the period subdivisions presented herein employs the traditional classification even if the terminology is currently under revision (Maxwell 1985; Desrosiers 2009; Desrosiers et al. 2006; Odess 2005; Ryan 2016).

Dorset culture developed progressively through all three stages, each of which can be subdivided into the Early and Middle periods, culminating in the Late Dorset period, which appeared approximately around AD 500 (Friesen 2007; Ryan 2016). The transition from one period to another seems not fully understood today, as important developments characterizing

---

[1] By essence, we can argue that archaeology is a colonialist endeavour. Therefore, this work aims to get away from perpetuating western values and methods and instead promote and acknowledge various ontologies.

each period occurred *in situ* in the eastern Arctic (Friesen 2007; Friesen 2016; Ryan 2016). The Early Dorset era coincides with an episode of climatic cooling in the eastern Arctic, responsible for extending sea ice along the coasts (Barry et al. 1997; Ryan 2016). Such conditions were favourable for sympagic (i.e., species that complete their entire life cycle on the sea ice) fauna to thrive, such as ringed seals and walrus (Kaplan 1983; Kaplan & Woollett 2016; Ryan 2016). Accordingly, faunal studies show that the Dorset economy was mainly oriented around marine resources, as supported by archaeological evidence of specialized and adapted technologies such as ice crampons, snow knives, and a significant quantity of blubber-burning soapstone vessels (Ryan 2016). However, the spatio-temporal dynamics of Dorset groups are unclear, in part because the areas in which this culture was identified were sparsely populated, and the occupations discontinuous. In the High Arctic, not all regions were occupied for the entire period. Large areas such as Greenland, Labrador, and Newfoundland may have been abandoned seasonally or for more extensive periods (Appelt et al. 2016; Friesen 2007, 2016; Ryan 2016). Further waves of populations would have migrated to these same areas later, thus making it challenging to understand the cultural shifts that occurred within the Dorset culture, specifically during the Late Dorset period.

The Late Dorset era constitutes the period that likely sees the first contact of Dorset people (from the west) with European Norse (from the east), therefore representing the first-time human populations had circled the world (Appelt et al. 2016; Friesen & Mason 2016). This period spans the eighth to tenth centuries AD (Appelt et al. 2016). During this period, significant changes occurred – both social and environmental. Climate change (e.g., Medieval Climate Anomaly) saw important warming episodes in the North American Arctic. This, combined with complex internal social factors, presumably led to the immigration of new populations and population movements, eventually leading to the extinction of the Late

Dorset archaeological tradition. During the Late Dorset Period, a prominent peak in population is observed through the archaeological record (e.g., abundance of archaeological sites and associated richer material culture), which suggests the confluence of critical resources to sustain a larger population, such as the affluence of sea mammals (Appelt et al. 2016; Friesen 2007; Murray 1999).

The economy of the Late Dorset was based on all available food resources in the eastern Arctic, but it was especially centered around aquatic resources and mammals such as walrus and seals (ringed, bearded, and harp), which were crucial in the Late Dorset people's diet. Caribou, Arctic hare and fox, muskoxen, and a wide array of birds (migratory and permanently resident species) appear in the archaeological record as well, both from middens and house contexts (Damkjar 2005; Friesen 2007, 2015; Maxwell 1985; Murray 1999; Woollett 2003). Species of fish such as Arctic char and trout also appear in the archaeological record during the Late period, once again found in middens (Friesen 2007). Due to geographic variability in the eastern Arctic, each region has its own economic patterns based on the locally abundant taxa. The seasonal availability of specific taxa also explains variability in resources. Because of that, the economic patterns varied greatly from season to season, leaving a relatively small window for resource harvesting and hunting throughout the year. Thus, storage was essential to Dorset economy strategies (Friesen 2007, 2015; Friesen & Mason 2016; Murray 1999; Ryan 2016).

When Dorset people migrated to Labrador, they would have encountered several different Indigenous cultures on their way. This includes other Palaeo-Inuit groups, such as the Groswater (on the coast of the Québec-Labrador Peninsula and in Newfoundland), but also Intermediate Period First Nations and Innu (in Labrador), and Beothuk (from Newfoundland). Some of these interactions and contacts seem poorly understood today (e.g., replacement of Groswater by Middle Dorset, see Fitzhugh 1978, 1980, 1981; Holly 2013; Rankin 2008), and it is unclear if the Dorset groups ever encountered their successors in Labrador, the Inuit. We know that the end of the Dorset period is intertwined with contacts with two other cultures: (1) Norse settlers from Greenland; and (2) ancestral Inuit. However, the nature and timing of these interactions are subject to debates within the discipline today (Appelt et al. 2016; Friesen & Mason 2016).

2.1.2 Inuit

Traditionally, ancestral Inuit were referred to as the 'Thule culture' within the discipline of archaeology, based on Therkel Mathiassen' (1927) Fifth Thule expedition in Greenland. The Thule term was subsequently reused in the 20th century by the National Socialist German Workers Party to designate a mythical Aryan homeland for members of that party (Friesen & Mason 2016; Whitridge 2016). As consistent application of names for specific ancient cultures and periods is central to academic communication, the term ancestral Inuit is preferred in this thesis, since it does not endorse a controversial connotation.

The ancestral Inuit culture emerged from Alaska and Siberia before moving eastward sometimes between 1000 and 800 BP (Park 2016). Archaeological evidence suggests that by AD 1200, they had migrated east rapidly across the Canadian Arctic during a short warm period (i.e., Medieval Warm Period), characterized by less sea ice than usual, which facilitated travelling by boats across the High Arctic (Woollett 2003). They would have reached the northern coastline of Labrador, the Arctic Archipelago and Greenland within only a few decades (Figure 2.1) (Friesen 2013; Whitridge 2016; Woollett 2003). Factors such as the increasing access of bowhead whales migrating east could explain the motive behind these ancestral migrations (Whitridge 2016). Although radiocarbon-based chronologies do not allow a precise date of when Inuit first reached the Labrador coast, available evidence suggests it occurred sometime between the mid-13th to late 15th centuries (Fitzhugh 2009; Hood 2008; Loring 1992; Ramsden & Rankin 2013; Rankin 2008, 2009; Sutton et al. 1981; Whitridge 2012; and Woollett 2003).

Figure 2.1 – Simplified map showing the potential migration route of ancestral Inuit around AD 1,000 to AD 1,200 as explained above – during a brief episode of warmer climate – before reaching northern Labrador. Figure made by the author, based on the current archaeological knowledge and the scientific literature (specifically Friesen & Mason (2016)).

The subsistence of many of the early Inuit groups who pioneered across the Canadian Arctic was focused on bowhead whale hunting. The importance of whales in ancestral Inuit culture is indeed manifested through various practices (e.g., preparation, preservation, and distribution of the meat among the community; oil fabrication using blubber; and bones and baleen used for tool-making and dwelling construction) (Kaplan & Woollett 2000; Rankin 2009; Whitridge 2012, 2016; Woollett 2003). In Labrador, whale hunting continued, but subsistence increasingly diversified, with harp, harbor, and ringed seal; as well as local fish, shellfish, birds; caribou, small terrestrial mammals, and berries being harvested (Hood 1997, 2008; Loring 1992; Ramsden & Rankin 2013; Rankin 2008, 2009; Whitridge 2012; Woollett 2003, 2008; Zutter 2012). Seal hunting was critical to Labrador Inuit economy. Seals wereavailable throughout the year on sea ice and using kayaks Inuit could ambush the mammals as they came up through the breathing holes on the ice, or while they were swimming (Cox 1977, 1978; Cox & Spiess 1980; Stopp 2002a, b; Woollett 2008).

Ancestral Inuit archaeological sites with extensive permafrost are described in the literature as producing the most "highly differentiated hunter-gatherers' assemblage in the world" (Whitridge 2016:834). The material culture includes highly specialized tools associated with resource harvesting, which illustrates how marine mammals were pursued from watercraft (e.g., kayak, umiaks) and from ice (e.g., dogsled), and hunted with lances, darts, and toggling harpoons. Each of these devices was remarkedly sophisticated and complex. Other types of equipment and associated skills were used to extract plant and animal fiber. These were made of bone, antler, ivory, tooth, horn, baleen, feather, gut, hair, and fat (Whitridge 2016). As a result, ancestral Inuit had a highly complex material culture representing their cosmological beliefs through ornaments, carvings, and other artistic expressions.

The transition between ancestral Inuit and Inuit is by nature semantic. Archaeologists stopped using the term 'ancestral' and replaced it with just 'Inuit' once contact with Europeans became evident archaeologically. It is worth noting that ancestral occupations of northern Labrador are not well dated either, since relatively a few sites have been excavated. Consequently, there is a paucity of radiocarbon dates (Kaplan & Woollett 2016: 856).

As mentioned above, probable scenarios suggest that the ancestral Inuit arrived in Labrador during the 15th century. They initially settled in the northern periphery (Kaplan & Woollett 2016). During that time, northern Labrador contained a dense diversity of resources. This access to unprecedented rich resources supported large Inuit communities until and throughout the 18th century (Burchell et al. 2018; Kaplan 1983, 2009, 2012; Kaplan & Woollett 2000, 2016; Whitridge 2012, 2018; Woollett 1999, 2003, 2008).

Inuit were moving seasonally between outer islands during winter to hunt seal and walrus, and inner coastal regions during the summer to hunt caribou, bears, and other terrestrial animals; and fish arctic char during their seasonal runs (Cox & Spiess 1980; Kaplan 1983; Loring et al. 2003; Rankin 2015; Stopp 2002a, b; Woollett 2003). These settlement patterns were attested across Labrador among the Inuit culture; however, they changed drastically during the 18th century (Kaplan & Woollett 2016; Woollett 1999, 2003). Initially, the winter houses consisted of an oval or rectangular semi-subterranean house with a paved entrance passage (tunnel), walled with rocks and sod, using skin and sod roofs supported by either whale ribs or mandibles and driftwood poles (Hood 1997, 2008; Ramsden & Rankin 2013; Rankin 2009, 2015; Whitridge 2008, 2012; Woollett 1999, 2003). These sod-houses typically held families of between six or eight members. However, essential changes in the social structures occurred when the climate in Labrador during the 18th century began to cool down. Coincidently, they moved into sheltered bays on the coast, and the dwellings expanded to communal houses that could accommodate up to forty individuals (Kaplan & Woollett 2016; Woollett 1999, 2003, 2008, 2010, 2011).

From the 16th century, ancestral Inuit knew of the European presence in the south of Labrador. Exotic materials such as metal became accessible on southern Labrador shores. Gradually, their interest in exchanging goods with European settlers resulted in their involvement in the North Atlantic trade network that linked Inuit communities with distant markets. Contacts with Europeans gave a variety of opportunities to Inuit people, accompanied by many challenges, but they nevertheless continued to exploit and benefit from Labrador's rich natural resources traditionally (Kaplan & Woollett 2016).

2.2 The development of new identities

During the 18th century, Inuit culture began to change as the complex contact situation inevitably contributed to shaping new identities. Even if some cultural traits gradually began to incorporate European ones, the Inuit continued to employ many of the technologies of their ancestors (Kaplan & Woollett 2016), including a toolkit made primarily with bone, antler, wood, ivory, copper, nephrite, slate, and iron (Friesen 2013; Hood 2008; Ramsden & Rankin 2013; Rankin 2009; Whitridge 2008, 2012; Woollett 2003). The increasing presence of European men in Labrador resulted in marriage unions with Inuit women, creating bi-cultural families. By the late 18th to early 19th centuries, these children grew up and reinforcing this cultural heritage (i.e., NunatuKavummiut), as they perpetuated unions between European men and Inuit women (Beaudoin 2013, 2014), and then amongst a culturally mixed population.

Archaeological evidence shows that the Inuit encountered other groups (Innu, Iroquois, Mi'kmaq, and Europeans) around the 18th century when they travelled south through the Strait of Belle Isle and Lower North Shore of Québec. In Newfoundland, they met the Beothuk on the northern coast (Delmas 2018; Fitzhugh 2009; Loring 1992; Rankin 2008). Documentary and ethnographic sources suggest that Inuit families lived in the area all year round and engaged with French and Basque whalers along the coast (Delmas 2018; Fitzhugh 2009; Loring 1992; Stopp 2002 a, b; Rankin 2009). European records indicate conflictual relationships with the Inuit. On the southern shore of Labrador, the socio-political climate was described as a 'state of war' (Brice-Bennett 1981; Loring 1992) in the early contact period, as both Europeans and Inuit fought each other. However, other documents indicate that their relationships became more amicable through time as both parties were interested in trading commodities (Loring 1992; Woollett 1999, 2003). The 18th century marked a period of fundamental changes, as depicted above, and by the mid-century, Inuit had adopted new dwellings for winter months, much larger than their previous winter houses (Woollett 1999, 2003). The establishment of Moravian missions in northern Labrador during the 19th century also contributed to reshaping Inuit settlement patterns and controlling Inuit's goods and resources management (e.g., sea mammal oil, furs, baleen, etc.) with the establishment of permanent trading posts along the coast (Loring 1992; Whitridge 2008; Woollett 2003).

The missionary initiative in Labrador followed the ones conducted among the Greenland Inuit initiated by Johann Christian Erhardt (Roberts 2009). Between 1740 and 1750, the Moravian administrative centre was relocated temporarily to England, encouraging evangelization in British North America. In 1749, the English Parliament recognized the Moravians as an "ancient Protestant episcopal church", thus motivating them to extend their missions in the North (Podmore 1998; Toft 2016). In the following years, a few Moravians conducted explorations in Labrador but failed to settle there permanently. In 1752, Jens Haven (a former carpenter from Denmark and missionary in Greenland) decided to continue the explorations to complete Erhardt's original mission. He engaged in three exploration journeys (Roberts 2009). After securing a land grant of 100,000 acres in 1769, a small group of 14 men and women succeeded in establishing in 1771 the first permanent Moravian settlement in the Nain region (Rollmann 2009). Two other missionary settlements were established in Labrador in the following years: Okak and Hopedale (Roberts 2009). Only the one in Okak will retain our attention below, as it is directly relevant to the archaeological site studied for this research, Kivalekh (Figure 2.2).

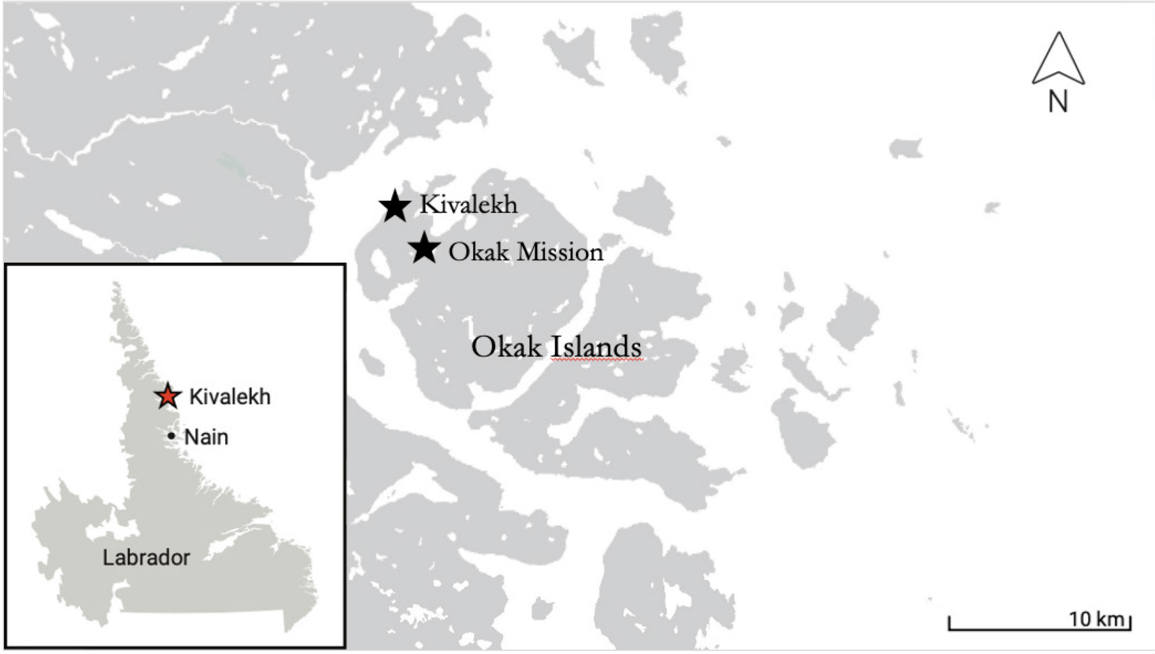


Figure 2.2 – Simplified map showing the proximity of the archaeological site of Kivalekh and the missionary settlement in Okak (1776-1919). Figure made by the author.

The missionary settlement in Okak (1776-1919) was the largest Inuit community on Labrador's north coast. It lasted until a year after the Spanish Influenza epidemic (1918) hit Labrador. The latter was responsible for the death of 357 people, representing a third of the Labrador Inuit population at the time (Budgell 2018; Roberts 2009). Only a few people survived the Spanish flu and left Okak, aided by their dogsleds carrying all their belongings. They resettled in different locations around the coast. Today, the only living reminder of the Okak settlement – among numerous building foundation structures and the cemetery – is the rhubarb patches planted by the Moravians in their many gardens (Budgell 2018).

During the 19th century, each major Moravian settlement had a large communal mission house and church, following German architecture's stylistic canons, with a graveyard nearby. The mission stations also included activity-specific buildings, such as workshops, provision houses, store buildings, sawmills, boat houses, and extensive gardens (Figure 2.3). Inuit participated in Moravian ways of living and slowly came to integrate their settlements permanently. Some Inuit worked in gardens, while others found employment in logging operations and building projects. The Moravian presence among Inuit communities was not always profitable for both parties, and in 1926, trading was relinquished to the Hudson's Bay Company (Roberts 2009). Still today, a few thousand Moravians live in Labrador (specifically within the congregations of Nain, Hopedale, Makkovik, and Happy Valley-Goose Bay). The churches are no longer administrated by Germany nor England, but by Labradorians themselves, for whom the vast majority are members who live in Nunatsiavut (Roberts 2009).

Figure 2.3 – Photo of Okak Moravian settlement (photograph taken sometimes before 1919). From Archives and Special Collections at Queen Elizabeth II Library, Memorial University of Newfoundland, St. John's.

Like any other, Labrador Inuit culture is complex and dynamic. Throughout contact with Europeans, communities showed ongoing flexibility and adaptation resulting from the emergence of a unique and resilient culture. Labrador is geographically isolated from more northern regions as any travel to reach the northern tip of the peninsula is challenging, either by boats, contouring the tip of Labrador, or through a few passes crossing the Torngat mountains that bridge the western and eastern coasts of the peninsula (Kaplan & Woollett 2016). Nevertheless, this did not prevent the Inuit from entering a world economy while their culture changed socially, economically, and politically (Kaplan & Woollett 2016). As they adapted to a changing environment and incorporated new social trends, they continued to employ the traditional technologies and strategies of their ancestors when they first arrived in Labrador, while selectively adopting some European ways of living.

Today, Labrador Inuit are self-governed within Nunatsiavut, under five communities (Nain, Hopedale, Postville, Makkovik, and Rigolet) (Figure 2.4), including their traditional lands and cultural practices (Nunatsiavut Government 2021).

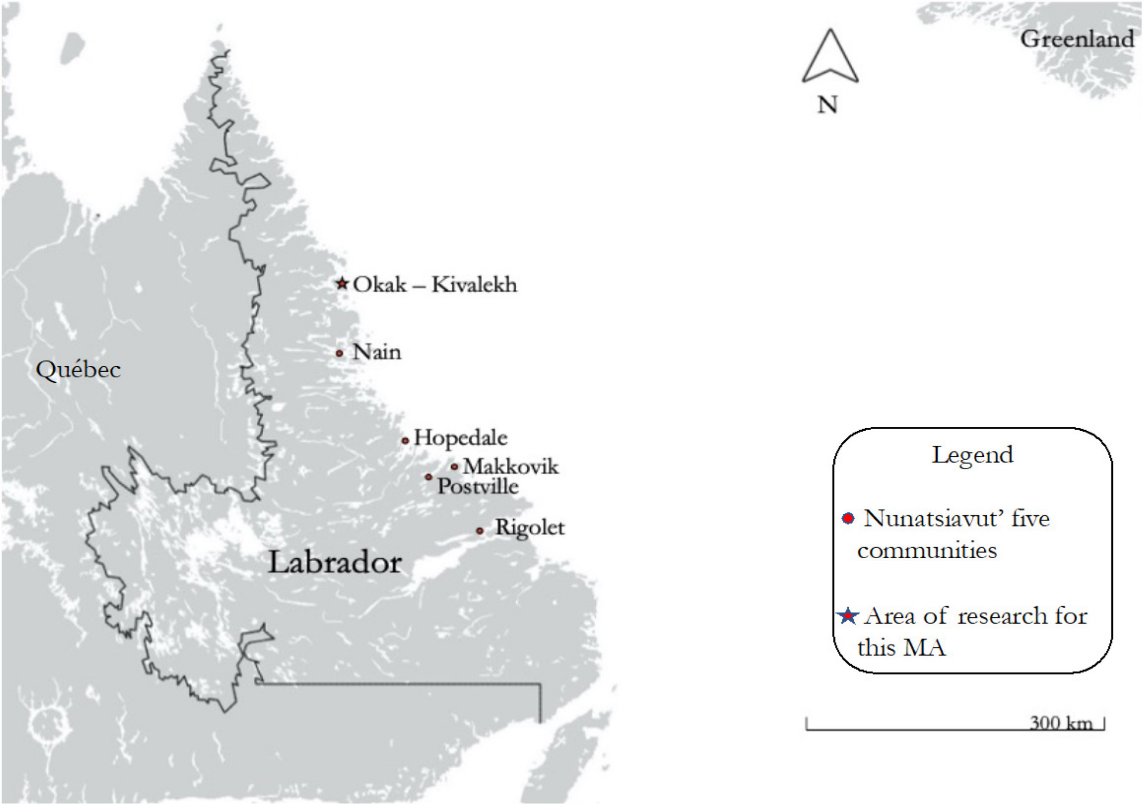


Figure 2.4 – Map showing Labrador, including the five communities of Nunatsiavut (Nain, Hopedale, Postville, Makkovik, and Rigolet) and the area of research for this MA. Figure made by the author.

2.3 To what extent are hunter-fisher-gatherers visible in the palaeoecological record?

The lifeways of the cultural groups described above have left evidence in the environment. To define the disturbances caused by hunter-fisher-gatherers on the environment, it is essential to examine ecological processes that have been documented near archaeological sites. Anthropogenic activities and climate fluctuations disrupt ecological systems to varying degrees and scales. These ecological disturbances can be, and have been, studied using different palaeoecological and environmental-archaeological methods. A recent MUNL Master's thesis by Ivan Carlson (2022) has identified geochemical analysis, palynology, sedimentology, paleolimnology, zooarchaeology, and archaeoentomology as particularly useful to identify, measure and interpret these. This thesis was a valuable resource to help find relevant literature and better understand what kinds of ecological traces and disturbances are likely to have been left in northern Labrador's landscapes due to human activities. The following section synthesizes and updates this literature review, by stressing key 'niche constructing' processes documented at or near Arctic archaeological sites.

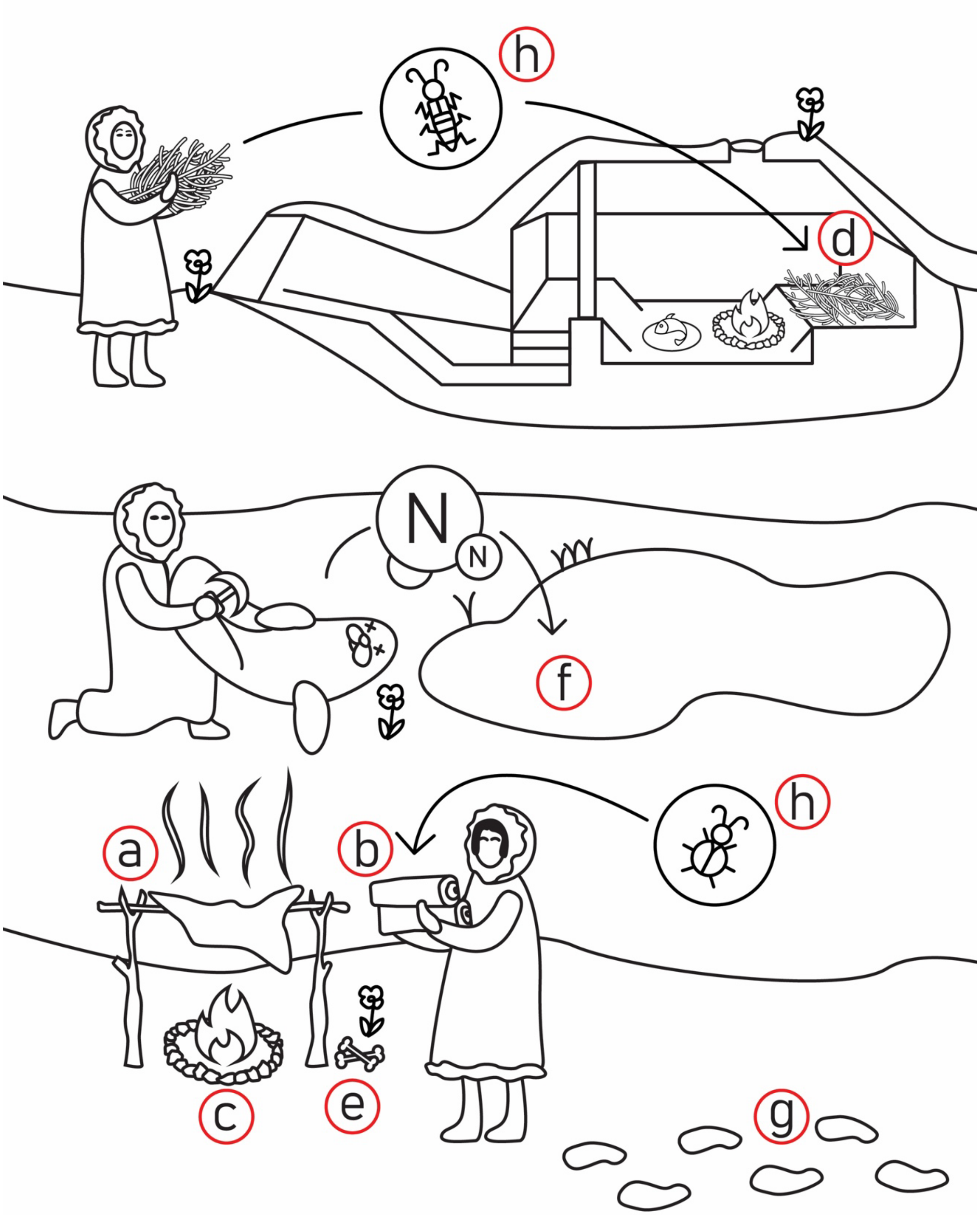


Figure 2.5 – "A day in the life of Labrador Inuit". Schematic representation of various human-environment interactions in the Labrador landscape as described in this chapter, inspired by the literature review by Carlson (2022). A total of eight (8) different activities are pictured: (a) animals (terrestrial or marine) were hunted in the area and brought back to the camp to be processed,

consumed, and discarded; (b) wood is harvested for a variety of purposes: cooking, heating, building tools and dwellings; (c) the presence of charcoal indicate hunter-fisher-gatherers' use of woodland resources, leaving traces in the soil matrix; (d) harvesting *Picea* (spruce) and using it for insulating dwellings, bedding, and as a flooring material offers opportunities for specific beetles to occupy niches inside the houses; (e) the presence of abundant discarded bones is responsible for increasing the presence of certain nutrients in the soil, resulting in the emergence of rich and diversified vegetation compared to occupation sites' 'natural' surroundings; (f) certain kinds of human activities, when undertaken near the edge of a body of water (such as here, skinning or processing a seal or its skin) affect the level of eutrophication in ponds and lakes through nitrogen inputs; (g) foot traffic (or trampling) can result in decreasing the presence of certain native plants that are sensitive to disturbance, and increasing those that thrive in such disturbed context; and finally (h) the transportation of specific resources (spruce, down, fur, feathers, wood, etc.) creates niches for beetles associated with organic matter, that can be transported or attracted to human homes. Figure made by the author in collaboration with Eric Aylward, using Adobe Illustrator.

2.3.1 Movement and concentration of animals, plants, and raw materials on archaeological sites

Hunter-fisher-gatherers' subsistence strategies essentially involved harvesting seasonally available resources in the area. Indeed, various animals (terrestrial or marine) were hunted in the area and brought back to the camp to be processed, consumed, and discarded (Figure 2.5a). When domestic activities occur in the environment, the natural ecosystem is disturbed as it creates microhabitats that attract various organisms (insects, plants, fungus, diatoms, etc.), in ways that are often visible in the palaeoecological record (e.g., Carlson 2022; Forbes 1996; Forbes et al. 2016, 2017, 2018; Ledger 2018; Oberndorfer et al. 2020; Panagiotakopulu & Buckland 2013, 2017; Renouf et al. 2009; Smith 2012). Another example of this is the use of wood found on archaeological sites (Figure 2.5b). Some Arctic peoples rely heavily on wood as a resource for building dwellings and various tools, as well as a source of fuel (Roy et al. 2021; Scott & Damblon 2010; Zutter 2009, 2012). Despite its sparsity in some areas, activities associated with its harvesting and uses are also manifested through the palaeoecological record. For instance, a decrease in tree pollen, an increase in wood-specific insect taxa, and an increase in micro- and macroscopic charcoal remains would likely be interpreted as deriving from anthropogenic disturbance caused by wood harvesting and use (e.g., Ohlson & Tryterud 2000). The presence of macroscopic charcoal remains found in soil or peat near or on archaeological sites is one way to observe hunter-fisher-gatherers' use of woodland resources (Figure 2.5c). However, natural phenomena such as forest fires could also be evident in the palynological record where microscopic charcoal is found. In addition to providing reliable material for radiocarbon assay, charcoal allows chronological reconstructions of site occupation (Egelkrault et al. 2018). Derived wood products, such as *Picea* (spruce) boughs, were harvested frequently as they were used to insulate dwellings as bedding, and as a flooring material (Roy et al. 2015) (Figure 2.5d). These practices associated with the uses of spruce offer opportunities for insects to occupy niches similar to ground litter, naturally found in the environment.

The activities described above demonstrate that the presence of humans in a landscape inevitably affects ecosystem dynamics, by transporting raw materials derived from locally harvested animals and plants to archaeological sites. More examples from recent case studies are presented below, to attempt an understanding of the processes of nutrient-enrichments and changes in biotic communities that also occur on archaeological sites in the Arctic.

2.3.2 Nutrient-enrichment

In the Arctic, it is well documented that archaeological sites create distinctive vegetation patterns that differ in species and colour compared to their broad surrounding environment, and which can therefore be observed on the site's surface (Dussault et al. 2016; Forbes 1996). These are understood as resulting from fluctuations of nutrients in soils (Forbes 1996; Hrdlicka 1937; Lutz 1951; McCartney 1979; Moore 1986; and Moore & Denton 1988).

The variability of these chemical signatures depends on the nature of the occupation of the site. The intensity of occupation, paired with specific activities such as resource harvesting, food preparation, and construction of dwellings (as described above), would impact, to a variable degree, the chemical composition of the soils (Barbel et al. 2020; Butler et al. 2018; Butler & Dawson 2013; Couture et al. 2014). Studies conducted in the tundra environment suggests that the anthropogenic signal resulting from chemical inputs begins as soon as humans establish themselves at a particular site, and persists after abandonment, due to the slow recovery of the environment in the Arctic (Fenger-Nielson et al. 2019; Forbes 1996). When structures are still visible on the surface (e.g., houses/dwellings), soil chemistry can demonstrate an enriched geochemical signature (Barbel et al. 2020; Butler et al. 2018; Couture et al. 2016).

On the other hand, when there are no apparent structures visible in the landscape, it is nevertheless possible to detect open-air activities as they appear as "patches of enriched areas" (Carlson 2022: 13) within the landscape (Butler & Davidson 2013; Frink & Knudson 2010; Knudson & Frink 2010). For instance, in Saunitarlik Kangiqsujuaq, Nunavik, an intensive hunting site with abundant discarded butchered bones, it was easy to identify what activity had been responsible for increasing nutrients in the soil composition (Bernier 2014) (Figure 2.5e). This directly influences the modern flora, which resulted in the emergence of rich and diversified vegetation compared to its 'natural' surroundings. It seems evident that the vegetation growth patterns observed on Arctic archaeological sites result from nutrient-enrichment, which is caused by the accumulation of organic matter resulting from human activities.

Similar observations have been made for ponds and lakes, but as these are less directly relevant to this thesis, they are only briefly summarized here. Like in terrestrial settings, activities such as waste disposal or trampling near the water's edge seem to cause an increase of available nutrients in the water, which then get deposited in lake sediment (for examples, see Douglas et al. 2004; Renouf et al. 2009) (Figure 2.5f). The intensity of occupation inherently affects the level of eutrophication (i.e., the relative richness of nutrients in lakes and ponds). A continued, intensive occupation seems more likely to affect water and lacustrine sediment in such a way. For instance, ponds near intensive Inuit occupation in the Canadian High Arctic show ecological changes associated with an increase in nitrogen level in the water, which is associated with the presence of sea mammals likely being discarded as waste (Michelutti et al. 2013). In contrast, no evidence of ecological changes has been attested with seasonal occupation sites (Michelutti et al. 2013).

These are examples where the soil chemistry (both terrestrial and aquatic) is altered via anthropogenic activities, causing a marked increase in nutrients. This can constitute an 'ecological footprint' for hunter-fisher-gatherers' groups.

2.3.3 Changes in biotic communities

Humans inhabiting a landscape would impact its ecology by creating opportunities for specific organisms to thrive and/or failing to constrain others. As discussed above, this is most readily observed through the vegetation found on and off archaeological sites across the Arctic. The vegetation growth patterns observed result from the succession of indigenous plant species to other species resistant to disturbance and which favour habitats rich in available nutrients (Aronsson 1994; Derry et al. 1999; Ledger 2018; Roy et al. 2015). In sub-Arctic and Arctic contexts, native plants growing in disturbed areas (i.e., apophytes) include *Montia fontana, Silene* spp*, Rumex* spp*, Ranunculus acris.*, *Achillea* spp., *Senecio* spp., and *Poaceae* (Harrault et al. 2019; Ledger 2018; Kamerling et al. 2017; Roy et al. 2015). Several palaeoecological studies have also observed how the abundance of *Sphagnum* spp. (moss) decreases throughout the human occupation due to foot traffic in the area (e.g., Ledger 2018; Roy et al. 2015) (Figure 2.5g). In circumpolar landscapes, where humans harvest woodland resources, a decrease in the population of certain trees (e.g., pine, birch, and spruce) is observable in the palynological record (Hicks 1993; Kamerling et al. 2017; Ledger 2018; Roy et al. 2012). After abandonment, these tree species increase significantly within the landscape.

Directly relevant to the focus of this research, insect communities are also known to show ecological behaviors in archaeological contexts. These patterns are characterized by abundant and rich biodiversity in areas close to Indigenous archaeology (Böcher & Fredskild 1993; Dussault et al. 2016; Forbes et al. 2015). This can manifest itself as an increase in insect taxa associated with a marsh-like environments as a specific site becomes wetter and warmer over time (Dussault et al. 2016), or as an increase of *Staphylinidae* (rove beetles), which are indicators of decaying organic matter (suggesting nutrient-rich habitats) likely to be associated with human activities (Forbes et al. 2017). Thus far, the only obligate synanthropic taxon associated with Indigenous populations is *Pediculus humanus* L. (human louse), which has been found in Inuit dwellings and associated structures across the circumpolar north (Forbes et al. 2015; Ledger & Forbes 2020). In archaeological contexts, it is common to find taxa that usually occupy niches that are rarely sampled in modern entomological recording surveys, such as bird nests, beaver dams, or bark (Forbes et al. 2014) (Figure 2.5h). The transportation of specific resources could explain this (e.g., down, fur or feathers used for clothing, bedding, insulation, or beavers as food resources; wood or sod for building dwellings, fuel, and so on), although it is also possible that the occupation sites simply mimic ecological conditions found in such contexts (Forbes et al. 2017). These examples demonstrate that human-built habitats are responsible for attracting certain taxa to the human-built environment and provide ideal niches for species that thrive in a 'disturbed' milieu (Forbes et al. 2017). Understanding this phenomenon also requires us to consider the mechanisms by which insects end up in archaeological deposits, including the fact that some insects can fly or walk there, while others could only be passively transported over considerable distance by being transported by humans (Kenward & Allison 1994). It is therefore important both to understand the population dynamics of the insect groups studied (e.g., the 'background fauna' to be expected in your context of study, Kenward 1982), as well as the ecological requirements and physiology of the individual species identified from the archaeological context.

2.4 Methodological considerations

Despite the usually well-preserved materials recovered on northern archaeological sites, there are still challenges with establishing precise chronologies in the Arctic (Ascough et al. 2007, 2010; Blaauw & Christen 2011; Forbes et al. 2015, 2020; Jensen 2017; Ledger 2018; Ledger et al. 2013, 2014a,b , 2015, 2016; Mihoub et al. 2017). There are many different factors responsible for that. The first one relates to the cold and dry climate of the Arctic, which affects soil formation processes (McGhee 2000). The short period of vegetation growth results in the incomplete, or sometimes absent, presence of stratified archaeology in these areas (Ledger et al. 2016). In order to date an archaeological context precisely, it is helpful to have a relatively deep and clear stratigraphy, as this provides a relative chronological framework in which individual radiocarbon dating assays can be contextualized. In such situations, it becomes possible to discern different occupations, and to establish some measure of their durations. When there is little to no soil accumulation, it is difficult or impossible to ascertain whether the site results from multiple events, as the archaeological record is time-averaged or interpreted as resulting from a single occupation of unknown length. Therefore, in High Arctic situations where stratigraphy is often absent, it becomes more difficult for archaeologists to build reliable and precise chronologies, beyond the chronological range provided by individual radiocarbon dates (Giddings 1967; Ledger et al. 2016).

The second main issue is related to taphonomic factors (e.g., marine reservoir effect, terrestrial reservoir effect, old wood problem, McGhee 2000; Tuck 1976), which has implications for selecting which materials are more reliable for dating. For instance, given that marine resources were central to the lifeways of many groups living in circumpolar regions, bones and other remains of marine species are commonly present in archaeological deposits. However, taphonomic issues associated with specific materials (bone, collagen, oil) that comes from marine species tend to provide an older time (i.e., inbuilt age), which reflects the time differential between the age of death and the date of deposition in the archaeological record. This principle is extended to terrestrial faunal materials as well. Methods have been developed to adjust and correct the dates affected by marine reservoir effects (e.g., Dumond & Griffin 2002); however, to avoid dealing with "inbuilt age" materials, short-lived organisms (e.g., twigs, seeds) could be prioritized as they do not accumulate carbon over several years or decades (unlike large marine mammals), therefore represent a more valuable resource for dating.

Finally, the last main issue when dating northern archaeology is more pragmatic as it relates to methods and logistics associated with fieldwork in the Arctic. It is difficult to access certain remote sites in the Arctic, and fieldwork require complex logistics (e.g., the costs for the field trip often imposes limits on the size of research teams; there often is only a small window in the summer to be able to get to these locations and excavated areas that are not frozen, etc.). These challenging logistics influence the way arctic researchers have excavated these sites. Methods like the planum (or Wheeler box-grid method), can afford low-cost and relatively fast excavation over larger areas. However, they also tend to sacrifice the stratigraphic resolution and sometimes oversimplify complex stratigraphy (Branch et al. 2005; Ledger et al. 2016). In order to be able to attain a higher-resolution chronology (from a few centuries to decades) and apply such techniques as Bayesian modelling (Bayliss 2009), it is necessary to be able to integrate radiocarbon dating assays into a relative chronological model (i.e., stratigraphy and contexts). In other words, single context recording is preferable to the planum method, because in this system, stratigraphic layers are the basic unit of recording, and a Harris matrix provides relative chronological models for all the deposits (and samples and finds within) that have been excavated at a site. As such, Bayesian statistical methods produce probabilistic models that are more reliable and precise than their single components (i.e., stratigraphy, artifacts, radiocarbon dates) (Bayliss 2009). It also allows to production of chronologies (or age range estimates) for previously undated activities, as well as inferring their duration in time (Ledger et al. 2018).

In order to overcome some of the challenges posed by the issues named above, Forbes and Ledger (my supervisor and her closest collaborator) have harnessed experience acquired through their graduate and postdoctoral research to attempt the development of a method for sampling peat bogs for radiocarbon and archaeological-environmental data that could provide the "chronological scaffolding" for individual site biographies. Ledger's experience reconstructing the cultural landscapes of Norse Greenland through palynology (Ledger et al. 2013; 2014a; 2014b) inspired them to target peat bogs instead of archaeological sites, and thus circumvent issues related to the lack, or complexity, of archaeological stratigraphy. Forbes' understanding of the taphonomic processes affecting insect assemblages on circumpolar farmer and forager sites (Forbes et al. 2015; 2016, Forbes & Milek 2014; Forbes & Sikes 2018) led them to test whether it would be possible to retrieve insect's indicative of human activity in peat bogs, and thus some distance away from actual archaeological deposits. Their first attempt at combining their expertise to develop a methodology for capturing a strong anthropogenic signal in plant and beetle data and produce a high-resolution chronology local environmental change was undertaken through their work at the Yup'ik site of Nunalleq in southwestern Alaska. They used a combination of palaeoenvironmental analysis (insect and plant macrofossils, macroscopic charcoal data, and pollen analysis), with radiocarbon dating and Bayesian modelling to try to generate high-resolution chronologies for the site of Nunalleq (Ledger & Forbes 2019). Their methodology did capture a strong signal from an Arctic forager (here, Yup'ik) site occupation, demonstrating that the increase in concentrations of beetles associated with organic matter observed on northern archaeological sites (cf. Forbes et al. 2017) was not restricted to the site itself, but also extended at least 30 meters away from the archaeological deposits. Another important consideration was the depth at which the peat needed to be sampled, and the thickness of the subsamples needed in order to achieve a chronological resolution high enough to be related to the activities and phases of occupation recorded at nearby sites (Ledger et al. 2018). Typically, because insect fossils studies use much larger volumes (~2L of bulk sediment) than palynological studies (only a couple of ml), much thicker layers of peat are analyzed by insect fossil specialists who reconstruct long-term environmental change (e.g., Dussault et al. 2016; Panagiotakopulu et al. 2020; Vickers & Panagiotakopulu 2013). This undoubtedly tends to sacrifice the temporal resolution. To overcome such methodological challenges, Ledger and Forbes started experimenting with custom-made monolith tins at Nunalleq, in an attempt to allow sampling from a wall section (trench profile), from which the monolith could be sliced into arbitrary layers (2 cm-thick) for Coleoptera analysis to attain sub-centennial chronological resolution (Forbes et al. 2020; Ledger & Forbes 2019). The monolith sampling allows the volume to be examined with more precision, in addition to providing better control on subsampling into smaller volumes, so that it becomes possible to increase the chronological resolution of the beetle data. The pollen and beetle work at Nunalleq (Forbes et al. 2020; Ledger & Forbes 2019) has shown that the increase in organisms that are ecologically associated with the nutrient-enriched microhabitats does coincide with the time of human occupation, and that their presence decreases (or stops) after abandonment or at the onset of a hiatus in occupation (Ledger & Forbes 2019). Beetles (and other insects such as lice) could thus complement pollen data and serve as an additional indicator for the timing and duration of a site's occupation by hunter-fisher-gatherers' populations, as long as the field methods are adapted to allow this (Ledger & Forbes 2019).

The methodology and the results of the Nunalleq studies mentioned above (Forbes et al. 2020; Ledger 2018; Ledger & Forbes 2019) have directly inspired and informed the present study's design. Here, archaeoentomology is combined with other proxies (macroscopic charcoal and pollen) in an attempt to capture a strong anthropogenic signal and achieve a refined chronology of the site of Kivalekh in northern Labrador. The present study targets a peat bog in the proximity of the archaeological site of Kivalekh, an ideal source of short-lived plant material that grew on the spot and which therefore constitute a reliable source for providing precise radiocarbon dates (cf. Ledger 2018; Ledger et al. 2016). It is worth noting that these proxies, such as beetles and pollen, tend to capture the ecological changes associated with the period of occupation, which decreases slowly in visibility in the palaeoecological record post- abandonment of a site, rather than resulting in a drastic ecological change after occupation. This is mainly explained by the nature of Arctic and sub-Arctic contexts as the environment recovers much more slowly than in warmer and temperate ones (Forbes 1996). This is also supported by the results of the pollen and beetle studies at Nunalleq (Forbes et al. 2020; Ledger 2018; Ledger & Forbes 2019).

To summarize: there are two main factors that need to be considered when collecting peat samples for insect remains with the goal of using them to date an archaeological site occupation: (1) the proximity of archaeological deposits to the sampling location, combined with (2) the depth of the peat. To examine the potential footprint of hunter-gatherer populations in the palaeoecological record, the peat deposits should be thick enough (at least 40 cm), close enough to the site of interest (ideally less than 100 meters) and have a level topography. These factors are crucial for sampling using a monolith tin (the peat sample should ideally fill up the full space within the tin) and to allow an examination of insect macrofossils and pollen (microfossils) assemblages at the same chronological resolution.

Examining ecological patterns derived from human presence in an environment helps correlate the palaeoecological data with specific activities for different cultures in time and space. Even though it is often difficult to distinguish the effect of climate from anthropogenic factors, it is necessary to become familiar with the archaeological, geographical, and environmental context of the site studies to reach an intimate level of comprehension of human landscape modifications that are difficult to observe through more traditional archaeological methods. This is why I have here discussed key considerations that informed the design of this research' methodology, for instance the facts that the sample was taken in the immediate periphery of the archaeological site of Kivalekh (30 meters away from the closest sod house) and that it was subsampled into 1-cm thick slices to increase the chronological resolution. Further methodological details are presented in Chapter 4. The next chapter contextualizes Kivalekh in time and space.

Chapter 3 – Spatial & temporal scope of this thesis

This chapter outlines the geographic and temporal scope of this project, and is therefore guided by three objectives: (1) to present the broader geography and climate that characterize Labrador; (2) to describe the environmental history of northern Labrador based on recent palaeoecological work conducted in the study area; and finally (3) to present the archaeological site of Kivalekh, by contextualizing its geography and environment. The latter will include a brief overview of archaeological and palaeoecological research conducted in the Okak region – where Kivalekh is located.

3.1 Labrador geography & climate

The Québec-Labrador Peninsula constitutes the northeastern boundary of mainland North America (Kaplan & Woollett 2016). Baffin Island bounds Labrador or *Nunatsuak* (Big Land) to the north as well as Greenland to the east, and Newfoundland to the south. As a significant landmass, Labrador transects several climatic and ecological zones. The climate is regulated by its proximity to marine currents and essential atmospheric circulation systems in the Arctic; therefore, the climate in Labrador is exceptionally cold for its latitude. In the northern part, specifically from Nain to Killinek, the Arctic climate is characterized by maximum mean monthly temperatures of less than 10 degrees C with short summers with less than 70 days free of frost (Mayewski et al. 1994; McManus & Wood 1991). Some areas of the coast are somewhat warmer and wetter. At the same time, the interior (e.g., as far as Hamilton Inlet) has a continental subarctic climate, with fewer than 90 days free of frost annually (McManus & Wood 1991).

The Labrador Current is probably the most influential environmental factor that conditions Labrador's climate. This major conveyor of Arctic Ocean water carries cold (0-3 degrees C) and low salinity waters southward along the coast of Labrador. This current transports pack ice from Davis Strait and other regions further north to Labrador's coast, chilling coastal waters and shores. Atmospheric circulation processes are also responsible for influencing Labrador's climate. Located between the Arctic and Polar Fronts, Labrador sees important variations in the strength of Arctic air circulation, both seasonally and interannually (Serreze & Barry 2005; Kaplan & Woollett 2016). The climatic linkages of Labrador to the Arctic are most evident during winter months as the Arctic Front dominates the region's climate, and the coastline is entirely bound in land-fast sea ice (Kaplan & Woollett 2016). Unlike some Central and High Arctic areas, Labrador has no local multiyear ice, and the coast is completely free of ice in the summer.

In Labrador, land-fast ice brings other crucial environmental phenomena: polynyas, rattles and sina. These are recurrent biologically productive open-water areas, such as McLelan Strait, part of Nachvak Fjord, and the Narrows of Hamilton Inlet, which appear amid fast ice in Labrador. A polynya is an open-water area and rattles are small open water areas in constricted waterways dominated by strong currents. Sina is the name given to a juncture of fast ice and open water (Kaplan & Woollett 2016). These phenomena are described in the literature as vital for animals and people as part of Labrador Inuit economic strategies.

3.2 Presentation of the study site

Kivalekh is located on Okak Islands, approximately 100 km north of Nain, on the Labrador coast (Figure 3.1). The Okak region, a coastal environment characterized by an arctic climate, is divided into three distinct ecological zones: the mainland, the inner islands, and the outer islands (Curtis et al. 2006). Okak Bay's mainland is characterized by forested vegetation following the southern tree line. The lowlands portions of the rivers (e.g., Siugak River) flow into a deep bay. The inner islands, including the Okak islands, are partially forested with spruce and brush. The outer islands, including Opingiviksuak, are characterized by tundra vegetation on a rocky-dominated landscape (Curtis et al. 2006).

Its proximity to well-documented sites (Uivak Point 1 and Oakes Bay 1, the latter located in the Nain area) makes Kivalekh an ideal place for this study, as it has the potential to complement existing environmental-archaeological data from the area with new insights into past Inuit-environment interactions and possibly into the chronology of occupation of the site as well as the Okak region as a whole.

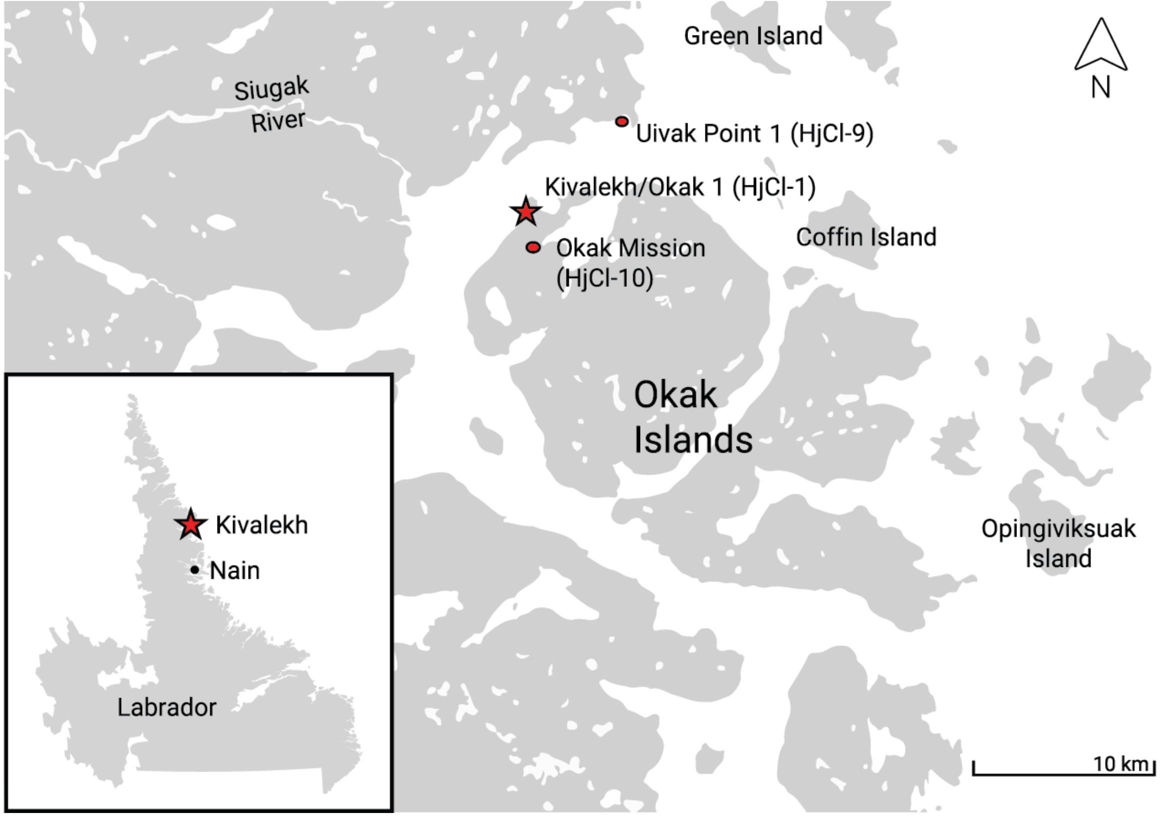


Figure 3.1 – Simplified map showing the archaeological site of Kivalekh with principal geographical features and important archaeological sites nearby as described herein. Figure made by the author.

3.2.1 Archaeology at Okak

The first systematic archaeological study of Okak was conducted by Steven Cox (1977) in 1974 and 1975. Cox surveyed more than sixty archaeological sites from which he selected specific sites to conduct more extensive excavations to document each major cultural period identified (Curtis et al. 2006; Onalik 2006). In 1977 and 1978, Fitzhugh and colleagues (1978, 1980) from the Smithsonian Institution led a larger project called the "Torngat Archaeological Project" in order to excavate and document the previous important sites identified between 1974 and 1975 by Cox. New sites continued to be recorded by several archaeologists who came to work in the area during the next few decades (e.g., Cox 2003; Hood 1997; Kaplan 1983; Sutton et al. 1981; Woollett 2003). Therefore, the Okak area is known to include 128 archaeological sites to date, representing all "cultural periods" known for the Labrador coast (Table 3.1). Because of its cultural and scientific importance, Okak was designated as a National Historic Site in 1978 (Agenda Paper 1978.06-SUA based on Cox's 1977 report). Okak's significance in terms of cultural history in the Arctic resides in the integrity of the archaeological sites that it regroups, rather than in a fraction of them (Curtis et al. 2006; Onalik 2006). Kivalekh (also known as Okak-1) is one of them.

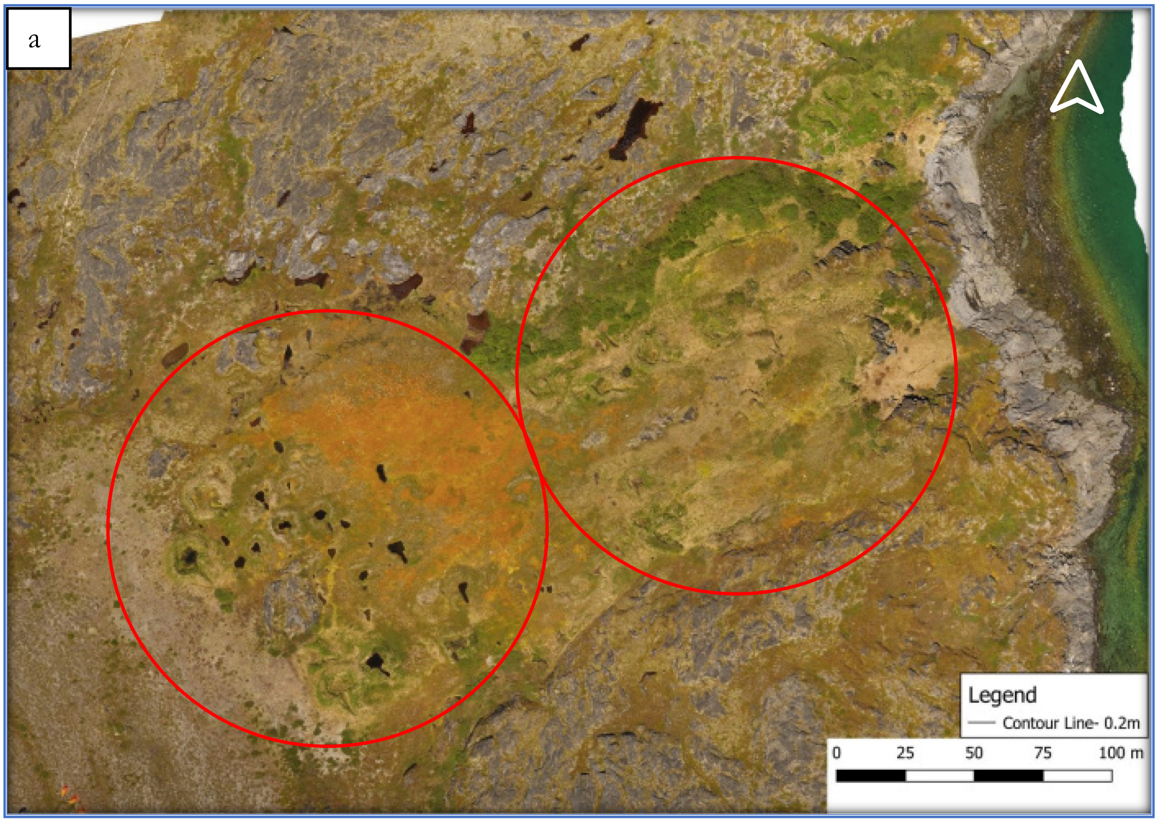
Cultural groups	Cultures	Dates (BP)	Number of sites at Okak
First Nations	Maritime Archaic	~ 8800 – 3200	20
	Intermediate	~ 3600 – 1500	6
Palaeo-Inuit	Groswater	~ 3000 – 2200	4
	Pre-Dorset	~ 4500 – 2700	37
	Dorset	~ 1500 – 700	35
Inuit	Inuit	1200 – present	50
	TOTAL		**154***

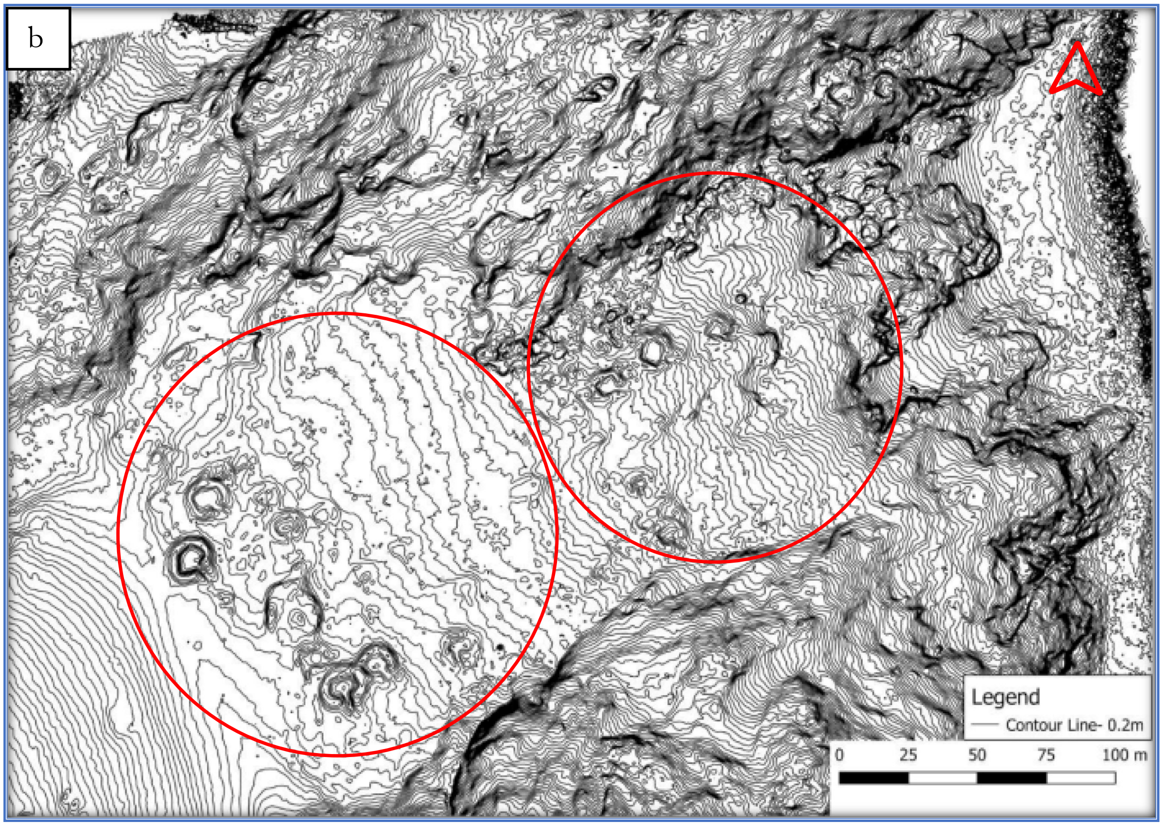
Table 3.1 – Table presenting a cultural history of northern Labrador established through the archaeological sites studied at Okak. This table is intended to illustrate the cumulative work conducted in that region and provided here to give a sense of the chronology and number of sites identified for each archaeological culture. Table initially made by Curtis et al. 2006: 6; adapted and modified by the author. *Please note that since some sites include cultural material from more than one culture, the total seen in the table is greater than the total of sites as described above (128 sites). Also, the dates proposed above are not finite. They are always subject to change and refinement as new research is conducted and new chronological data obtained.

The archaeological site of Kivalekh is situated on the beach pass, adjacent to a small peninsula at the northwestern tip of the Okak Islands. It is reported to be the largest known Inuit winter settlements in Labrador, consisting of 49 semisubterranean sod houses ranging in size from 15 m^2 to 70 m^2 (Figure 3.2). These include small single-family houses and large multi-family 'communal' dwellings (Whitridge 2018). Several have been tested over a decade (from 1974 to 1984), with extensive area tests and excavations of pre-Inuit deposits occurring in the vicinity of Kivalekh (e.g., Cox 1977; Sutton et al. 1981; Kaplan 1984); however, they are not well described in the literature, and the artifacts associated with the features have not been published. Even if these findings were revisited more recently (Curtis et al. 2006), the information is still hardly accessible in the scientific community. Recent spatial analysis (topographic map using a compact RTK system; generate aerial imagery using with a drone (or RPAS) to produce a photomosaic and 3D model of the site) delivered accurate and precise maps (Figure 3.3) of the features and archaeological activities, helping to gain a general sense of the site (Whitridge 2018).

Besides the agglomeration of sod houses on the eastern portion (i.e., referred to as Kivalekh itself), a modest scatter of historical (from a recent period) caches, in addition to tent rings, have been found at the northern tip of the peninsula (Whitridge 2018). A dense concentration of burial cairns on the eastern side, immediately north of the sod houses, has also been identified. Occasional inuksuit and simple cairns were also present at prominent locations (Figure 3.4).

Figure 3.2 – Example of a large sod house visible on the surface of the site, found at the western end of the archaeological site of Kivalekh, facing North. Photo courtesy of Dr. Peter Whitridge (2018).




b
Legend
Contour Line- 0.2m
0
25
50
75
100 m

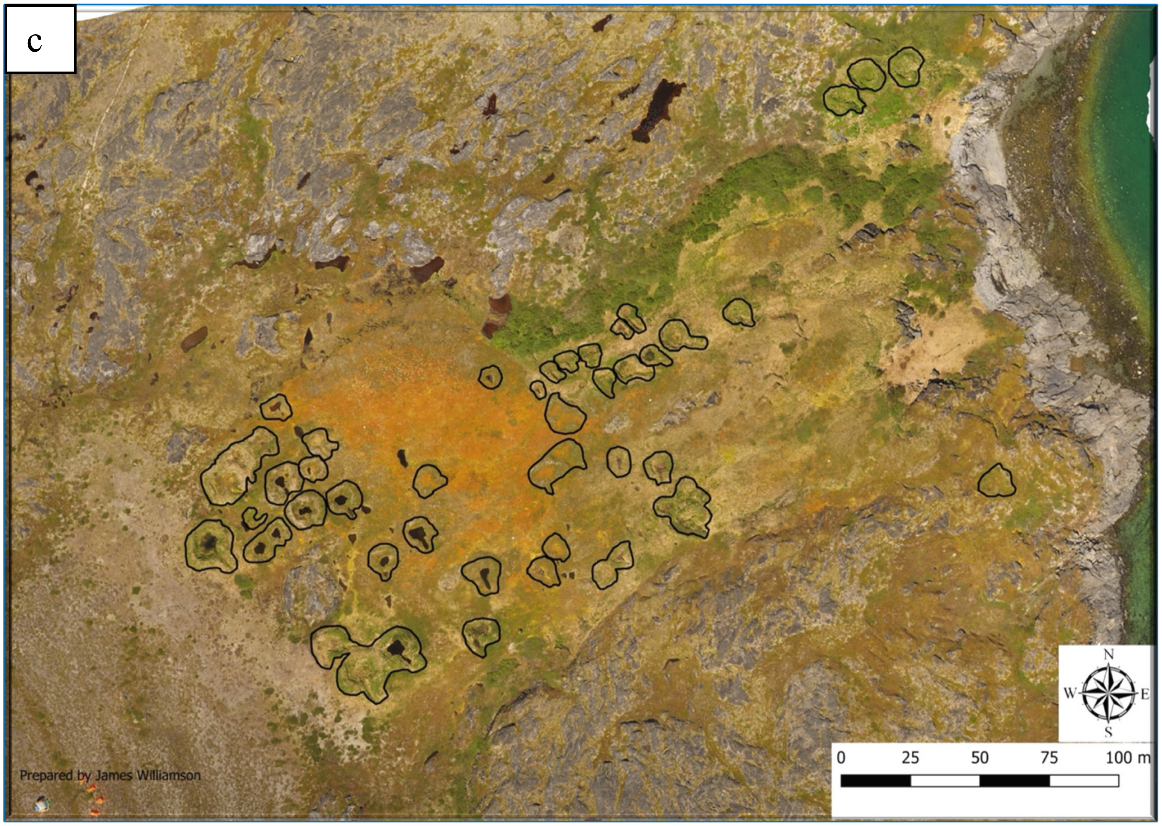

c
N
W
E
S
0
25
50
75
100 m
Prepared by James Williamson

Figure 3.3 a – Orthophoto mosaic of the archaeological site of Kivalekh generated from RPAS imagery. The agglomeration of sod-houses (red circles) like the one seen from the ground as shown in Figure 8, is easily observable using drone technologies. b – Contour map of the archaeological site of Kivalekh (same picture as in Figure 3.2), generated in QGIS. Red circles highlight the two agglomerations of sod-houses. c – Orthophoto mosaic of the same area presenting the sod-houses (underlined). All these are a courtesy of James Williamson.

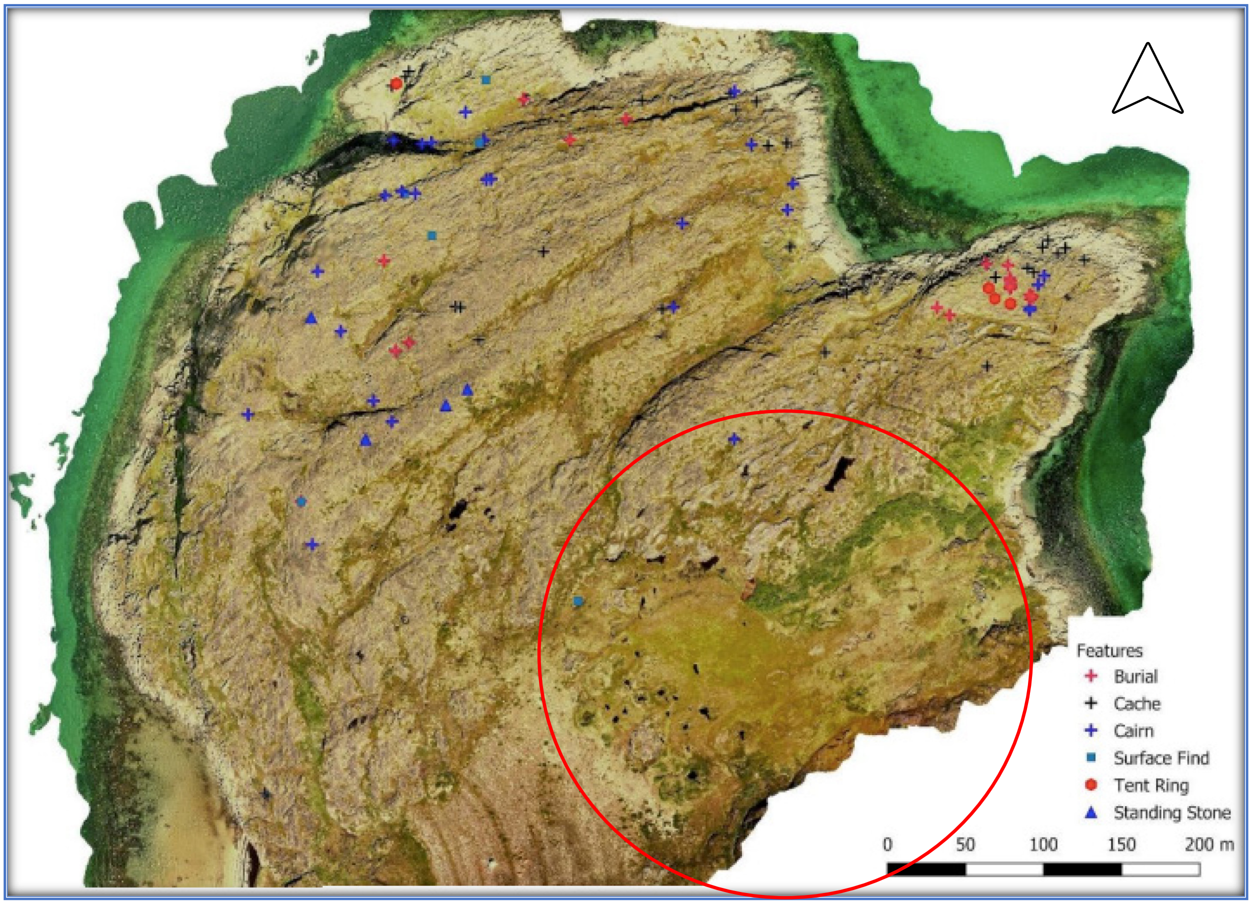


Figure 3.4 – Archaeological features surveyed and recorded, located north of the winter houses at Kivalekh. Courtesy of James Williamson. The large red circle shows the agglomeration of winter sod houses of Kivalekh, as depicted in Figure 3.3.

As mentioned in the previous chapter, the Moravian mission in Okak was established in Okak Harbor in AD 1776, and gradually Inuit families from Kivalekh relocated to the mission site (Taylor & Taylor 1977). The Moravian diaries indicate that at least six houses were occupied in Kivalekh during the winter of AD 1772-1773. Other records from that period indicate that the population resident at Kivalekh in 1778-1779 numbered 152 people (Curtis et al. 2006; Taylor 1974). The 49 sod-houses documented at Kivalekh represent repeated occupations over many years. This is supported by Cox's (1977) research on one of the houses from which they recovered faunal remains along with European artifacts of the 18th to early 19th century. The same house excavated also revealed Dorset stratified material culture, right beneath the cultural layers associated with the Inuit, which indicates a longer cultural sequence at the site. This is also supported by subsequent surveys (Sutton et al. 1981) conducted on the site, which revealed traces of Groswater and Pre-Dorset occupations, stressing once again that Kivalekh was occupied repeatedly over several hundred years (Curtis et al. 2006). Although mainly described as a winter occupation site, other adjacent structures were found indicating that it has been occupied during warmer seasons as well. This includes a late summer camp dated to AD 1781 through information in Moravian diaries, which explicitly attest that at least seven summer tents were placed at this very location, among the sod-houses (Taylor 1974:19). It is important to keep in mind that the structures so-called "winter house" or "summer tent" could have been occupied or reused for other purposes in between seasons. Synanthropic organisms associated with these structures could have occupied these structures all year round, inherently affecting our understanding of what we consider an abandoned or occupied site.

The written documentation and the results of archaeological work, taken together, demonstrate the importance of Kivalekh as a cultural landscape. The region was a major settlement area in northern Labrador until its abandonment in AD 1919. As of today, no excavation has been conducted at the Okak Mission site (where Inuit living at Kivalekh relocated in the 18th century), as it is still a sensitive matter in Inuit's living memory in Labrador (Budgell 2018). Kivalekh has a long cultural sequence that mirrors the whole cultural history of the region, with the exception of the later historic periods (Curtis et al. 2006:18). Strategically located, the Okak Mission site also shares Kivalekh's significance as both Moravian and Inuit interacted and lived together there for over a century. Rich marine, terrestrial, and stone resources are all key components of Okak's cultural landscape as they have shaped its inhabitants' lifeways (and vice-versa) for a few thousand years (Curtis et al. 2006).

3.2.2 Palaeoecology at Okak Islands

Over the last few years, work in environmental archaeology has focused on the detailed reconstruction of specific elements of Inuit culture in northern Labrador, illuminating aspects of settlement and land-use patterns and economic activities (Bain 2000a,b, 2001; Brice-Bennett 1977; Couture 2014; D'Arrigo et al. 2003; Kaplan & Woollett 2000; Roy 2010; Roy et al. 2012; 2015; Woollett 2003, 2008, 2010, 2011; Woollett et al. 2000; Zutter 2009). Large collaborative projects have sought to define the nature of human-environment relationships in specific landscapes to examine how they have been shaped by human presence and climatic and ecological processes (Hardesty & Fowler 2001). Following that premise, other researchers (Kaplan & Woollett 2000) applied this model of palaeoecology in order to better understand the relationships between environmental dynamics and social and historical processes pertaining to Inuit cultural change from the 16th to the late 19th centuries (Kaplan & Woollett 2000; Kaplan 1983, 2009, 2012). In order to do so, they collected samples as part of targeted excavations (Uivak Point 1 – HjCl-09 and Oakes Bay 1 – HeCg-08) to be analyzed using various methods such as palaeoethnobotany, zooarchaeology, and archaeoentomology. Additionally, the application of dendrochronology was used as a dating method to provide precise dates that integrate high-resolution palaeoclimate records and correlates them with the environmental archaeology data produced throughout their collaborative research work (Bain 2000a, b; D'Arrigo et al. 2003; Kaplan 2012; Woollett 2003, 2007; Woollett et al. 2000; and Zutter 2009). These projects allowed the identification of land-use activities, including the economic and seasonal particularities of the Inuit occupation at Uivak Point 1 and Oakes Bay 1. Although there are still subtle complexities that are poorly understood in terms of linking the signals of Inuit-environment interactions read in the palaeoecological record to specific activities or groups, these projects have proposed approaches capable of reconstructing environments and land-use patterns of human impacts, and refined chronologies of site occupations for the context of interest here (Couture 2014; Roy 2010; Roy et al. 2012, 2015). Integrating pedology, sedimentology, geochemistry, and micromorphology with the study of sea-level changes and peat formation allowed 'ecohistories' (Crumley 1994) to be provided for northern Labrador. Palaeoecological data recovered from Uivak Point houses show that both human activities and climate triggered temporal changes in the vegetation (Roy et al. 2015), suggesting broad ecological phases that can help contextualize the present study within the wider ecological history of Labrador.

During the late 11th century, the Okak region was covered by shrub tundra (dominated by *Ericacea*e, *Betula* spp., *Alnus* spp., and *Cyperaceae*) (Roy et al. 2015). The spruce forest cover was open, which indicated a cold and dry climate (such as the one associated with the end of the Neoglacial period). Successively for a short period, dated from the mid 13th century to the late 14th century, climatic conditions became much warmer and wetter, resulting in the expansion of trees and the diversification of shrubs and herbs. Then from AD 1380, a shift from a warmer and wetter climate to an abundance of dry taxa may indicate the Little Ice Age (LIA) (drier and colder conditions in the Arctic and sub-Arctic between AD 1450 and 1850). Recently, the abundance of certain kinds of vegetation in the region has been induced by a long-term warming period.

Regarding human-induced environmental change, many of the local plant species growing in the vicinity of Uivak Point were likely used by the Inuit in various contexts (fuel, food, floor coverings, bedding, medicine, clothing, lamp wicks, etc.). Certain macrofossils found in the matrix of samples (e.g., burned fat, leaves, moss, and charcoal remains) seem to indicate that researchers captured the human presence on-site. While some of these may have derived from resource use and harvesting or trampling around the houses, no drastic changes by Inuit (e.g., deforestation) seemed to have been observed in the palaeoecological sequence, except for *Picea* sp. remains found in the assemblage. Disturbance and nutrient-enrichment resulting from human activity is likely to have triggered the establishment of some weeds, such as *Montia fontana*. The palaeoecological data produced by the research conducted in Uivak Point, combined with chronostratigraphic data, suggest that the site was occupied periodically from as early as AD 1400 (Roy et al. 2015; Woollett 2003; Zutter 2009). Hence, in order to examine ecological patterns derived from human presence in the environment in similar contexts, more sampling like the one used for the present study is necessary. Indeed, to capture the anthropogenic signal sampling needs to occur within the vicinity of the archaeological disturbances (sampling targeted <30 meters off site), so we can minimize the effect of mixing climate-fluctuation signals which occur when targeting larger areas (<50-100 meters off site).

In summary, palaeoenvironmental research conducted in the study area (more specifically around Okak Islands and Oakes Bay) paints a picture of a landscape fluctuating between periods of cultural changes, especially during the 17th century with the arrival of European settlers along the coast and the establishment of Moravian missionaries in the area. In addition to the influx of new groups in northern Labrador, a period of climatic instability with the advent of the Little Ice Age (extending from the 16th to the 19th centuries approximately) saw a significant regional cooling in the North Atlantic and the Eastern Arctic, inherently impacting both the environment and the people inhabiting the landscape over a few centuries. Of course, previous occupations are more challenging to capture archaeologically, but more research is needed to examine Palaeo- and Neo-Inuit landscapes.

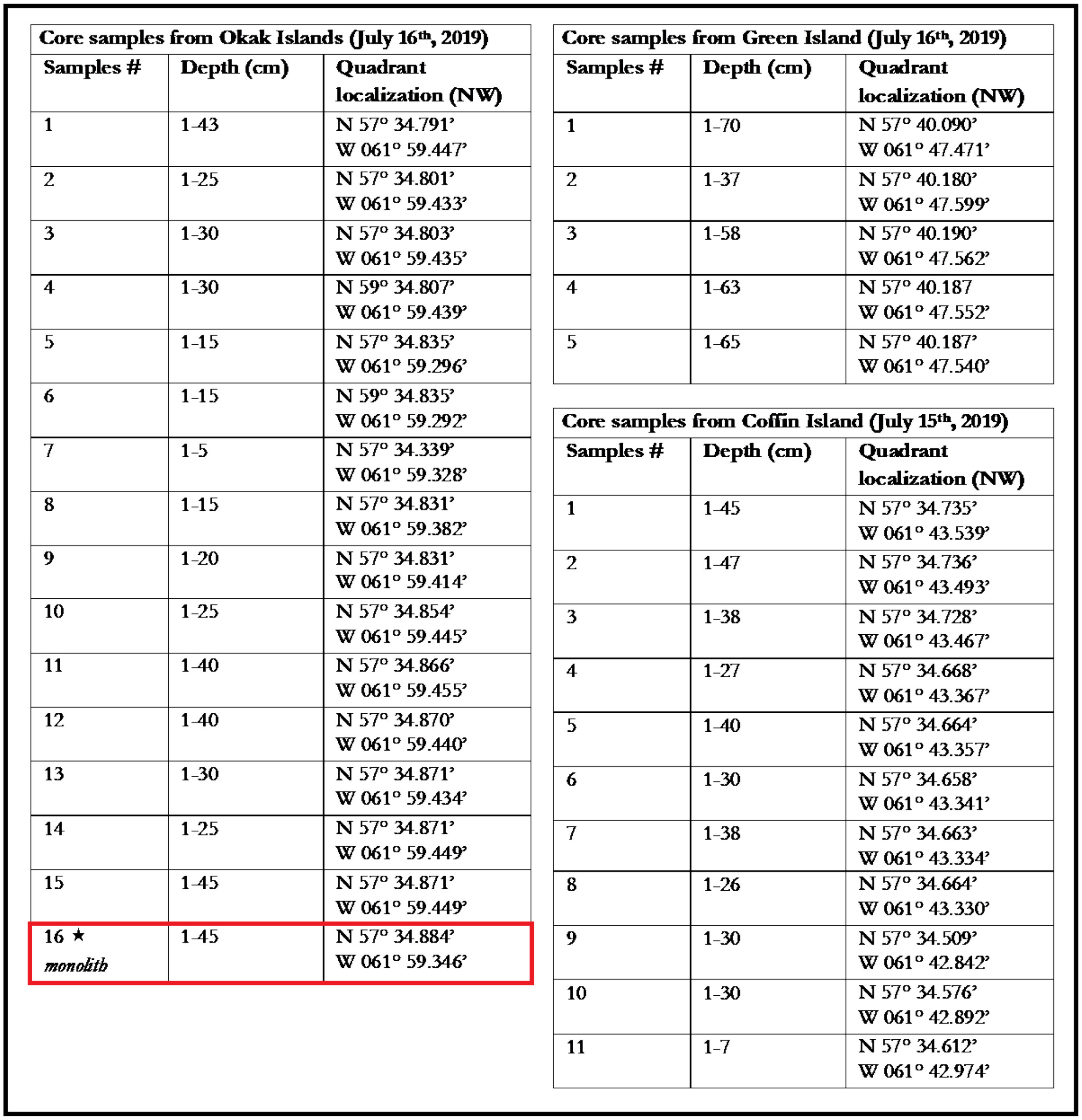
This chapter presented Labrador's geographic and climatic singularities, as well as the archaeological site of Kivalekh and its wider area. Despite a relatively small number of sites that has been the object of environmental-archaeological analyses in the Arctic (Forbes et al. 2014; 2017), current understanding of the movements and lifeways of past Inuit are still, in many ways, poorly understood and therefore subject to further examinations. The following chapter (Chapter 4) presents the materials and methods used to generate new data on the story of Inuit-environment interactions in this part of the world. It broadly follows general guidelines for a palaeoecological research agenda in Labrador established by Carlson (2022) and adapted for the present study context.

Chapter 4 – Materials & methods

This chapter presents the methodology used in this multi-proxy study of human-environment interactions at Kivalekh, including (1) the fieldwork conducted at Kivalekh to collect the samples analyzed for this thesis, and (2) the laboratory methods employed to process and analyze palaeoecological samples.

4.1 Fieldwork

Between July 19th and August 6th 2019, a Memorial University team including Dr. Véronique Forbes, Dr. Peter Whitridge, their Master's student Ivan Carlson, and two other MUNL students, Sarah Wilson and James Williamson travelled to the area of Okak Islands in northern Labrador to conduct fieldwork. They were accompanied by two residents from the community of Nain, Alfred Winters and Stephen Denniston. Researchers have conducted a reconnaissance survey around the Inuit winter village of Kivalekh (Okak 1 – HjCl-01), 2 km northwest of the historic site of Okak Mission (HjCl-10) (Figure 7). One of the objectives of this field season was to find a suitable location to collect a peat monolith sample to conduct insect fossil analyses. To achieve this, Carlson and Forbes did a walkover survey of peatlands in three different areas: (1) Coffin Island, (2) Green Island, and (3) Okak Islands (also seen in Figure 3.1). They used a soil auger to make general observations about the matrix composition and to test the depth of peat and permafrost in various locations. A total of sixteen (16) cores were inspected in the vicinity of Kivalekh, five (5) on Green Island and eleven (11) on Coffin Island. The cores were described (Appendix 1) before being discarded, and their locations were recorded (Table 4.1). The result of this exercise identified the area surrounding Kivalekh (located on Okak Islands) as the most suitable location for the collection of a large peat monolith, as it is only there that areas of unfrozen peat deep enough to allow the insertion of the 40-cm high sampling tin into a trench wall were encountered.



Core samples from Okak Islands (July 16th, 2019)

Samples #	Depth (cm)	Quadrant localization (NW)
1	1-43	N 57° 34.791’ W 061° 59.447’
2	1-25	N 57° 34.801’ W 061° 59.433’
3	1-30	N 57° 34.803’ W 061° 59.435’
4	1-30	N 59° 34.807’ W 061° 59.439’
5	1-15	N 57° 34.835’ W 061° 59.296’
6	1-15	N 59° 34.835’ W 061° 59.292’
7	1-5	N 57° 34.339’ W 061° 59.328’
8	1-15	N 57° 34.831’ W 061° 59.382’
9	1-20	N 57° 34.831’ W 061° 59.414’
10	1-25	N 57° 34.854’ W 061° 59.445’
11	1-40	N 57° 34.866’ W 061° 59.455’
12	1-40	N 57° 34.870’ W 061° 59.440’
13	1-30	N 57° 34.871’ W 061° 59.434’
14	1-25	N 57° 34.871’ W 061° 59.449’
15	1-45	N 57° 34.871’ W 061° 59.449’
16 ★ *monolith*	1-45	N 57° 34.884’ W 061° 59.346’

Core samples from Green Island (July 16th, 2019)

Samples #	Depth (cm)	Quadrant localization (NW)
1	1-70	N 57° 40.090’ W 061° 47.471’
2	1-37	N 57° 40.180’ W 061° 47.599’
3	1-58	N 57° 40.190’ W 061° 47.562’
4	1-63	N 57° 40.187 W 061° 47.552’
5	1-65	N 57° 40.187’ W 061° 47.540’

Core samples from Coffin Island (July 15th, 2019)

Samples #	Depth (cm)	Quadrant localization (NW)
1	1-45	N 57° 34.735’ W 061° 43.539’
2	1-47	N 57° 34.736’ W 061° 43.493’
3	1-38	N 57° 34.728’ W 061° 43.467’
4	1-27	N 57° 34.668’ W 061° 43.367’
5	1-40	N 57° 34.664’ W 061° 43.357’
6	1-30	N 57° 34.658’ W 061° 43.341’
7	1-38	N 57° 34.663’ W 061° 43.334’
8	1-26	N 57° 34.664’ W 061° 43.330’
9	1-30	N 57° 34.509’ W 061° 42.842’
10	1-30	N 57° 34.576’ W 061° 42.892’
11	1-7	N 57° 34.612’ W 061° 42.974’

Table 4.1 – List of the cores extracted in Okak, Green, and Coffin Islands to find a location at which to collect the peat sample. The red rectangle corresponds to the location where the trench from which the monolith analyzed herein was extracted. The depth for each core varies, as the depth of (unfrozen) sediment/peat varies from one location to another. Each core was described (Appendix 1) before being discarded and its location (NW) recorded.

Following the coring, three test pits (Figure 4.1) were excavated in areas where the coring showed that the depth of unfrozen peat\sediment was suitable. The first trench (referred as to Palaeoecological Trench #1, or P.E.T #1), measuring 2m x 1m, met the basic requirements for sampling, such as enough depth of sediment; however, the nature of sediment was too mineral (more sandy, less organic), potentially resulting in poor preservation of the insect remains. For that reason, Forbes and Carlson decided to explore further and excavate another trench (P.E.T. #2). The second one (1.5m x 1m) contained a large rock at the bottom of the trench, therefore it was not possible to dig deep enough to ensure proper sampling. Finally, the third trench (P.E.T. #3), measuring 1m x 1m, met all the requirements to allow a reliable sampling according to the initial research objectives. The matrix was described as "peaty and highly organic". Deeper in the layers (around 30-45 cm depth), the organic matter changed from "peaty to sandy before reaching the permafrost" (see Appendix 1).

It is worth mentioning that the sampling location was on the margin of the archaeological site of Kivalekh, approximately 30 meters northwest, of the house groupings down a natural slope on which the settlement was located. The peat monolith was collected using one monolith tin (40 x 35 x 35 cm), consisted of a stainless-steel box that Carlson inserted using a hammer into an exposed peat section (Figure 4.2a). The profile was recorded first, with the aid of photographs, drawings, and a matrix description (Figure 4.3). Then, the monolith was inserted into the wall using a mallet, a cake slicer, a trowel, and a spade (Figure 4.2b).

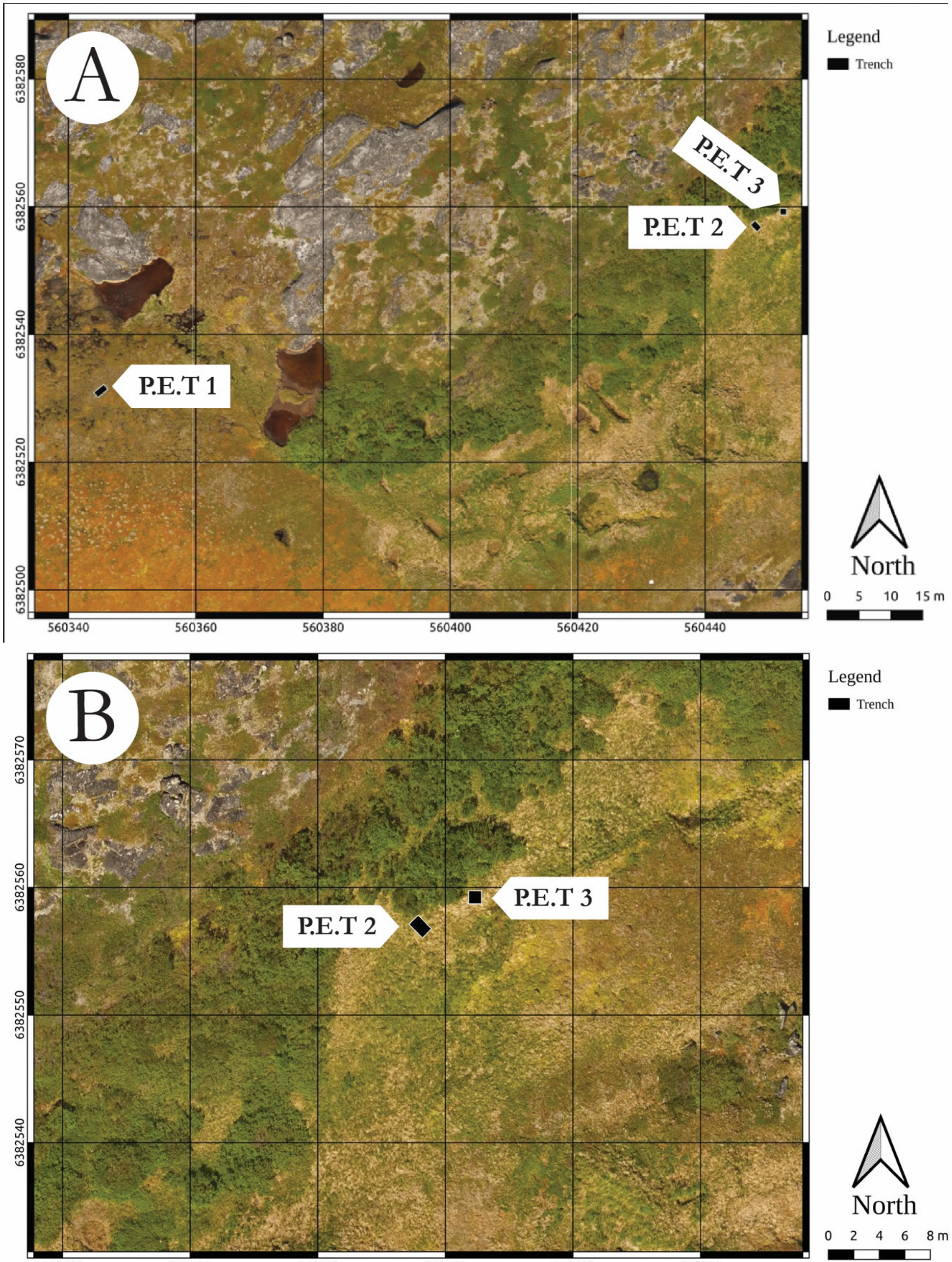


Figure 4.1 a – Locations of the trenches (P.E.T.) #1,2,3. b – Locations of the trench P.E.T #3 measuring 1m x 1m, from which the monolith studied herein come from. Courtesy of James Williamson for producing these maps, although modified by the author.

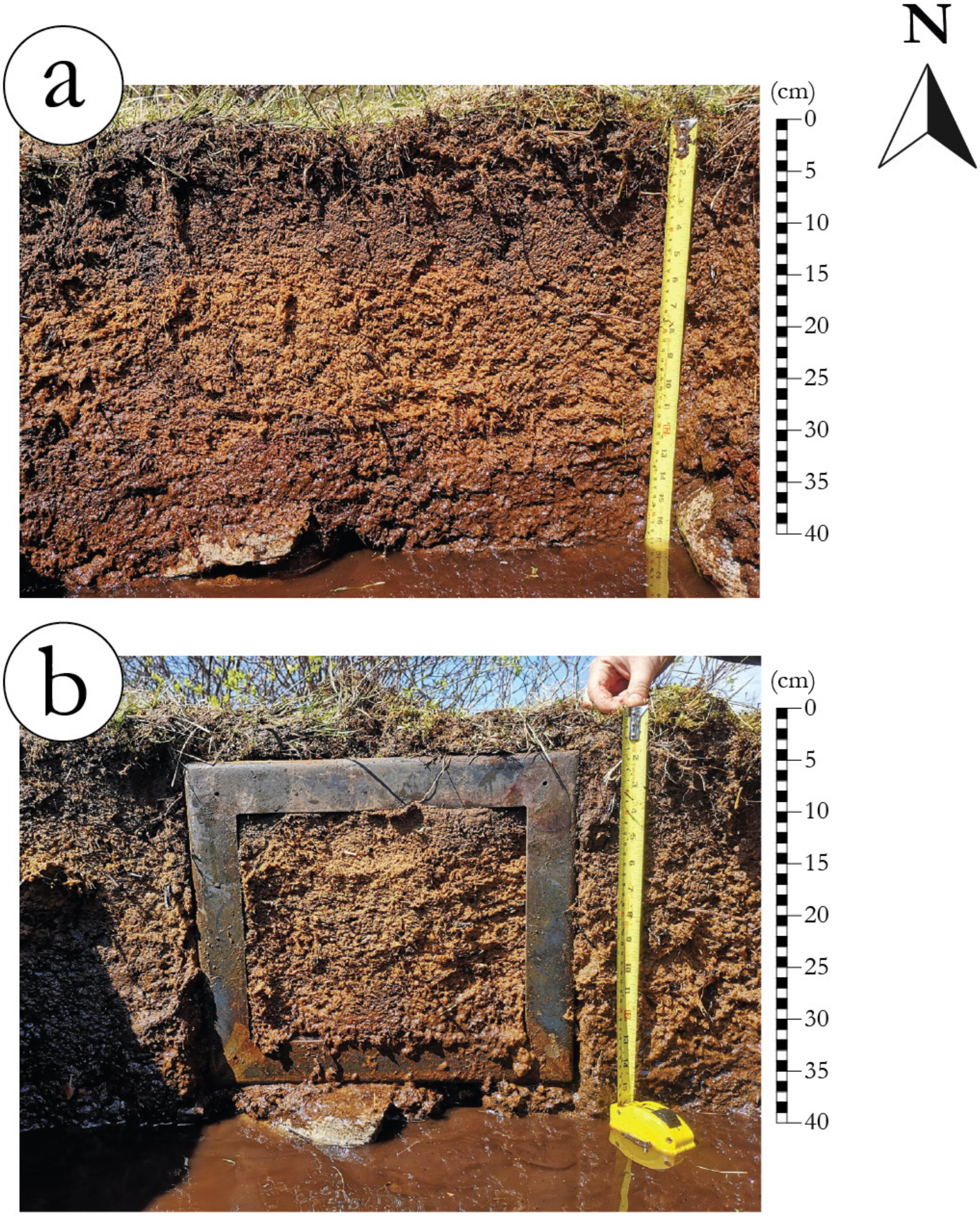


Figure 4.2 a – Photo of Kivalekh's P.E.T #3 profile North before tin insertion.
b – Photo of the monolith inserted into Kivalekh's P.E.T #3 profile North. The scale is provided to help read the measures from the tape. Photos are a courtesy of Ivan Carlson (2019). Figure made by the author.

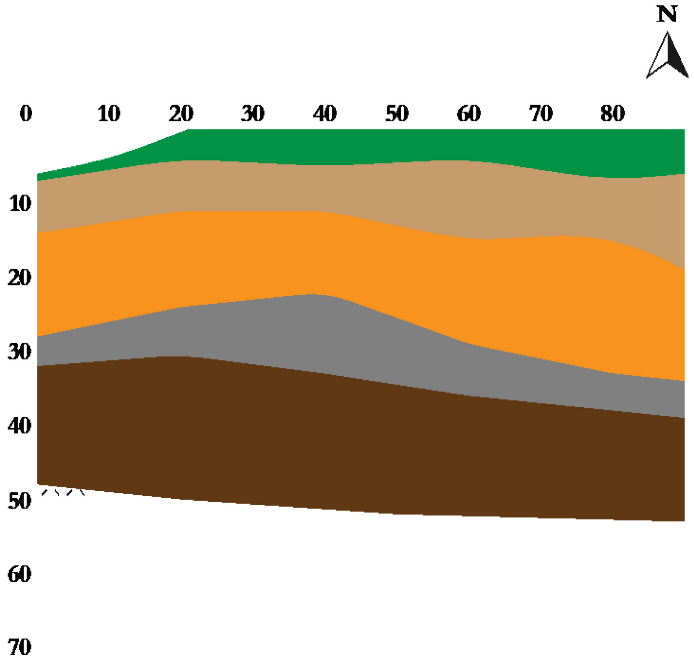


Figure 4.3 – Stratigraphy of Kivalekh's P.E.T. #3 North' Profile with matrix descriptions. Initially drew on the field by Ivan Carlson and Véronique Forbes, but transcribed by the author, using Adobe Illustrator.

Once the monolith had been successfully extracted from the peat section, it was brought back to camp, where Carlson, assisted by Forbes and Alfred Winters, cleaned (using a trowel) and recorded the monolith in preparation for sub-sampling. A few centimeters were left at the top and the bottom of the monolith in order to avoid potential contamination from tin insertion. Before slicing the whole monolith, smaller subsamples for pollen analyses and radiocarbon dating were extracted using an exacto knife (Figure 4.4). Then, Forbes, Carlson, and Winters sub-sampled the remaining monolith by slicing it into 1-cm thick sub-samples. This proved challenging, as the nature of the peat made it difficult to achieve regular, clean-cuts every 1-cm. Utmost care was devoted to trying to do this as best as possible, but it is likely that some samples incorporate some deposits from the upper and lower cm slices as well. This will be considered in data interpretation. Each sub-sample was carefully bagged separately and labelled by number (from the bottom to the top), and its associated depth in the profile noted on each bag (e.g., sample#33 [38-39 cm]).

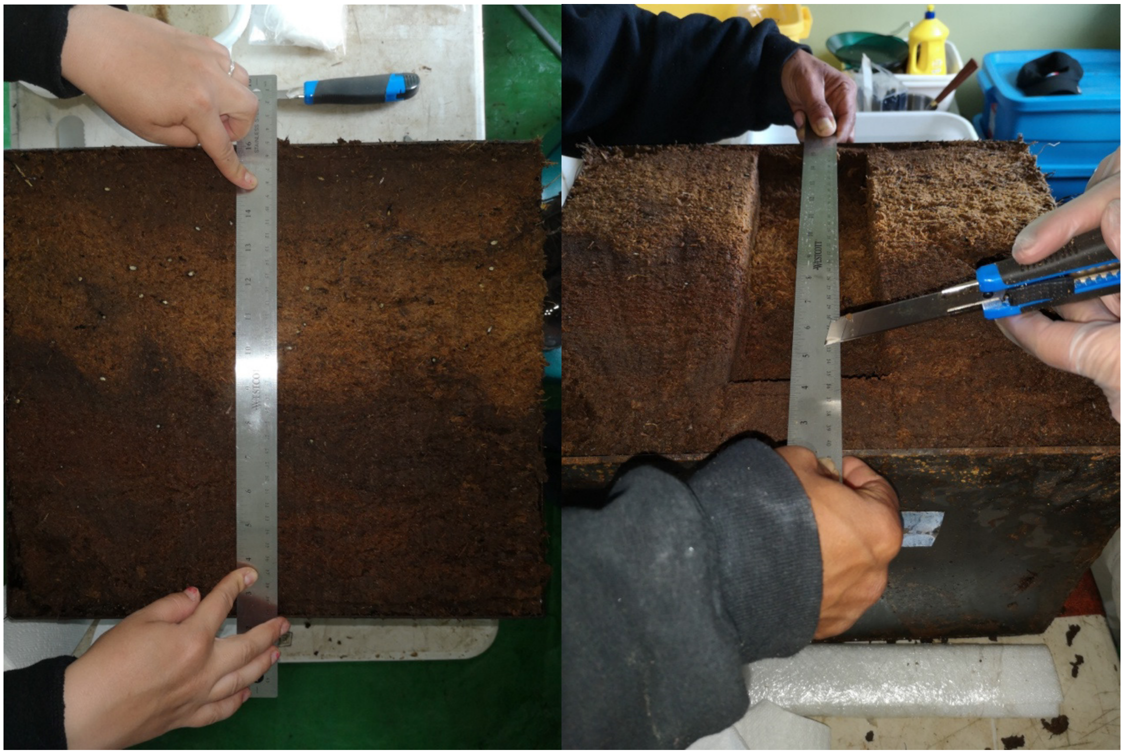


Figure 4.4 – Forbes, Winters, and Carlson are subsampling smaller volumes for pollen analysis (2019). Courtesy of Ivan Carlson.

4.2 Laboratory analysis

After the 2019 field season, samples were brought to the Palaeoecology, Environmental Archaeology and Timescales Laboratory at Memorial University (P.E.A.T. Lab.) to be refrigerated to prevent dehydration and mold that could contaminate the entomological remains.

4.2.1 Sample selection & preparation

Of the 33 samples extracted from the monolith for the insect analysis, for a total depth of 39 cm of the ground level, a total of 12 sub-samples were selected for this analysis (Table 4.2). The selection was made in function of two (2) radiocarbon dates generated at various depths from the monolith (Table 4.3).

Samples #	Depth (cm)	Volume (ml)
22	27-28	50
23	28-29	50
24	29-30	50
25	30-31	50
26	31-32	50
27	32-33	50
28	33-34	50
29	34-35	57
30	35-36	57
31	36-37	57
32	37-38	57
33	38-39	557

Table 4.2 – List of the 12 samples and their associated depths (cm) from the ground level and volume (ml) analyzed for this research. 50 ml were analyzed for insect analysis. Note that the volumes change from samples #29 and below as complementary analysis (charcoal) were added on the total volume analyzed. Sample #33 has a larger volume (557 ml) as MA student Ivan Carlson sorted 500 ml prior to the pandemic, which was taken into account for this research. Further details are provided below in this chapter.

Lab code	Sample #	Depth (cm)	Material	^{14}C BP yr	±	Calibrated age (yr AD)
UOC-11531	11	16-17	*Sphagnum* spp.	58	23	1695-1915
UOC-11532	32	37-38	*Sphagnum* spp.	394	23	1445-1630

Table 4.3 – Radiocarbon results provided by AMS analysts, Dr. Xiao-Lei Zhao, and Carley Crann from A.E. Lalonde Laboratory in University of Ottawa.

The soil matrix of the samples analyzed was dominated by sphagnum-peat. Because of this, it was not necessary to soak the samples in a weak (<1% approximately) cold solution of NaOH prior to the analysis as traditionally described in archaeoentomological protocols (e.g., Coope & Osborne 1967; Kenward et al. 1980). Instead, a volume of 50 ml was taken from each of the selected c. 2L subsamples. Each sub-sample (50 ml) was washed with hot water for approximately ten minutes over a 250-μm mesh standard geological sieve, before being collected and vialed separately (i.e., one vial per sub-sample).

There are two main reasons for analyzing volumes of 50 ml: (1) as one aim of this research is to propose a high-resolution chronology, larger volumes would need to be paired with thicker samples, meaning a loss of chronological resolution (see previous chapter for more detail); and (2) analyzing larger volumes requires much more analysis time, especially where one is working with peat (from which it is harder to separate insect fossils from the matrix than silty sediment). Therefore, it would simply not have been possible to conduct this research within the framework of a Master's if higher volumes were processed. Sustainable research practices and methods (like the one described herein) are required if archaeoentomology is to continue to expand and be useful to long-term ecological/biodiversity research, and as a worthwhile career path for students. The methodology for this study therefore represents a further development from the one first employed in the Nunalleq project (Forbes et al. 2020; Ledger & Forbes 2019), the results of which will be used to inform further methodological developments.

4.2.2 Documenting the biostratigraphy

Loss-on-Ignition

The stratigraphic profile captured in the peat monolith was described in the field as peaty and highly organic, from 1 to 30 cm below the ground level. From 30 cm to 45 cm, the peaty matter changed to sandy and mineral before reaching the permafrost. As the soil matrix is composed – among other things – of living organisms, carbonates, carbon, water, and decomposing matter, in order to determine how much of these components make up the soil mass, the Loss-on-ignition (LOI) test is helpful as it measures the amount of organic matter contained in the soil. This was measured by weighing a small amount of soil from the monolith's samples using crucibles, before and after laboratory ignition in a furnace at 550° Celsius for a duration of 4 hours (Figure 4.5). The organic content is represented as a percentage of the dry sample. The LOI test was achieved on the 33 samples (covering the total depth of the monolith).

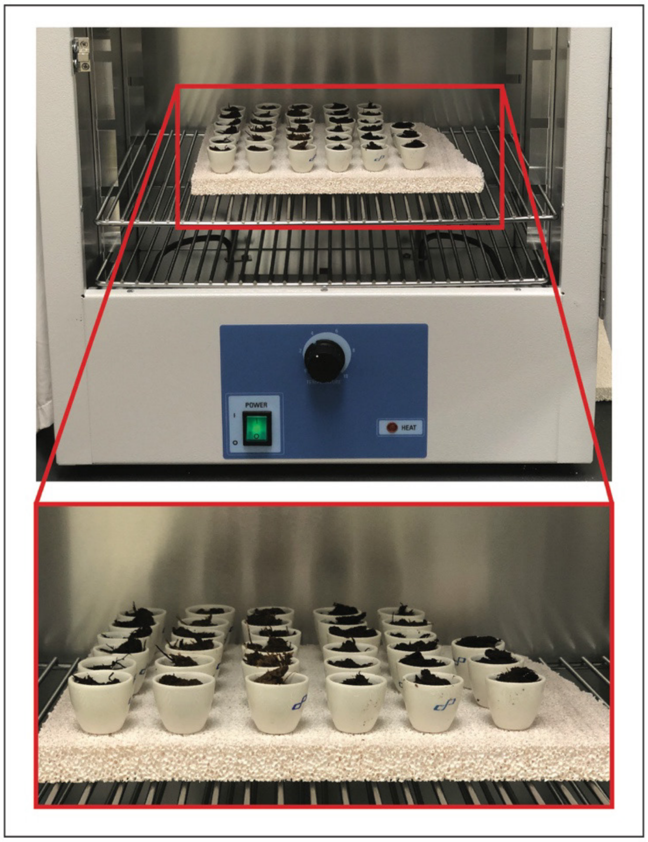


Figure 4.5 – The loss-on-ignition (LOI) test was undertaken by weighing a small amount of soil from the monolith's samples, placing them in crucibles, and weighing them again after laboratory ignition in a furnace at 550 °Celsius for a duration of 4 hours. Photo taken by the author.

Charcoal

Selection of subsamples for macroscopic charcoal analysis was based on the observation of charcoal remains as present while sorting the insect parts from the subsamples. As the layers at the bottom of the monolith appeared to be richest in terms of concentration (further discussed in the following chapter), small arbitrary volumes of 7 ml were prepared and washed with hot water through a geological sieve of 60 mesh (250 μm) to look at this more systematically. Then, charcoal fragments were counted for abundance per size class (<0.5 mm, 0.5-1 mm, 1-1.5 mm, 1.5-2 mm, >2 mm), using a microscope eyepiece graticule at a magnification of 10x. These data were then used to calculate charcoal concentration values for each subsample. It is worth noting that charcoal has been quantified and not identified for this research.

4.2.3 Insect analysis

Once each subsample was prepared (according to steps described in 4.2.1), it was sorted carefully in water under a binocular microscope in order to separate the Coleoptera from the bulk of the material. All identifiable beetle remains were picked out from the sample and kept in a vial filled with distilled water (Figure 4.6a). Before identification, the collected insect remains were carefully glued on entomology boards using tragacanth (*Astragalus* spp.), a plant-derived gum (Figure 4.6b). This glue is water-soluble and, therefore, safe for the entomological remains (Deans & Sandall 2018). This facilitated the identification of each beetle remain, allowing each specimen to be easily manipulated and organized in the reference collection by taxonomic order. These specimens are now part of the entomological reference collection in the P.E.A.T. Laboratory at Memorial University (Figure 4.6c).

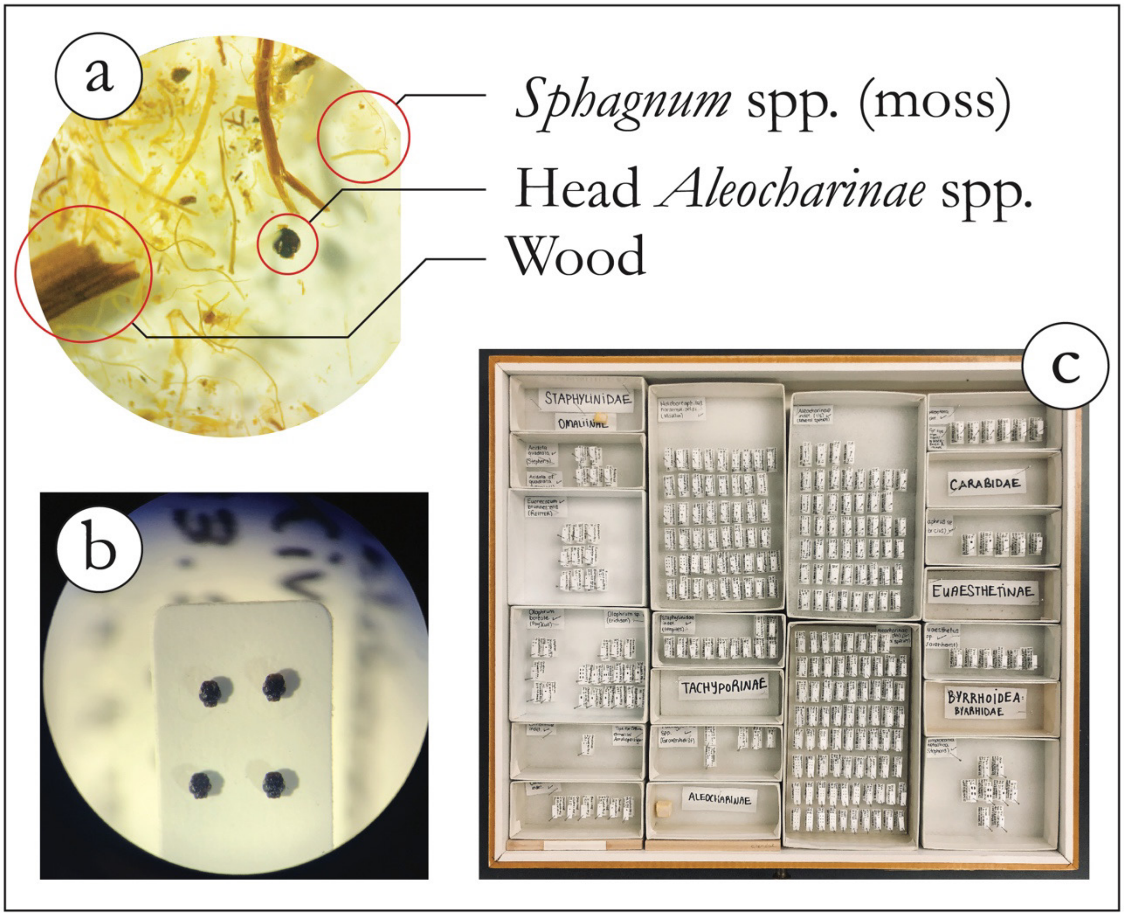


Figure 4.6 a – Example of what we see under the binocular microscope during the process of sorting for Coleoptera remains. Depicted in the picture is mainly what dominates the peat matrix (*Sphagnum* spp. moss), wood, and a head of an *Aleocharinae* indet. b – Example of specimens (heads of *Holoboreaphilus nordenskioeldi*) glued on entomological cards prior to proceed to the identification. c – The dataset generated throughout this thesis is now part of the Entomological collection in the P.E.A.T. Laboratory at Memorial University, alongside with other fossil specimens from other contexts. Photos taken by the author.

The identification of insects was performed through direct morphological comparison with specimens from the P.E.A.T. Lab., aided by consultation of the relevant entomological literature (e.g., Bousquet et al. 2013; Campbell 1978, 1979, 1982, 1983, 1984, 1991; Chernov et al. 2014; Elias 1992, 1994, 2000, 2010; Johnson 1991; Klimaszewski et al. 2008, 2016; Lindroth 1961, 1963a, b, 1966, 1968, 1969a, b; Lohse et al. 1990; Majka et al. 2007; Matthews 1983; O'Brien 1970). Each beetle's head, pronotum, and elytron (Figure 4.7) were identified to the highest taxonomic level possible (i.e., to species where possible). Once identifications were completed, the Minimum Number of Individuals (MNI) was calculated based on the most abundant morphological element for each identified taxon in each sub-sample (depth) (Elias 2010; Smith 2012). The minimum number of specimens is easily calculated since each insect has the same number of body parts (1 head, 1 pronotum, and 1 left and 1 right elytron) (Figure 4.7). However, as some remains were not well preserved or did not exhibit characteristics allowing them to be identified to a high taxonomic level, I needed to consider that not all beetle remains were identified to the same taxonomic level in my MNI calculations. This means they were likely identified to family or genus level with a mention (indet., cf., or spp). To be as precise as possible, they were counted separately from those identified to genus or species level so their representativity in the assemblage is accurate. Taxonomy and nomenclature follow the latest published checklist of insects from Canada and Alaska (Bousquet et al. 2013).

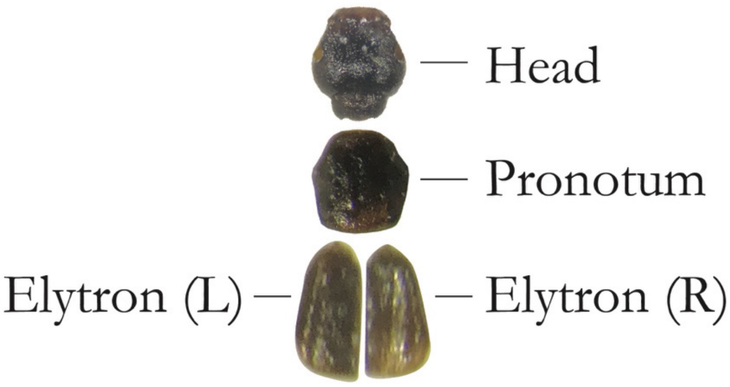


Figure 4.7 – The Minimum Number of Individual (MNI) is easily calculated as Coleoptera have the same number of body parts (1 head, 1 pronotum, and 1 right and left elytron). Photo of a *Holoboreaphilus nordenskioeldi* (Mäklin) taken by the author. Figure made by the author, in collaboration with Eric Aylward using Adobe Illustrator.

Once the taxonomic classification was achieved, the next step was to collect information regarding the ecological requirements of each individual taxon identified from the fossil assemblage. This information was obtained using the scientific literature about modern beetles from the circumpolar north (e.g., Arnett 2000; Arnett & Thomas 2001; Arnett et al. 2002; Böcher 1988; Böcher & Fredskild 1993; Larochelle & Larivière 2003; Larson et al. 2000; Speight et al. 1999).

4.2.4 Radiocarbon dating & age-depth modelling

The chronology of the peat section was established through radiocarbon dating assays on short-lived plant macrofossils (*Sphagnum* spp. moss) extracted at two locations in the peat monolith (Table 4). Samples were disaggregated in weak NaOH (2%) before being washed through a 125 μm sieve. Residues were examined under a binocular microscope and cleaned to remove roots of *Ericaceae*, monocots, and fungal mycelium. The remaining macrofossil leaves were then stored in distilled water containing a drop of HCl. Radiocarbon dating was performed at the André E. Lalonde Accelerator Mass Spectrometry Laboratory at the University of Ottawa. Dates were calibrated using the IntCal20 calibration curve (Reimer et al. 2020) using OxCal v4.4 (Bronk Ramsey 2009). Calibrated results are given as a range with an associated probability, as point estimates (mean, median) cannot represent the uncertainties involved (Millard 2014). Age-depth modelling was undertaken using the classical techniques in *Clam* (Blaauw 2010).

4.3 Integration of data: A multi-proxy approach

Biostratigraphic zonation of the coleopteran dataset was undertaken using CONISS (Grimm 1987) following square root transformation of percentage data. To standardize the data presented in the Frequency diagram, it was adjusted to account for different volumes (ml) analyzed. To do so, the proxies (MNI) and volumes associated are projected in litres (L) instead of millilitres (ml).

Chapter 5 – Results

5.1 Biostratigraphy

5.1.1 Loss-on-ignition (LOI) results

The profile from the peat section is highly organic throughout the monolith. From the base of the monolith (39 cm) to the top (6 cm), the LOI percentage varies between 69% and 91% (Appendix 2), coherent with the description of the matrix as "peaty-rich organic, containing highly degraded organic remains". LOI was performed on each monolith's sub-sample (1-cm intervals, covering 6 cm to 39 cm below ground level) (Figure 5.1); however, only sub-samples #22 to #39 were integrated into the Frequency diagram (Figure 24). The LOI results do not coincide with a relatively sharp lithological change in samples where charcoal was encountered. The subtle nature of this stratigraphic transition is suggestive of a stable-organic deposit. Furthermore, it is important to stress that most of the winter houses at the archaeological site of Kivalekh were southwest of and higher than the sampling location, therefore erosion or transport through meltwater may have occurred, which could partly explain the highly organic nature of the matrix. However, there is no visual evidence for this.

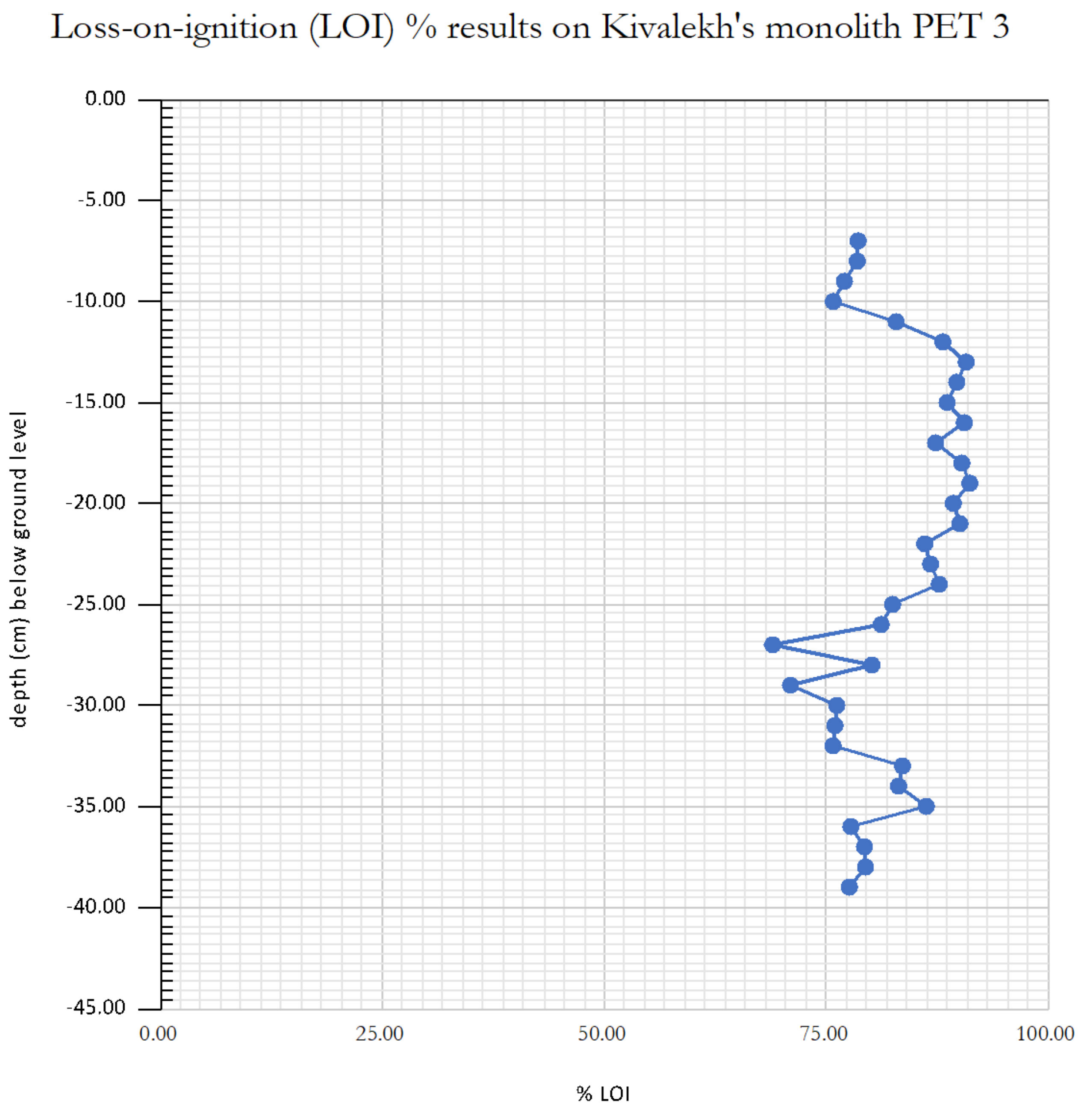


Figure 5.1 - Loss-on-ignition (LOI) % on Kivalekh's monolith whole sequence. This represent a highly organic matrix throughout the monolith.

5.1.2 Macroscopic charcoal

Charcoal analysis results are presented in Table 5.1. The highest concentration of charcoal is found in sample #33, between 38 and 39 cm depth. However, between 36 and 38 cm, a modest number of charcoal remains were quantified, decreasing in concentration above 35 cm depth. Most of the remains were highly fragmented (<0.5 mm or 500 μm), with only a few (3) measuring >2.0 mm (200 μm). Charcoal fragments of <0.5 mm in sediment samples tend to be of local origin because of the difficulty of their transport (Ohlson & Tryterud 2000). Accordingly, the charcoal found in the matrix is likely a residue of human activities that took place at Kivalekh itself (further discussed in the following chapter).

Sample #	**Depth (cm)**	**Vol (ml)**	**<0.5 mm**	**0.5-1.0 mm**	**1.0-1.5 mm**	**1.5-2.0 mm**	**>2.0 mm**
29	34-35	7	0	0	0	0	0
30	35-36	7	0	0	0	0	0
31	36-37	7	5	11	2	0	2
32	37-38	7	3	1	3	0	0
33	38-39	7	76	48	21	7	3

Table 5.1 – Charcoal concentration results (MNI) for sub samples #29 (34-35 cm) to #33 (38-39 cm).

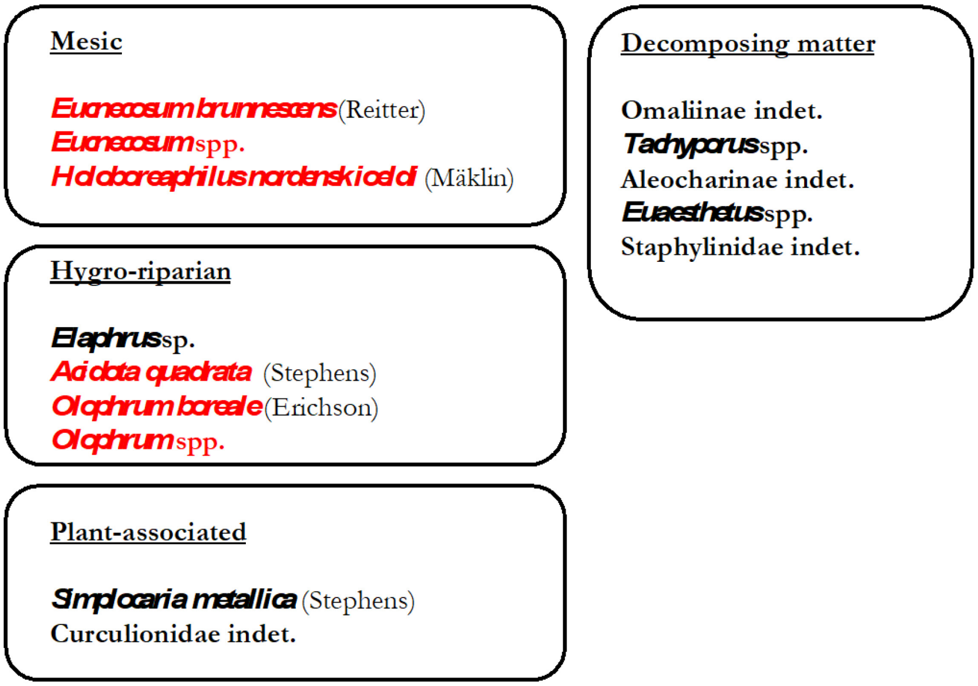
5.2 Insect macrofossils

Of 210 beetle parts recovered, a total of fourteen (14) different beetle taxa were identified in the samples analyzed (Appendix 3, 4). This includes five (5) taxa identified to species plus nine (9) other taxa identified to lower taxonomic levels (e.g., tribe, family, genus, or subgenus). Rove beetles (Staphylinidae family) dominate the assemblage, which also contains other families: Carabidae (ground beetles), Byrrhidae (pill beetles), and Curculionidae (weevils). Some Coleoptera were not sufficiently well-preserved; therefore, they did not allow a species, genus, or family level identification. In these cases, they were nevertheless quantified, with a mention indetermined (i.e., *indet.*).

All of the specimens identified are Holarctic in distribution, which refers to the biogeographic region that includes the northern parts of both the so-called 'Old' (Palearctic) and 'New' (Nearctic) worlds. However, one Byrrhidae (*Simplocaria metallica* [Stephens]) recovered from the assemblage is considered adventive (i.e., introduced) in North America, according to Bousquet et al. (2013).

5.2.1 Ecological groupings of taxa

Reconstructing past climatic conditions and human-environment interactions on the basis of ecological information is directly derived from the beetle remains preserved in the archaeology (Forbes et al. 2015). Therefore, as one aim of this project was to reconstruct the palaeoenvironmental conditions at Kivalekh, we must pay special attention to the species micro-habitat preferences in order to evaluate local ecological conditions and how they may have changed through the peat sequence. To facilitate this, each identified taxon has been classified into an ecological group (Figure 5.2). The "Mesic" group contains taxa that are typical of tundra habitats. This also includes the shrub tundra habitat and moderately moist areas of the open tundra. That category groups rove beetle members from the genus *Eucnecosum* spp., and *Holoboreaphilus nordenskioeldi* (Mäklin). As for the group "Hygro-riparian", it includes beetles that prefer wetter habitats, such as the banks of rivers, streams, lakes, or ponds. This category includes a Carabidae belonging to the genus *Elaphrus* sp. and other Staphylinidae (rove-beetles) from the genus *Acidota* spp. and *Olophrum* spp. The "Plant-associated" group includes taxa that feed directly on plants (Curculionidae). Finally, the larger group "In decomposing matter" includes most of the Staphylinidae identified in the assemblage, such as the ones from the subfamily Omaliinae, and the genus *Tachyporus* spp., alongside aleocharines (Aleocharinae indet.) and *Euaesthetus* spp. It also regroups the other rove beetles that could not be identified further than their superfamily (Staphylinidae indet.), which are included there because they share the same ecological requirements and feed primarily on organic matter in decomposition (Coiffait 1984).



Mesic

Eucnecosum brunnescens (Reitter)
Eucnecosum **spp.**
Holoboreaphilus nordenskioeldi (Mäklin)

Hygro-riparian

Elaphrus **sp.**
Acidota quadrata (Stephens)
Olophrum boreale (Erichson)
Olophrum **spp.**

Plant-associated

Simplocaria metallica (Stephens)
Curculionidae indet.

Decomposing matter

Omaliinae indet.
Tachyporus **spp.**
Aleocharinae indet.
Euaesthetus **spp.**
Staphylinidae indet.

Figure 5.2 – Groupings of identified taxa according to their ecology and habitat. Taxa in bold red font are those that belongs to mesic and riparian (macro-) habitat groups, but which are known to be associated with microhabitats in decomposing organic matter (such as leaf litter and debris on house floors) that are common on archaeological sites (Bousquet et al. 2013; Forbes & Sikes 2018).

Taxa associated with "In decomposing matter" are the most abundant in this study (Figure 5.3). About a third of the species identified have been associated with the "Mesic" group, typical of wet tundra found on the northern coast of Labrador.

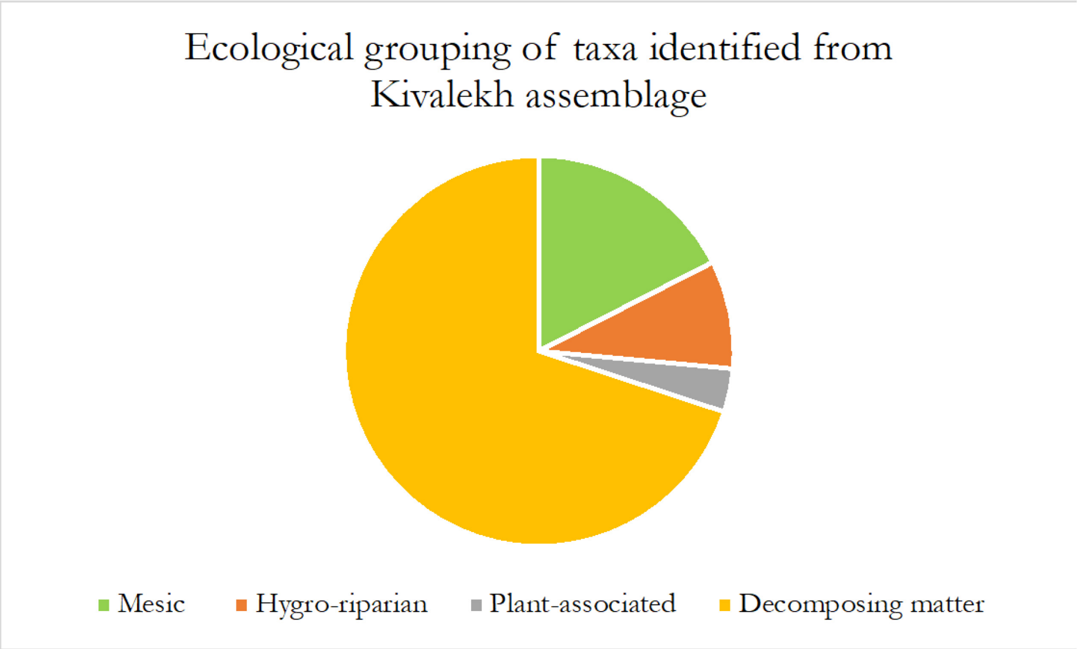


Figure 5.3 – Pie chart illustrating the proportion of beetles (MNI) associated with each ecological grouping identified from Kivalekh. Taxa associated with "In decomposing matter" are the most represented in this study.

The second most important category refers to the "Mesic" group. These taxa are found in tundra environments. However, they appear to exploit niches associated with decomposing organic matter as well (e.g., leaf litter, floor debris, and rotting wood) (Forbes & Sikes 2018) (Figure 5.4). We can therefore consider the 'mesic' tundra as their macrohabitat but decaying organic matter as their microhabitat. This distinction – between macro and microhabitat - is directly relevant to archaeological contexts, however, it can be complicated to translate this into archaeoentomological interpretations. As this research aims to produce a high-resolution chronology and to reconstruct the ecological conditions (human-environment interactions) over time in Kivalekh's landscape through a consideration of the activities and practices undertaken at the site, it can be argued that a species' microhabitat preference (for instance, decaying vegetation) may be more important to consider than its macrohabitat. As discussed in chapter two, human presence within the environment has been shown to generate an abundance of nutrient-rich habitats, which is ‘unmatched’ in natural settings (Forbes et al. 2014; Forbes et al. 2017; Forbes & Sikes 2018). This is because subfossil insects recovered directly from archaeological sites (such as from middens or floors) are typically dominated by mold-feeders and predators in decomposing vegetation, many of which are known to occupy similar niches in the natural environment (again, such as forest litter, bird nests, beaver dams, burrows, and tree hollows) (Kenward & Allison 1994; Forbes & Sikes 2018). This is readily observed for permanent or seasonal settlements associated with hunter-fisher-gatherers, which are usually very much dominated by taxa such as *Aleocharinae* indet. *Eucnecosum* spp., and *Euaesthetus* spp., even though results of modern pitfall trap surveys may not capture such insects in particularly high numbers (Forbes et al. 2017). Considering these parameters, it is likely that tundra species that are known to inhabit decomposing matter in natural settings were, therefore, able to colonize the nutrient-rich niches available as a result of human activity in the past (as schematically depicted in Figure 2.5) (Forbes & Sikes 2018).

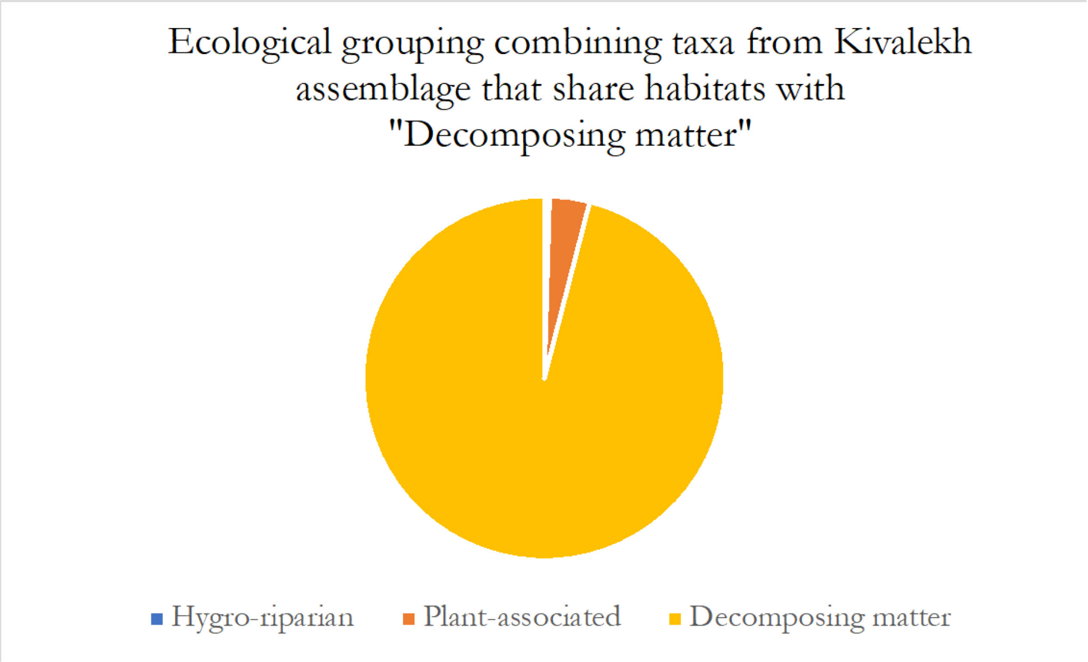


Figure 5.4 – Pie chart illustrating the proportion of beetles (MNI) associated with each ecological grouping identified from Kivalekh, but using an alternate classification, where all taxa which can be considered as having decomposing matter as their microhabitat (e.g., those in red font in Figure 19) are grouped together.

5.2.2 New locality record for Labrador

Notably, this dataset includes the first known record for two Omaliinae species in Labrador: *Holoboreaphilus nordenskioeldi* (Mäklin) and *Olophrum boreale* (Paykull). Both are Holarctic in distribution (Figure 5.5) but have never been collected before in Labrador. This illustrated well the problem mentioned before about the relative paucity of ecological and locality data for beetle's species in northern geographic areas, something which this study begins to address.

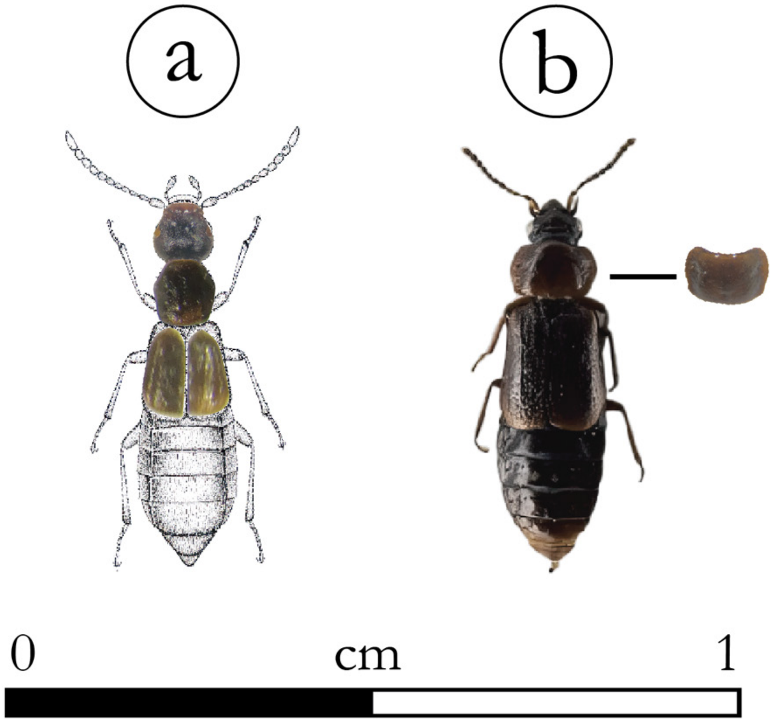


Figure 5.5 – New locality records for Labrador: a) the Omaliinae *Holoboreaphilus nordenskioeldi* (Mäklin), for which heads, pronota, and elytra have been identified in the Kivalekh fossil assemblage (drawing underneath by Campbell 1978); and b) *Olophrum boreale* (Paykull) photograph of a complete specimen

from Staphyliniformia world catalog database (GBIF 2022), with a photograph from one of the pronota identified by the author.

5.3 Stratigraphic diagram

Radiocarbon dating results are presented in Table 4.3 (previous chapter) and based on these, interpolated ages (AD) for Kivalekh's monolith have been inserted into the Frequency diagram (Figure 5.7). All the dates fall within the last seven centuries and have broad errors, owing to the unfavourable shape of the radiocarbon calibration curve for that period. The data are conformable (i.e., they get older with depth), thus there is no reason to suspect they are in any way inaccurate. Age-depth modelling (Figure 5.6) was conducted, and there is no evidence for a hiatus. The two samples analyzed (from bottom to top) are estimated to date from the mid-15th century to early 17th century AD and from the end of the 17th century to the beginning of the 20th century. The Frequency diagram presented below (Figure 5.7) presents the results of the proxies analyzed for this research, organized in a way that facilitates their comparison across the stratigraphic profile (through time). Palaeoenvironmental assemblage zones (KIV-1 and KIV-2) have been suggested using CONISS (Grimm 1987), based on changes in the Coleoptera record

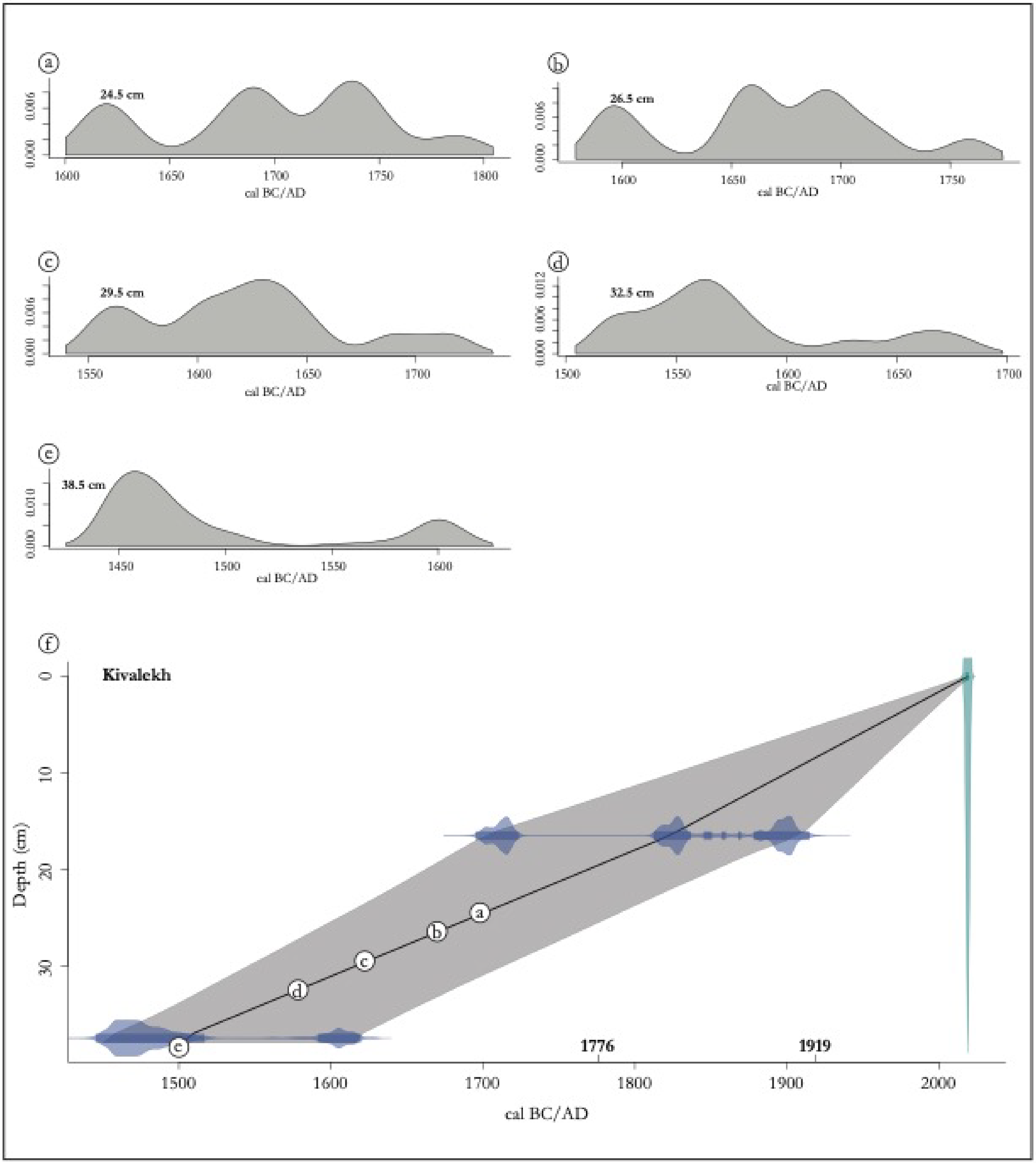


Figure 5.6 – Graph illustrating posterior density estimates of the age of the events and their various depths for the Kivalekh profile using Clam. The shaded grey area in the model (f) indicates the age-depth model based on the two radiocarbon dates with a smoothed spline fitted to the data. Dates in

bold on the *x* axis indicate Kivalekh's important events recorded in the archives, respectively, the establishment of Okak Mission site by the Moravian missionaries, and its abandonment (Curtis et al. 2006; Taylor 1974). Their incorporation in the chronology shows that they occurred *after* the ecological footprint (or KIV-1) obtained in Kivalekh's samples.

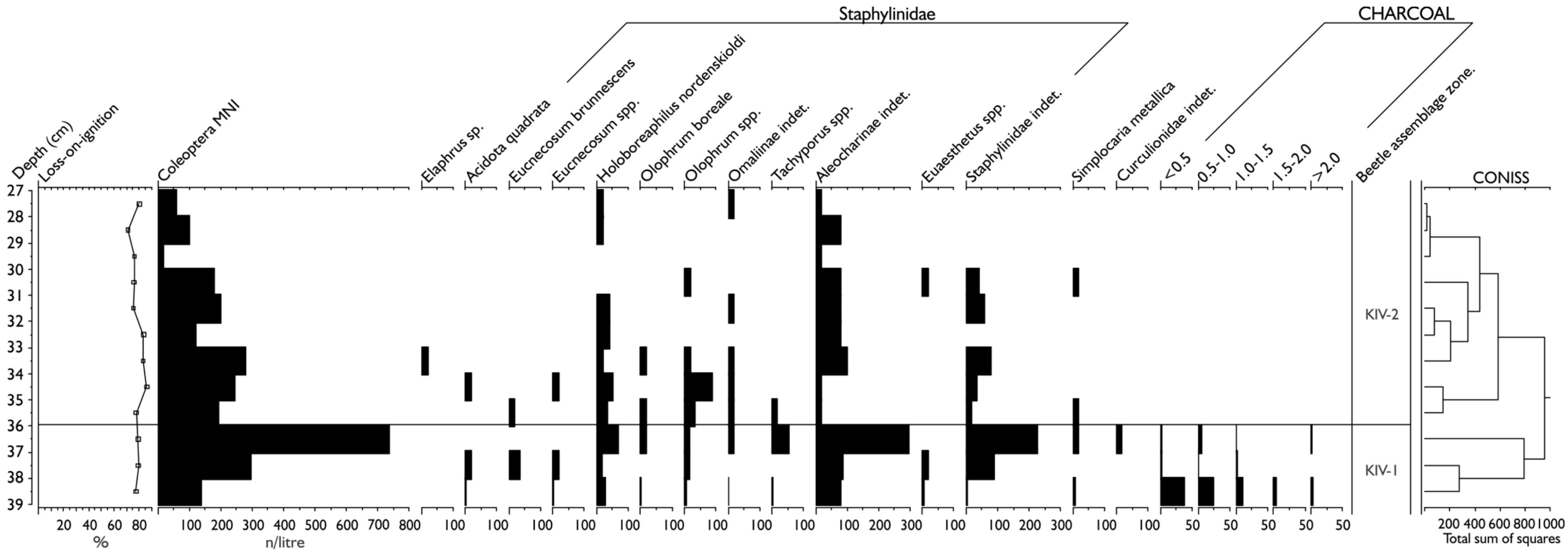


Figure 5.7 – Frequency diagram (or summary stratigraphic diagram) for the Kivalekh profile displaying loss-on-ignition (LOI), identified Coleoptera classified in taxonomic order, and charcoal data displayed as macroscopic charcoal concentrations and counts of macroscopic charcoal fragments per size class. Also displayed are the beetle assemblage zones (KIV-1 and KIV-2). This biostratigraphic diagram was undertaken using CONISS following square root transformation of percentage data to define different zones of activity. This diagram was constructed by Dr. Paul Ledger. * Note that the data illustrated into the diagram were adjusted to account for different volumes analyzed.

Chapter 6 – Discussion

6.1 Is the ecological footprint of hunter-fisher-gatherers evident?

Kivalekh's profile shows ecological patterns in terms of proxies throughout the monolith: changes in the beetle data, complemented with LOI and macroscopic charcoal data, occur in the sequence. To help make sense of this data, CONISS has been a valuable tool, as it allows us to read the frequency diagram as divided into two main zones: KIV-1 and KIV-2. Here, these two zones are suggested to be two different, succeeding events. For that reason, they will be described and interpreted separately.

KIV-1 [mid 15h century to early 17th century]

Between 39-36 cm, macroscopic charcoal is the most abundant, decreasing and disappearing gradually when transitioning to KIV-2. It is between 39-37 cm that the signal is the most evident. As seen in Chapter 2, hunter-fisher-gatherer's use of wood has been observed in the palaeoecological record (e.g., in peat profiles) as well as on archaeological sites. Its presence here in the lower part of the sequence can be interpreted as associated with the presence of humans in Kivalekh's landscape, as studies show that macroscopic charcoal will not be transported far from its initial source (Birks 2002). Archaeologically, charcoal helps indicate fire-related activities at the local scale. Therefore, the presence of charcoal fragment in the Kivalekh samples could have derived from domestic activities occurring in the winter village, such as cooking, heating, and smoking meat and fish (Oswalt 1992; Scott & Damblon 2010), rather than natural fire (the latter would present generally larger fragments (up to about 2 mm) in the samples).

Regarding Kivalekh's insect data, there is a gradual increase in beetle concentration from 39 cm depth below ground level (bgl), to 37 cm bgl. It is between 38-36 cm bgl that the biodiversity (MNI) increased significantly. KIV-1 assemblage includes: *Acidota* sp. *quadrata* (Stephens), *Eucnecosum* sp. *brunnescens* (Reitter), *Holoboreaphilus nordenskioeldi*, (Mäklin), *Olophrum* sp. *boreale* (Erichson), *Tachyporus* spp. (Gravenhorst), *Aleocharinae* spp. (Fleming), *Euaesthetus* spp., (Gravenhorst), one Byrrhidae *Simplocaria metallica* (Sturm), one Carabidae *Elaphrus* sp. (Fabricius), and finally, one Curculionidae indet. Among these taxa, Staphylinidae (rove beetles) dominate in KIV-1. Coherent with other studies, species within that family are often found on archaeological sites as the family as a whole tend to be associated with decaying organic matter, and therefore is often found in domestic waste and associated human disturbances (e.g., Böcher & Fredskild 1993; Dussault et al. 2016; Forbes & Sikes 2018; Forbes et al. 2015, 2017). As demonstrated in Chapter five, the Ecological groupings suggest that many species belong to more than one ecological group, making the insect communities associated with decomposing matter more abundant, while other habitats indicated by the surrounding environment are absent in the assemblage. Most beetles recovered from archaeological deposits are associated with decomposing matter, meaning they would invade in the early stage of decomposition, contributing to breaking down organic matter and releasing nutrients into the ecosystems. As seen throughout this thesis, evidence shows that anthropogenic activities are responsible for creating this surplus of organic matter in the environment, supporting an increased presence of beetles in these same environment (e.g., Kenward 1975, 1976, 1982, 1997; Hall & Kenward 1982). When a site is abandoned, on the other hand, and when the organic matter has broken down, the conditions are less favourable for beetles' proliferation, resulting in an observed decrease in biodiversity. The ecological information associated with the species identified must be cautiously interpreted, alongside their occurrence in the assemblage. The occurrence of a specific taxon does indeed provide new temporal-locality data for that taxon, though we must be careful to interpret the ecological significance of a *single* taxon found in our samples. Studies of modern insect assemblages (e.g., Carrott & Kenward 2001; Forbes & Sikes 2018; Kenward 1976, 1982) have demonstrated that there are a few common errors when interpreting archaeological insect assemblage. For instance, we must consider the transportation of these insects and their capacity (or incapacity) to fly. This is why understanding the "background fauna" is essential. Thus, Kivalekh is coherent with other archaeoentomological research, supported by a proliferation of insects associated with decomposing matter.

The beetle data combined with macroscopic charcoal results, likely result from the human presence within Kivalekh's landscape. The higher concentration of beetles associated with organic matters is likely a consequence of disturbances involving discard of organic material associated with various activities occurring on site. The charcoal, on the other hand, is probably derived from the use of wood in domestic fires nearby. However, because it was not possible to sample below 40 cm (due to the presence of a rock at the sampling location, and the fact that this was roughly where permafrost started to occur), the beginning of this signal for the presence of hunter-fisher-gatherers' groups at the site is unknown at present. It likely remains in the permafrost below.

The patterns described above should be understood as the manifestation of a broader ecological phenomena, namely niche construction processes. LOI and macroscopic charcoal analysis are tools and methods that helped me document the biostratigraphy. These, combined with matrix descriptions (e.g., occurrence in % of *Sphagnum* spp. moss and *Montia fontana* in the subsamples), serve to illuminate how hunter-fisher-gatherers have modified their local environment, and thus affected local beetle communities. As discussed in Chapter 2, nitrophilous plants such as, *Montia fontana* are common in Arctic and sub-Arctic habitations sites (e.g., Blondeau & Roy 2004), a phenomenon that is linked with nutrient-enrichment of a specific area. In that manner, niche construction involves metabolic activities such as those described in Figure 6, often resulting in inputs of nutrients into soils, disturbing the "natural environment". These processes of ecosystem modification (or niche construction) mean that organisms such as plants, fungi, spores, diatoms, and beetles influence each other, relocate in space, and modify their (micro)environment (Laland & O'Brien 2010; Odling-Smee et al. 2013). This is visible in Kivalekh's palaeoecological assemblage, drawing general patterns coherent with other research work conducted in similar contexts. It therefore represents convincing evidence that the presence of hunter-fisher-gatherers in this area of northern Labrador has been captured.

KIV-2 [mid 17th century to mid 18th century]

The transition between KIV-1 and KIV-2 is based primarily on a sharp decrease in beetle biodiversity at 36cm below the ground level, and the disappearance of macroscopic charcoal remains in the samples from this depth up to the top. The lithology of the matrix remains highly organic (~ <80%), and the results of the LOI did not show any significant fluctuations throughout the sequence that could help explain the change between the two zones. The most pronounced palaeoenvironmental shift at Kivalekh occurs at 36 cm (at the boundary between KIV-1 and KIV-2, as depicted in the diagram, Figure 24). As macroscopic charcoal proved to be a reliable proxy to locate human activity in Arctic and Subarctic contexts, a sharp decrease (or rather, a sudden disappearance) within the sequence likely reflects a hiatus of occupation or the abandonment of Kivalekh. However, the extent to which subsequent palaeoenvironmental change indicates human activity or natural environmental processes is uncertain. Different scenarios could help explain the sharp decrease of beetle remains and the disappearance of macroscopic charcoal between KIV-1 and KIV-2. For instance, a periodic occupation of the site or its abandonment could be reflected in the palaeoecological sequence at Kivalekh. Taphonomic processes should also be considered. For example, erosion caused by snow-melting from the winter village, could have potentially contributed to erasing or transporting the ecological signal we wish to examine. Palaeoenvironmental studies have shown that it is complicated to ascertain changes in the nature of occupation in the environment. For that reason, separating natural phenomena from anthropogenic disturbances is challenging. To overcome such challenge, it is important to establish as high-resolution a chronology as possible, as this helps correlate the palaeoenvironmental data with the archaeology. Here, the transition between KIV-1 and KIV-2 occurs earlier (sometime between the mid-15th to the mid-17th centuries) than Kivalekh's (known) Inuit occupation (late 18th to early 20th centuries). Consequently, the ecological footprint captured between 38 and 27 cm bgl captured a period not well-documented in the record to date as is interpreted to be older than the Inuit occupation at Kivalekh (specifically associated with the structures of the site). The hiatus observed in KIV-2 could be associated with the abandonment of the site, or with a less intensive occupation, at least until archives confirmed that the site was occupied during the winter of AD 1772 by groups of Labrador Inuit (Taylor & Taylor 1977). Using ethnographic documents and archives helps correlate the dataset analyzed for this research and supports the hypothesis that the ecological footprint (here, KIV-1) is indeed older than the dates associated with the structures of the site itself.

6.2 Palaeoecology as an alternative dating method: limits & challenges

One of the main objectives of this research was to test whether palaeoecological data recovered from Kivalekh's peat profile may help improve our understanding of the chronology of occupation at the site by integrating the results of the multi-proxy analysis with radiocarbon dates. As I was able to produce a chronology for the context studied, I was, however, unable to associate it with a specific cultural group. Indeed, establishing and identifying the presence of hunter-fisher-gatherers in the palaeoecological record is shown to be relatively straightforward – using the literature presented previously and the results of this study. However, dating the point at which evidence for human activity starts and ceases in the palaeoecological record from Kivalekh is more complicated, explained by the asynchronous changes interpreted as key indicators of human activity (Ledger 2018). A few technical challenges have been encountered on site, preventing us from dating the beginning of the occupation of the site captured in the monolith. Since the lowermost depth of the monolith already captured the signal for human occupation as demonstrated above, the beginning is, on the other hand, missing as it was impossible to obtain a sample from peat having accumulated prior to human occupation, due to the presence of permafrost at 40 cm and below the ground level. As for the end of occupation in the sequence analyzed, it is likely that the disappearance of macroscopic charcoal from 35 cm depth onwards (KIV-2) reflects the abandonment of the site or a shift towards a less intensive occupation (e.g., a seasonal one). The abandonment dates derived from the palaeoecological sequence seem to provide an older age estimate than the archaeology, suggesting the following: (1) the sod-houses near the sampling location were abandoned earlier than previously thought. This is likely induced by the sensitivity of the ecological footprint for human disturbances in the palaeoecological record. Indeed, if domestic activities moved spatially, the strength of the palaeoecological signal may have been affected as well; 2) the ecological footprint is older than the sod-houses themselves, mirroring a Palaeo-Inuit occupation (see Table 1) instead of being associated with the winter village itself, occupied by Labrador Inuit groups later in the 18th century; or (3) taphonomic factors are responsible for erasing of moving the ecological signal in Kivalekh's landscape.

To establish which of the above scenarios is most likely, we must go back to the key elements presented previously in this thesis to understand the chronology obtained via radiocarbon measurements. As shown in Chapter 2, evidence shows that Inuit arrived in northern Labrador sometime in the mid-fifteen century following the Medieval Warm Period (MWP), dating approximately from AD 950 to 1250. Following the MWP, the Little Ice Age (LIA), extending from AD 1450 to AD 1850, is approximately attested to be the coolest time of the whole Holocene in the Arctic (Finkelstein 2016). As the role of climate change has long been debated in the interpretation of the archaeological record, there has been renewed interest in exploring the role of paleoclimate and environmental change in explaining cultural shifts. Explained by the extreme nature of the climate in the Arctic, one must consider the paleoclimate record of the area studied to understand its broad environmental and cultural dynamics over time (Finkelstein 2016; Meese et al. 1994; Rockman & Maase 2017). As shown by the radiocarbon dating results, the bottom of the monolith dates to the mid-15th to early 17th centuries, corresponding to the end of the MWP and the beginning of the LIA. The end of the sequence analyzed in this thesis corresponds to 27-28 cm depth (sample #22) and is dated between the mid-16th to mid-18th century, which by including the climatic data, would encompass the later LIA.

In addition to the climatic data, archaeological research conducted in the region revealed important information which could help interpret Kivalekh's dataset. In the literature, Palaeo-Inuit sites throughout the Arctic (from Siberia to Greenland) were relatively small and comprised only a few dwellings (Dyke et al. 2011; Friesen 2016). Archaeological evidence suggest that earlier Palaeo-Inuit sites were also occupied relatively briefly, hence the paucity of artifacts and ecofacts associated with these groups. This pattern is explained by the unpredictable fluctuation of resource distributions, consistent with high-level of residential mobility (Friesen 2016:677). Later, around the 15th century, studies (Kaplan 1983; Roy et al. 2015; Woollett 2007) have shown that winter settlement patterns changed in northern Labrador, resulting in the adoption of communal houses by groups of ancestral Inuit. Indeed, up to the 17th century, in outer bays and on exposed outer islands off the northern Labrador coast, semi-sedentary winter settlements with sod houses and temporary camps with tent rings or multi-tiered stone structures were characteristic. Locational analyses based on extensive regional surveys and land-use patterns have demonstrated that the sites around Okak Bay are located amidst the seasonal migration routes of marine mammals – in the proximity of the sina, or polynyas, which are habitats for a wide variety of birds and sea mammals usually present from fall to spring (Kaplan 1983:218; Woollett 2007:72). Archaeological evidence shows that these groups had a marine-based economy usually centered on relatively permanent winter settlements, depending on the seasonal pulse of resources requiring logistical mobility (Woollett 2007). This is coherent with the settlement pattern associated with the winter village at Kivalekh, since the houses found in Kivalekh were large (up to 70 m^2), suggesting multi-family dwellings – or communal houses. Since structures associated with Palaeo-Inuit occupations were often sparse and relatively small, leaving only a few traces in the environment, understanding human-environment relationships with these groups is more complicated. Though we know that at Kivalekh, beneath the cultural layers associated with the Inuit occupation, Dorset material has been encountered, and subsequent surveys at the site revealed traces of Groswater and Pre-Dorset occupations (e.g., Curtis et al. 2006; Cox

2003; Fitzhugh et al. 1978,1980; Hood 1997; Onalik 2006; Sutton et al. 1981; Kaplan 1984). Despite the fact that the occupation associated with the winter village at Kivalekh is attested to be the most important in terms of the density of cultural material and structures, the site has a much older sequence of occupation. These prior occupations could have been captured palaeoecologically through my samples, stressing the importance of Kivalekh, which mirrors the whole cultural history of the region (Curtis et al. 2006:18). Knowing its archaeological importance, the ecological footprint (KIV-1) captured in Kivalekh's samples, predate the age of the Inuit occupation (associated with the structures of the site), supporting that the ecological footprint could be associated with one of these Palaeo-Inuit groups mentioned above, or perhaps refined chronologies of the ancestral- and Inuit occupations at the site. More palaeoecological and archaeoentomological analysis need to be done to being able to attribute a palaeoecological signal to a specific cultural group. For that reason, the ecological footprint captured herein is associated with hunter-fisher-gatherers as a general cultural group.

6.3 New beetle locality records for Labrador

The arthropod fauna of Labrador has been less studied than in southern provinces, as northern regions are challenging to access due to their remoteness from urban centers. Topography and hydrology are physical factors that make it challenging. Labrador is no exception to this statement. Indeed, Labrador's northern coast is composed of many rocky islands, where the tundra environment is dissected by rivers, ponds, streams, and bogs characterized by discontinuous permafrost as found in other sub-Arctic contexts (cf., Forbes & Sikes 2018). Knowing the study locale's insect fauna is imperative to successfully identify disarticulated sub-fossil remains and derive ecological information from them (cf. Elias 2010, Forbes et al. 2016; Forbes & Sikes 2018).

Accordingly, this study produced new entomological records that provide information about the local native fauna over a few hundred years. Subfossils from two species belonging to the family Staphylinidae (rove beetles), namely *Holoboreaphilus nordenskioeldi* (Mäklin) and *Olophrum boreale* (Paykull), were identified in the Kivalekh assemblage, allowing them to be recorded in Labrador for the first time. Although the fact that they are Holarctic in distribution (Bousquet et al. 2013) suggests they have probably been established in northern Labrador for a long time, they nevertheless produced a chronological range of AD mid-15th to early 17th century, *terminus ante quem* for their presence in Labrador. It is also likely that these species still live in northern Labrador, but perhaps have never been collected there simply due to a geographical sampling bias.

Using insect macrofossils to help document how past humans have impacted the landscape will help understand the ecological requirements and processes of the modern fauna found in northern contexts, which are more and more affected by climate change. Although existing research has documented a general trend regarding species from the south migrating north as the climate warms, there is a lot that remains unknown due to a lack of knowledge of the native fauna in northern areas (IPCC 2013; for further reflections, see Froyd & Willis 2008; Jeffers et al. 2015). Accordingly, this research successfully achieved its third objective by providing another opportunity to enrich entomological (and archaeoentomological) databases (c.f., BugCEP [Buckland 2007, 2009]), providing us with new locality data points that extend the known records of these northern beetle species in space and in time. More archaeoentomological analysis in Kivalekh (and elsewhere in the North Atlantic), ideally combining palaeoecological sampling and modern entomological surveys, would be beneficial to clarify the significance of these beetles for the reconstruction of past hunter-fisher-gatherers' lifeways and biodiversity change.

So, establishing what constitutes an ecological footprint for hunter-fisher-gatherers, and more specifically in this case, for Labrador Inuit, is complex and far from straightforward, as is supported by similar studies (e.g., Bhiry et al. 2016; Ledger 2018; Renouf 2003; Renouf et al. 2009; Roy et al. 2015). As demonstrated throughout this thesis, Arctic forager societies were, and still are today, intrinsically complex and diverse, therefore interacting within the environment in a multitude of ways, and potentially in unique fashions for different cultural groups. Despite these challenges and numerous pitfalls, it proved possible to identify human presence through palaeoecological methods within Kivalekh's landscape as resulting from ecological feedback and niche construction processes rather than being able to identify and target specific domestic activities (with the exception perhaps of the presence of charcoal in association with the use of woodland resources). Although the ecological signal captured could not be associated with a particular cultural group (i.e., Labrador Inuit) or with a specific occupation, it nevertheless showed convincing evidence of being attributed with hunter-fisher-gatherers as a general group. Kivalekh offered another great opportunity to investigate its cultural history through time by examining past human-environment relationships within Labrador's Indigenous landscapes.

Chapter 7 – Conclusion

Capturing and defining an ecological footprint for hunter-fisher-gatherers in the palaeoecological record is, in many ways, a novel research topic and therefore one that has only just begun in North America. In order to better understand the ecological interactions between foragers' activities and their environments in northern Labrador, I have conducted an analysis of beetle subfossils from a peat sequence close to the archaeological site of Kivalekh. I have combined other methods to document its biostratigraphy, such as macroscopic charcoal analysis and loss-on-ignition.

This study was able to successfully capture a strong signal on the periphery of the archaeological features and define an "ecological footprint" (KIV-1) associated with hunter-fisher-gatherers broadly – without, however, being able to associate it with a specific cultural group. The footprint is characterized by an increase in the number of beetles, specifically rove beetles (family Staphylinidae), which likely found ideal niches in the nutrient-enriched habitats generated as a result of human activity, combined with charcoal and a general decrease of *Montia fontana* in the matrix. These proxies, when combined, are interpreted as being associated with anthropic activities in the area.

The project also generated new insights about the cultural chronology of a site located in the Arctic. For the sequence analyzed, the earliest date ranges (AD mid-15th to early 17th centuries) captures an occupation that appears to be pioneered by the Labrador Inuit in the 15th century, which pre-date the archaeology associated with that occupation of the winter settlement at Kivalekh that is dated to be later in the 18th century. As for KIV-2 (dated from the late 17th to mid-18th centuries) is interpreted as a hiatus of occupation, or a change in anthropogenic activities in the area. The absence of charcoal in the upper layers, paired with a sharp decrease in beetles (MNI) numbers, and an increase of *Montia fontana,* are all indicators of a hiatus of occupation or decrease of activity in the immediate vicinity of the sampling location. The general pattern observed through Kivalekh's peat monolith offers a novel way to improve our understanding of the chronology of the recent past of hunter-fisher-gatherers in North America. One thing is certain though: the methodology employed in this research, by combining proxies with chronological modelling of radiocarbon dates helps to engage with chronological debates in the Arctic. Improving chronological resolution for such contexts only introduces new forms of evidence into these debates. Only then are we able to "map and relate" (Bayliss 2009) palaeoecological records, explain environmental and cultural changes among sites or contexts studied. Precise dates or refined chronologies only become meaningful when they are compared between locations, between different events, and between different cultures in the past.

Finally, this study has extended the temporal and spatial record of two beetle species, which were identified as subfossil that represent the first records of these taxa in Labrador. This includes the two rove beetles *Holoboreaphilus nordenskioeldi* and *Olophrum boreale*, which we now know were present in Labrador from at least the mid-15th century. This demonstrates how archaeoentomology can enrich entomological databases and distribution maps in ways that can help provide a greater time-depth to our understanding of the biogeography of the native fauna in Holarctic contexts.

The approach employed here also highlighted some methodological considerations. For example, the sampling location is crucial as samples taken from too close to human activity areas may be affected by the domestic activities occurring on site, influencing the impacts we wish to examine. Furthermore, it is important that the samples of peat are not affected by archaeological excavations, disturbing the original soil stratigraphy. Peat monoliths should be recovered around visible or known structures to ensure that the anthropogenic disturbances are observable through time, captured in the depth of the soil monolith. In addition, small volumes (indubitably paired with thinness) are crucial to ensure precise and accurate chronological resolution. The work produced herein is no exception in this regard. Lastly, it is crucial to understand insect communities and their capacity to exploit new habitats resulting from human activity on a specific site. It is only then that we are capable of establishing their significance in archaeological contexts. However, as previously shown, there are many gaps in the entomological knowledge regarding insect habitat characteristics. The habitat (or range of habitats) of most insects commonly encountered in urban situations or ancient death assemblages is remarkably poorly understood. Consequently, little is known regarding insects' behaviour and life histories, except perhaps for species having economic importance (Carrott & Kenward 2001). The only way we can improve our interpretations is to produce more data, hence the importance of archaeoentomology as a sub-discipline.

7.1 Recommendations for future research

More palaeoecological sequences like the one produced here must be documented to draw a robust picture of human-environment interactions and refine the chronology of occupations at Kivalekh. This study was successful, however, there were also some limitations. Firstly, to overcome the difficulty of digging where the permafrost is encountered in the field, alternative tools and adapted equipment is needed to help with digging in frozen ground. A hydraulic ripper, rotary cutter or a small version of a hydraulic hammer could help get through the permafrost. Heating the ground of a designated area is also an alternative solution. For instance, if a trench is open and dug down to the permafrost level, letting the section open with a plastic tarp (or thick plastic sheeting), the permafrost might thaw faster over a couple of hours or days, or get softer so hand tools can work well. These are ideas for potential solutions to problems encountered in the field, though experiments are necessary to see if they are doable.

As for the laboratory, it would be interesting to study the rest of Kivalekh's monolith sequence (27 cm onwards) to see what it looks like in terms of ecological footprint, specifically during the historical period associated with the presence of Moravians in the area (historical census records compiled by Moravian missionaries seem to indicate that sod houses at Kivalekh were occupied virtually between 1776 and 1807). Therefore, more questions arise from this research, such as "would the ecological signal differ from the one captured in the bottom of the monolith with the presence of Europeans in the picture?" or, "Would the signal from Palaeo-Inuit and Inuit differ from one another?" As I suspect it would, it offers another useful opportunity to incorporate the rest of the sequence into a future doctoral project. Only then would we be able to test this hypothesis by comparing the ecological signals between groups over time. Moreover, several spring, summer, and fall tent camp occupations were also noted in the Moravian census, extending well into the more recent period (19th century), giving another opportunity to compare other palaeoecological signals with summer occupations at the site.

Re-examining the archaeological site of Kivalekh using palaeoecological methods like the ones used herein could help to gain a broader perspective on the character and scale of Inuit landscape impact, especially considering its importance as the site has been occupied during a period of notable cultural change and environmental dynamism. Peat bogs surrounding Kivalekh's landscape have proven to be a precious biocultural archive, which are worth investigating further.

REFERENCES CITED

Alberti, B. (2016) Archaeologies of ontology. *Annual review of anthropology* 45(1): 163-179.

Alberti, B., Fowles, S, Holbraad, M., Marshall, Y., and Witmore, C. (2011) Worlds otherwise: Archaeology, anthropology, and ontological difference. *Current Anthropology* 52(6): 896-912.

Amorosi, T., Buckland, P.C., Dugmore, A., Ingimundarson, J.H., and McGovern, T.H. (1997) Raiding the landscape: Human impact in the Scandinavian North Atlantic. *Human Ecology* 25(3): 491-518.

Anderson, S.L. and Freeburg, A. (2014) High latitude coastal settlement patterns: Cape Krusenstern, Alaska. *Anthropology Faculty Publications and Presentations*, Paper 32.

Appelt, M., Damkjar, E., and Friesen, T.M. (2016) Late Dorset. In *The Oxford handbook of the prehistoric Arctic*. Friesen & Mason (eds)Oxford University Press, Oxford.

Arneborg, J. & Grønnow, B. (2006) Dynamics of northern societies. *National Museum*, Copenhagen, Demark.

Arnett, R.H., Jr. (2000) *American insects: A handbook of the insects of America north of Mexico*, 2nd ed. CRC Press, Boca Raton.

Arnett, R.H. & Thomas, M.C. (2001) *American Beetles, Volume 1: Archostemata, Myxophaga, Adephaga, Polyphaga: Staphyliniformia*. CRC Press, Boca Raton.

Arnett, R.H., Thomas, M.C., Skelley, P.E., Frank, J.H. (2002) *American Beetles, Volume 2: Scaracbaeoidea through Curculionidae*. CRC Press, Boca Raton.

Arnold, J.E. (1996) The archaeology of complex hunter-gatherers. *Journal of Archaeological method and theory* 3: 77-126.

Aronsson, K. (1994) Pollen evidence of Saami settlement and reindeer herding in the boreal forest of northernmost Sweden – An example of modern pollen rain studies as an aid in the interpretation of marginal human interference from fossil pollen data. *Review of Palaeobotany and palynology* 82(1-2): 37-45.

Ascough, P.L., Cook, G., Church, M., Dugmore, A.J., McGovern, T.H., Dunbar, E., Einarsson, A., Friðriksson, A. and Gestsdóttir, H. (2007) Reservoirs and radiocarbon 14 C dating problems in Mývatnssveit, Northern Iceland. *Radiocarbon* 49(2):1-15.

Ascough, P.L., Cook, G., Church, M., Dugmore, A.J., Perdikaris, S., Hastie, H., McGovern, T.H., Dunbar, E., Einarsson, A., Friðriksson, A. and Gestsdóttir, H. (2010) Temporal and spatial variations in freshwater 14C reservoir effects: Lake Mývatn, Northern Iceland. *Radiocarbon* 52(3): 1098-1112.

Atalay, S. (2006) Indigenous archaeology as decolonizing practice. *American Indian Quarterly* 30(3/4): 280-310.

Atalay, S. (2012) *Community-based archaeology: Research with, by, and for Indigenous and local communities*. University of California Press, Berkley, CA.

Bain, A. (2000a) *Uivak archaeoentomological analysis.* Report, Hunter College and Bowdoin College, Brunswick, ME.

Bain, A. (2000b) *Uivak archaeoentomological analysis 2*. Report on file in the office of Susan A. Kaplan, Bowdoin College, Brunswick, Maine.

Bain, A. (2001) U*ivak archaeoentomological – 2 analysis.* Report, Hunter College and Bowdoin College, Brunswick, ME.

Balée, W. (1999) *Introduction. In* advances in Historical Ecology. W. Balée (ed). Columbia University Press, New York, pp. 1-10.

Balée, W. (2006) The research program of Historical Ecology. *Annual Review of Anthropology* 35(1): 75-98.

Barbel, H., Todisco, D., and Bhiry, N. (2020) A geochemical investigation of an early Inuit semi-subterranean winter dwelling in a periglacial context. *Journal of Archaeological Science:* Reports 33: 1-16.

Barry, R.G., Arundale, W.H. Andrew, J.T., Bradley, R.S., and Nichols, H. (1997) Environmental change and cultural change in the eastern Canadian Arctic during the last 5000 years. *Arctic and Alpine Research* 9: 193-210.

Bayliss, A. (2009) Rolling out revolution: Using radiocarbon dating in archaeology. Radiocarbon 51(1): 123-147.

Beaudoin, M.A. (2013) A hybrid identity in a pluralistic 19th century colonial context. Historical Archaeology 47(2): 45-63.

Beaudoin, M.A. (2014) The process of hybridization among the Labrador Métis. In Rethinking colonial pasts through archaeology, Harrison, F.R., and Wilcox, M.V. (eds). Oxford University Press, Oxford, UK: 315-322.

Bernier, J.-F. (2014) Géoarchaeology de la Rivière aux ossements (Saunitarlik), Kangiqsujuaq (Nunavik, Canada). *MSc thesis presented for Université Laval, Québec.*

Bhiry, N., Marguerie, D., and Lofthouse, S. (2016) Paleoenvironmental reconstruction and timeline of a Dorset-Thule settlement at Quaqtaq (Nunavik, Canada). *Arctic, Antarctic, and Alpine Research* 48(2): 293-313.

Billington, R.A. (1981) *Land of savagery, land of promise: The European image of the American frontier in the nineteenth century.* Norman: University of Oklahoma Press.

Bishop, R.R., Church, M.J., Dugmore, A.J., Koch-Madsen, C. and Møller, N.A. (2013) A charcoal-rich horizon at Ø69, Greenland: evidence for vegetation burning during the Norse landnám? *Journal of Archaeological Science* 40(11): 3890-3902.

Birks, H.H. (2002) *Plant macrofossils. In* Tracking environmental change using lake sediments, pp. 49-74, Springer.

Blaauw, M. (2010) Methods and code for 'classical' age-modelling of radiocarbon sequences. *Quaternary Geochronology* 5(5): 512-518.

Blaauw, M. & Christen, J.A. (2011) Flexible palaeoclimate age-depth models using an autoregressive gamma process. *Bayesian Analysis* 6:457-474.

Blondeau, M. & Roy, C. (2004) *Atlas of plants of the Nunavik village*. Sainte-Foy: Multimondes.

Böcher, J. (1988) The Coleoptera of Greenland. Meddelelser om Grønland, *Biosciences* 26. 100 pp.

Böcher, J. & Fredskild, B. (1993) Plant and arthropod remains from the Palaeo-Eskimo site on Qeqertasussuk, West Greenland. Meddelelser om Grønland, *Geoscience* 30. Copenhagen: Museum Tuscalanum Press.

Bousquet, Y., Bouchard, P., Davies, A.E., and Sikes, D. (2013) *Checklist of Beetles* (Coleoptera) *of Canada and Alaska*. Second Edition. Pensoft, Sofia-Moscow.

Bottema, S., Entjes-Nielborg, G., and vanZeist, W. (eds) (1990) *Man's role in the shaping of the Eastern Mediterranean landscape*. Rotterdam: Balkema.

Braje, T.J., Leppard, T.P., Fitzpatrick, S.M., and Erlandson, J.M. (2017) Archaeology, historical ecology and anthropogenic island ecosystems. *Environmental conservation* 44(3): 286-297.

Brown, J.H. (1995) Macroecology. Chicago: University of Chicago Press.

Brice-Bennett, C. (1977) *Our footprints are everywhere: Inuit land-use and occupancy in Labrador*. Nain, Newfoundland and Labrador: Labrador Inuit Association.

Brice-Bennett, C. (ed) (1981) *Two opinions: Inuit and Moravian missionaries in Labrador*. M.A. thesis, Department of Anthropology, Memorial University of Newfoundland.

Briggs, J.M., Spielmann, K.A., Schaafsma, H., Kintigh, K.W., Kruse, M., Morehouse, K., and Schollmeyer, K. (2006) Why ecology needs archaeologists and archaeology needs ecologists. *The Ecological Society of America* 4(4): 180-188.

Bronk Ramsey, C. (2009) Bayesian analysis of radiocarbon dates. *Radiocarbon* 51(1): 337-360.

Buckland, P.I. (2007) The development and implementation of software for palaeoenvironmental and palaeoclimatological research: The Bugs Coleopteran Ecology Package (BugsCEP). *Archaeology and Environment* 23. Umeå: University of Umeå, Department of Archaeology and Sami Studies.

Buckland, P.I. (2009) The Bugs Coleopteran Ecology Package (BugsCEP). The development and implementation of a software for palaeoenvironmental and palaeoclimatological research. VDM Verlag Dr. Mūller Aktiengesellschaft & Co, Saarbrüken.

Buckland, P.C. Edwards, K.J., Panagiotakopulu, E. and Schofield, J.E. (2009) Palaeoecological and historical evidence for manuring and irrigation at Gardar (Igaliku) Norse eastern settlement, Greenland. *Holocene* 19: 105-116.

Budgell, A. (2018) *We all expected to die: Spanish influenza in Labrador 1918-1919*. ISER Books.

Burchell, M., Stopp, M.P., Cannon, A., and Hallmann, N. (2018) Determining seasonality of mussel collection from an early historic Inuit site, Labrador, Canada: Comparing thin-sections with high-resolution stable oxygen isotope analysis. *Journal of Archaeological Science: Report*s 21:1215-1224.

Butler, D. (2011) Exploring soilscapes and places inside Labrador Inuit winter dwellings. *Canadian Journal of Archaeology* 35(1): 55-85.

Butler, D.H. & Dawson, P.C. (2013) Accessing hunter-gatherer site structures using Fourier transform infrared spectroscopy: Applications at a Taltheilei settlement in the Canadian sub-Arctic. *Journal of Archaeological Science* 40(4): 1731-1742.

Butler, D.H., Lopez-Forment, A., and Dawson, P.C. (2018) Multi-element and biomolecular analysis of soils as a mean of sustainable site structure research on hunter-gatherer sites: A case study from the Canadian Arctic. *Journal of Archaeological Science: Reports* 17: 973-991.

Butzer, K.W. (1982) Archaeology as human ecology: Methods & theory for a contextual approach. Cambridge: Cambridge University Press.

Butzer, K.W. (1996) Ecology in the long view: Settlement, agrosystem strategies, and ecological performance. Journal of Field Archaeology 23(2): 141-150.

Campbell, J.M. (1978) A revision of the North American Omaliinae (Coleoptera: Staphylinidae) 1. The Genera Haida Keen, Pseudohaida Hatch, and Eudectoides new genus. 2. The tribe Coryphiini. *Memoirs of the Entomological Society of Canada* 106: 1-87.

Campbell, J.M. (1979) A revision of the genus Tachyporus (Gravenhorst) (Coleoptera: Staphylinidae) of North and Central America. *Memoirs of the Entomological Society of Canada* 109: 1-95.

Campbell, J.M. (1982) A revision of the North American Omaliinae (Coleoptera: Staphylinidae) 3. The genus *Acidota* (Stephens). *The Canadian Entomologist* 114: 1003-1029.

Campbell, J.M. (1983) A revision of the North American Omaliinae (Coleoptera: Staphylinidae) The genus *Olophrum* (Erichson). *The Canadian Entomologist* 115: 577-622.

Campbell, J.M. (1984) A revision of the North American Omaliinae (Coleoptera: Staphylinidae) The genera *Arpedium* (Erichson) and *Eucnecosum* (Reitter). *The Canadian Entomologist* 116: 487-527.

Campbell, J.M. (1991) A revision of the genera *Mycetoporus* (Mannerheim) and *Ischnosoma* (Stephens) (Coleoptera: Staphylinidae: Tachyporinae) of North and Central America. *Memoirs of the Entomological Society of Canada* 156.

Carlson, I. (2022) The genesis of Labrador's Indigenous landscapes: A review of research approaches and current knowledge. *MA thesis*, Memorial University of Newfoundland, St. John's, NL.

Carrott, J. & Kenward, H. (2001) Species associations among insect remains from urban archaeological deposits and their significance in reconstructing the past human environment. *Journal of Archaeological Science* 28: 887-905.

Chase-Dunn, C.K. (1997) *Rise and demise: Comparing World-systems*. Westview Press.

Chase-Dunn, C.K & Mann, K.M. (1998) *The Wintu and their neighbors: A very small World-System in northern California*. Tucson: University of Arizona Press.

Chase-Dunn, C.K & Hall, T.D. (2011) Comparing World-Systems to explain social evolution. In *World System history: The social science of long-term change*. Robert A. Denemark, Jonathan Friedman, Barry K. Gills, and George Modelski (eds), London: Routledge, pp. 85-111.

Chase-Dunn, C., Kardulias, N., and Hall, T.D. (2011) World-Systems analysis and archaeology: Continuing the dialogue. Journal of archaeological research 19(3): 233-279.

Chase, J.M. & Leibold, M.A. (2003) *Ecological Niches: Linking classical and contemporary approaches*. Chicago: The University of Chicago Press.

Chernov, Y.I., Makarova, O.L., Penev, L.D., and Khruleva, O.A. (2014) Beetles (Insecta, Coleoptera) in the Arctic fauna: Communication 1. Faunal composition. *Entomological Review* 94(4): 438-478.

Coiffait, H. (1984) *Coléoptères Staphylinidae de la région paléarctique occidentale.* Volume 1-5, Pemberley Books, CNRS, Toulouse.

Coope, G.R. & Osborne, P.J. (1967) Report on the coleopterous fauna of the Roman well at Barnsley Park, Gloucestershire. *Transactions of the Bristol and Gloucestershire Archaeological Society* 86: 84-87.

Couture, A. (2014) Configuration de l'espace domestique des Inuit historiques du nord du Labrador pendant la période de contacts : Approches archéologiques, micromorphologique et géochimique. *Doctoral dissertation*, Université Laval, Québec, QC.

Couture, A., Bhiry, N., Monette, Y., and Woollett, J. (2016) A geochemical analysis of the 18th – century Inuit communal house floors in northern Labrador. *Journal of Archaeological Science: Report* 6:71-81.

Cox, S.L. (1977) Prehistoric settlement and culture change. *Ph.D. thesis presented for Harvard University*, Cambridge, Massachusetts, May 1977.

Cox, S.L. (1978) Paleo-Eskimo occupations of the North Labrador coast. *Arctic Anthropology* 15(2).

Cox, S.L. (2003) Palaeoeskimo structures in the Okak region of Labrador. *Études/Inuit/Studies* 27(1-2):417-433.

Cox, S.L. & Spiess, A. (1980) Dorset settlement and subsistence in northern Labrador. *Arctic* 33(3).

Crann, C.A., Museli, S., St-Jean, G., Zhao, X., Clark, I.D., and Kieser, W.E. (2017) First status report on radiocarbon sample preparation at the A.E. Lalonde AMS Laboratory (Ottawa, Canada). *Radiocarbon* 59(3): 695-704.

Crumley, C.L. (1994) *Historical Ecology: A multidimensional ecological orientation: Cultural knowledge and changing landscapes*. School of American Research Press, Santa Fee: 1-16.

Crumley, C.L. (2021) Historical Ecology: A robust bridge between archaeology and ecology. *Sustainability* 13(15): 8210.

Curtis, J., Baikie, G., Merkuratsuk, J., Onalik, L., Mitchell, K., Ford, B., Jarause, W., Fay, A., and Webb, F.J. (2006) Okak National historic site: Cultural landscape site visit.

Damkjar, E.R. (2005) Late Dorset longhouses: A look inside. In *Contributions to the study of the Dorset Palaeo-Eskimos*, edited by Patricia D. Sutherland, pp. 147-165. National Museum of Man Mercury Series, Archaeological Survey of Canada Papers no. 167. Canadian Museum of Civilization, Gatineau, Québec.

D'Antonio, C. & Thomsen, M. (2004) Ecological resistance in theory and practice. *Weed Technology* 18:1572-1577.

D'Arrigo, R., Buckley, B., Kaplan, S.A., and Woollett, J. (2003) Interannual to multidecadal modes of Labrador climate variability inferred from tree-rings. *Climate Dynamics* 20: 219-228.

Deans, A.R. & Sandall, E.L. (2018) PVA is not OK? A short review of adhesives for insect specimens. *Entomological Collections Network annual meeting* (Vancouver, BC, Canada).

Delmas, V. (2018) Indigenous traces on Basque sites: Direct contact or later reoccupation? *Newfoundland and Labrador Studies* 33(1): 20-62.

Denevan, W.M. (1992) The 'Pristine Myth' revisited. *Geographical review* 101(4): 575-591.

Desrosiers, P.M. (2009) À l'origine du Dorsétien : Apport de la technologie lithique des sites GhGk-63 et Tayara (KbFk-7) au Nunavik. *Unpublished PhD dissertation*, Université Paris 1, Panthéon-Sorbonne, Paris.

Desrosiers, P.M., Gendron, D., and Rahmani, N. (2006) Harpoon head seriation and the Dorset phases: About the Tayara sliced and the other types. In *Dynamics of Northern societies: proceedings of the SILA-NABO Conference on Arctic and North Atlantic archaeology*, Arneborg, J. and Grønnow, B. (eds). Pp. 131-144. Studies in Archaeology and History no. 10. Greenland Research Centre, Danish National Museum, Copenhagen.

Derry, A.M., Kevan, P.G. and Rowley, S.D.M. (1999) Soil nutrients and vegetation characteristics of a Dorset/Thule site in Canadian Arctic. *Arctic* 52(2): 204-213.

Dickason, O.P. (1997) *The myth of the savage and the beginnings of French colonialism in the Americas*. Edmonton: The University of Alberta Press.

Douglas, M.S.V., Smol, J.P., Savelle, J.M., Blais, J.M., and Schindler, D.W. (2004) Prehistoric Inuit whalers affected Arctic freshwater ecosystems. *Proceedings of the National Academy of Sciences* 101(6): 1613-1617.

Dugmore, A.J., Keller, C., and McGovern, T.H. (2007a) Reflections on climate change, trade, and the contrasting fates of human settlements in the North Atlantic islands. *Arctic Anthropology* 44(1):12-37.

Dugmore, A.J., Douglas, M., Borthwick, M., Church, J., Dawson, A., Edwards, K.J., Keller, C., Mayewski, P., McGovern, T.H., Mairs, K.A. and Sveinbjarnardóttir, G. (2007b) The role of climate in settlement and landscape change in the North Atlantic islands: An assessment of cumulative deviations in high-resolution proxy climate records. *Human Ecology* 35:169-178.

Dugmore, A.J., Keller, C., McGovern, T.H., Casely, A.F., and Smiarowski, K. (2009) Norse Greenland settlement and limits to adaptation. *In* W.N. Adger, I. Lorenzoni, K.L. O'Brien (eds) *Adapting to climate change: threshold, values, governance*. Cambridge University Press: 96-114.

Dugmore, A.J., McGovern, T.H., Streeter, R., Koch-Madsen, C., Smiarowski, K. and Keller, C. (2013) *Clumsy solutions' and 'elegant failures': Lessons on climate change adaptation from the settlement of the North Atlantic islands,* chapter 38. *In* A changing environment for human security: transformative approaches to research, policy, and action. L. Sygna, K. O'Brien and J. Wolfe (eds). Routledge UK London.

Dussault, F., Bell, T.J., and Grimes, V. (2016) Archaeoentomological perspectives on Dorset occupations in Newfoundland. *Arctic* 69(1): 1-15.

Dyke, A.S., Savelle, J.M., and Johnson, D.S. (2011) Palaeoeskimo demography and Holocene sea-level history, Gulf of Boothia, Arctic Canada, *Arctic* 64: 151-168.

Echo-Hawk, R.C. (2000) Ancient history in the New World: Integrating oral traditions and the archaeological record in deep time. *American Antiquity* 65(2): 267-290.

Egelkrault, D., Aronsson, K., Allard, A., Åkerholm, M., Stark, S., and Olofsson, J. (2018) Multiple feedbacks contribute to a centennial legacy of reindeer on tundra vegetation. *Ecosystems* 21(8): 1545-1563.

Elias, S.A. (1992) Late Quaternary beetle faunas of southwestern Alaska: evidence of a refugium for mesic and hygrophilous species. *Arctic and Alpine Research* 24(2): 133-144.

Elias, S.A. (1994) *Quaternary insects and their environments*. Washington, D.C.: Smithsonian Institution Press.

Elias, S.A. (2000) Late Pleistocene climates of Beringia, based on analysis of fossil beetles. *Quaternary Research* 53: 229-235.

Elias, S.A. (2010) *Advances in Quaternary Entomology*. Elsevier, Amsterdam.

Fenger-Nielsen, R., Hollesen, J., Matthiesen, H., Andersen, E.A., Westergaard-Nielsen, A., Harmsen, H., Michelsen, A., and Elberling, B. (2019) Footprints from the past: The influences of past human activities on vegetation and soil across five archaeological sites in Greenland. *Science of the Total Environment* 654: 895-905.

Fitzhugh, W.W. (1978) Maritime Archaic cultures of the central and northern Labrador coast. *Arctic Anthropology* 15(2):61-95.

Fitzhugh, W.W. (1980) A review of Palaeo-Eskimo culture history in southern Québec-Labrador and Newfoundland. *Études/Inuit/Studies* 4(1-2): 21-31.

Fitzhugh, W.W. (1981) *Smithsonian archaeological surveys, central and northern Labrador* (1980). *In* Archaeology in Newfoundland and Labrador, Thomson, J.S., and Ransom, B. (eds) pp. 26-47. St. John's: Provincial Archaeology Office.

Fitzhugh, W.W. (2009) On the track of the Thule culture from Bering Strait to East Greenland. *Proceedings of the SILA Conference "The Thule culture – New perspectives in Inuit prehistory".* Copenhagen, Denmark.

Forbes, B.C. (1996) Plant communities of archaeological sites, abandoned dwellings, and trampled tundra in the eastern Canadian Arctic: A multivariate analysis. *Arctic* 49(2): 141-154.

Forbes, V. & Milek, K.B. (2014) Insects, activity areas and turf buildings' interiors: An ethno-archaeoentomological case study from 19th to early 20th century Þverá, Northeast-Iceland. *Quaternary International* 341: 195-215.

Forbes, V., Dussault, F., and Bain, A. (2014) Archaeoentomological research in the North Atlantic: past, present, and future. *Journal of the North Atlantic* 26: 1-24.

Forbes, V., Britton, K., and Knecht, R. (2015) Preliminary archaeoentomological analyses of permafrost-preserved cultural layers form the pre-contact Yup'ik Eskimo site of Nunalleq, Alaska: Implications, potential and methodological considerations. *Environmental Archaeology* 20(2): 158-167.

Forbes, V., Dugmore, A.J., and Ólafsson, E. (2016) The life and death of barn beetles: faunas from manure and stored hay inside farm buildings in Northern Iceland. *Ecological Entomology* 41: 480-499.

Forbes, V., Dussault, F., Lalonde, O., and Bain, A. (2017) Coléoptères, poux et puces subfossiles provenant d'habitat de chasseurs-cueilleurs : l'apport des recherches archéoentomologiques dans le nord circumpolaire. *Recherches Amérindiennes au Québec*.

Forbes, V., & Sikes, D. (2018) A survey of beetles (Coleoptera) from the Tundra surrounding the Nunalleq archaeological site, Quinhagak, Southwestern Alaska. *Biodiversity Data Journal* 6: e22788.

Forbes, V., Ledger, P.M., Cretu, D., and Elias, S.A. (2020) A sub-centennial, Little Ice Age climate reconstruction using beetle subfossil data from Nunalleq, Southwestern Alaska. *Quaternary International* 549: 118-129.

Foster, D., Swanson, F., Aber, J., Burke, I., Brokaw, N., Tilman, D., and Knapp, A. (2003) The importance of land-use legacies to ecology and conservation. *BioScience* 53(1): 77-88.

Fredskild, B. (1988) Agriculture in a marginal area – South Greenland from the Norse *landnám* (985 A.D.) to the present (1985 A.D.). H.H. Birks, H.J.B. Birks, P.E. Kaland and E. Moe (eds). *In The cultural landscape – past, present, and future.* Cambridge University Press, Cambridge: 381-393.

Finkelstein, S.A. (2016) Reconstructing middle and late Holocene paleoclimates of the eastern Arctic and Greenland. In *The Oxford handbook of the prehistoric Arctic.* Oxford University Press, Oxford, pp. 653-671.

Friesen, T.M. (2007) Hearth rows, hierarchies, and Arctic hunter-gatherers: The construction of equality in the Late Dorset period. *World Archaeology* 39(2): 194-214.

Friesen, T.M. (2013) When worlds collide: Hunter-gatherer world-system change in the 19th century Canadian Arctic. University of Arizona Press

Friesen, T.M. (2015) On the naming of Arctic archaeological traditions: The case for Paleo-Inuit. *Arctic* 68(3): 3-4.

Friesen, T.M. & Mason, O.K. (2016) *The Oxford handbook of the prehistoric Arctic*. Oxford University Press, Oxford.

Frink, L. & Knudson, K.J. (2010) Using ethnoarchaeology and soils chemistry to examine fisheries on the Arctic Alaskan coast. *North American Archaeologists* 31(2): 221-247.

Froyd, C.A. & Willis, K.J. (2008) Emerging issues in biodiversity and conservation management: the need for a palaeoecological perspective. *Quaternary Science Reviews* 27: 1723-1732.

Global Biodiversity Information Facility (GBIF) (2022) *Olophrum boreale* (Paykull, 1792), URL: www.gbif.org/species/4444206, consulted 2022.

Guillemot, T., Bichet, V., Gauthier, E., Zocatelli, R., Massa, C., and Richard, H. (2016) Environmental responses of past and recent agropastoral activities on south Greenlandic ecosystems through molecular biomarkers. *Holocene* 26: 783-795.

Grimm, E.C. (1987) CONISS: A FORTRAN 77 program for stratigraphically constrained cluster analysis by the method of incremental sum of squares. *Computers & Geoscience* 13: 13-35.

Hardesty, D.L., & Fowler, D.D. (2001) *Archaeology and environmental changes. In* New Directions in archaeology and environment: Intersections. C.L. Crumley (ed), pp. 72-89. Walnut Creek, CA: AltaMira Press.

Harrault, L., Milek, K., Jardé, E., Jeanneau, L., Derrien, M., and Anderson, D.G. (2019) Faecal biomarkers can distinguish specific mammalian species in modern and past environments. *Plos One* 14(2): e0211119.

Hariston, N.G., Jr. (1995) Commentary. *Ecology* 76:1371.

Hartman, S., Ogilvie, A., Ingimundarsson, J.H., Dugmore, A.J., Hambrecht, G., McGovern, T.H. (2017) Integrated environmental humanities: medieval Iceland, Greenland, and the new human condition. *Global and Planetary change* 156: 123-139.

Hegmon, M., Arneborg, J., Dugmore, A.J., Hambrecht, G., Ingram, S., Kintigh, K., McGovern, T.H., Nelson, M.C., Peeples, M.A., Simpson, I., Spielmann, K., Streeter, R., and Vésteinsson, O. (2013) The human experiences of social changes and continuity: The southwest and northwest Atlantic in 'interesting times' ca. 1300, *In Climates of change: the shifting environments of archaeology*, S. Lacey, C. Tremain and M. Sawyer (eds). Proceedings of the 44th Annual Chacmool Conference, University of Calgary.

Hicks, S. (1993) Pollen evidence of localized impact on the vegetation of northernmost Finland by hunter-gatherers. *Vegetation History and Archaeobotany* 2(3): 137-144.

Holly Jr, D.H. (2013) *History in the making: The archaeology of the eastern subarctic.* AltaMira Press, Plymouth, United Kingdom.

Hood, B. (1997) *Archaeological surveys between the Nain and Hebron regions, Northern Labrador. In* Archaeology in Newfoundland and Labrador (1997) Nelmes, K. (ed), pp. 1-17, St. John's: Provincial Archaeology Office.

Hood, B.C. (2008) *Towards an Archaeology of the Nain region, Labrador*. Arctic Studies Center, National Museum of Natural History, Smithsonian Institution, Washington, D.C.

Hrdlicka, A. (1937) Man and plants in Alaska. *Science* 86(2242): 559-560.

Ingold, T. (1992) Foraging for data, camping with theories: Hunter-gatherers and nomadic pastoralists in archaeology and anthropology. *Antiquity* 66(252): 790-803.

IPCC (Intergovernmental Panel on Climate Change) (2013) Climate change 2013: The physical science basis exit EPA disclaimer. Contributions of working group 1. In T.F. Stocker, D. Qui, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xias, V. Bex and P.M. Midgley (eds). Contribution of working group 1 to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge.

Jackson, R., Arneborg, J., Dugmore, A., Koch Madsen, C., McGovern, T.H., Smiarowski, K. and Streeter, R. (2018) Disequilibrium, adaptation, and the Norse settlement of Greenland. *Human Ecology* 46: 665-684.

Jeffers, E.S., Nogué, S. and Willis, K.J. (2015) The role of palaeoecological records in assessing ecosystems services. *Quaternary Science Reviews* 112: 17-32.

Jensen, A.M. (2017) *Threatened heritage and community archaeology on Alaska's North Slope*. *In* Public archaeology and climate change. Oxbow Books, Oxford.

Johnson, P.J. (1991) Taxonomic notes, new records, and a key to the adults of North American Byrrhidae (Coleoptera). *Proceedings to the Entomological Society of Washington* 93(2): 322-332.

Kamerling, I.M., Schofield, J.E., Edwards, K.J., and Aronsson, K. (2017) High-resolution palynology reveals the land use history of a Sami Renvall in northern Sweden. *Vegetation History and Archaeobotany* 26(4): 369-388.

Kaplan, S. (1983) Economic and social change in Labrador Neo-Eskimo culture. *Ph.D. thesis presented for Bryn Mawr College.*

Kaplan, S.A. (2009) From forested bays to tundra covered passes: Transformation of the Labrador landscape. *Conference "The Thule culture – New perspectives in Inuit Prehistory". Papers in Honour of Hans Christian Gulløv*, edited by Bjarne Grønnow, pp. 119-128. Studies in Archaeology and History, no. 15. Greenland Research Centre, Danish National Museum, Copenhagen.

Kaplan, S.A. (2012) Labrador Inuit ingenuity and resourcefulness: Adapting to a complex environmental, social, and spiritual environment. In *Settlement, Subsistence, and Change among the Labrador Inuit: The Nunatsiavummiut Experience*, edited by David C. Natcher, Lawrence Felt, and Andrea Proctor, pp. 15-42. University of Manitoba Press, Winnipeg.

Kaplan, S.A. & Woollett, J.M. (2000) Challenges and choices: Exploring the interplay of climate, history, and culture on Canada's Labrador coast. *Arctic, Antarctic, and Alpine Research* 32(3): 351-359.

Kaplan, S.A. & Woollett, J.M. (2016) Labrador Inuit: Thriving on the periphery of the Inuit world. In *The Oxford handbook of the prehistoric Arctic.* Friesen & Mason (eds)Oxford University Press, Oxford.

Kareiva, P., Tallis, H., Ricketts, T.H., Daily, G.C., and Polasky, S. (2011) *Natural Capital: Theory and practice of mapping ecosystem services.* Oxford: Oxford University Press.

Kenward, H.K. (1975) Pitfalls in the environmental interpretation of insect death assemblages. *Journal of Archaeological Science* 2: 85-94.

Kenward, H.K. (1976) Reconstructing ancient ecological conditions from insect remains: some problems and an experimental approach. *Ecological Entomology* 1: 7-17.

Kenward, H.K. (1982) Insect communities and death assemblages, past and present. In Environmental archaeology in the urban contexts, A.R. Hall & H.K. Kenward (eds)., London.

Kenward, H.K. (1997) Synanthropic decomposer insects and the size, remoteness, and longevity of archaeological occupation sites: Applying concepts from biogeography to past 'Island' of human occupation. *Studies in Quaternary Entomology* 5: 135-151.

Kenward, H.K. & Allison, E. (1994) Rural origins of the urban insect fauna. In *Urban-rural connexions: Perspectives from environmental archaeology*, Kenward H.K. and Allison E. (eds) Oxbow Books, Oxford.

Kenward, H.K., Hall, A.R., and Jones, A.K.G. (1980) A tested set of techniques for the extraction of plant and animal macrofossils from waterlogged archaeological deposits. *Science and Archaeology* 22: 3-15.

Klimaszewski, J., Savard, K., Pelletier, G. and Webster, R. (2008) Species review of the genus Gnypeta Thomson from Canada, Alaska, and Greenland (Coleoptera, Staphylinidae, Aleocharinae): systematics, bionomics, and distributions. *ZooKeys* 2:11-84.

Klimaszewski, J., Langor, D.W., Bourdon, C., Gilbert, A., and Labrecque, M. (2016) Two new species and new provincial records of Aleocharinae rove beetles from Newfoundland and Labrador, Canada (Coleoptera, Staphylinidae, Aleocharinae). *ZooKeys* 593: 49-89.

Knudson, K.J. & Frink, L. (2010) Ethnoarchaeological analysis of Arctic fish processing: Chemical characterization of soils on Nelson Island, Alaska. *Journal of Archaeological Science* 37(4): 769-783.

Laland, K.N. & O'Brien, M.J. (2010) Niche construction theory and archaeology. *Journal of Archaeological Methods and Theory* 17: 303-322.

Larochelle, A. & Larivière, M.C. (2003) *A natural history of the ground beetles* (Coleoptera Carabidae*) of America north of Mexico*. Pensoft, Sofia-Moscow.

Larson, D.J., Alarie, Y., and Roughley, R.E. (2000) *Predaceous diving beetles* (Coleoptera: Dystiscidae) *of the Nearctic region, with emphasis on the fauna of Canada and Alaska*. NRN Research Press, Ottawa.

Ledger, P.M. (2018) Are circumpolar hunter-gatherers visible in the palaeoenvironmental record? Pollen analytical evidence from Nunalleq, Southwestern Alaska. *The Holocene* 28: 415-426.

Ledger, P.M. & Forbes, V. (2020) Paleoenvironmental analysis from Nunalleq, Alaska illustrates a novel means to date Pre-Inuit and Inuit archaeology. *Arctic anthropology* 56(2): 39-51.

Ledger, P.M., Edwards, K.J. and Schofield, E.J. (2013) Shieling activity in the Norse Eastern settlement: Palaeoenvironment of the 'Mountain farm'. Vatnahverfi, Greenland. *The Holocene* 26(6): 810-822.

Ledger, P.M., Edwards, K.J., Schofield, J.E. (2014a) Vatnahverfi: A green and pleasant land? Palaeoecological reconstructions of environmental and land use change. *Journal of the North Atlantic* 6: 29-46.

Ledger, P.M., Edwards, K.J., Schofield, J.E. (2014b) A multiple profile approach to the palynological reconstruction of Norse landscapes in Greenland's Eastern settlement. *Quaternary Research* 82(1): 22-37.

Ledger, P.M., Forbes, V., Masson-MacLean, E. and Knetch, R.A. (2016) Dating and digging stratified archaeology in circumpolar North America: A view from Nunalleq, southwestern Alaska. *Arctic* 69(4): 378-390.

Ledger, P.M., Masson-MacLean, E., Forbes, V. and Hillerdal, C. (2018) Three generations under one roof? Bayesian modelling of radiocarbon data from Nunalleq, Yukon-Kuskokwim delta Alaska. *American Antiquity*: 1-20.

Ledger, P.M., Girdland-Flink, L. and Forbes, V. (2019) New horizons at L'Anse aux Meadows. *PNAS* 116(31): 15341-15343.

Ledger, P.M., Mayoral, A., Berger, J.-F., Peiry, J.-L., and Miras, Y. (2020) Five millennia of human-environment interactions reconstructed from pedosedimentary archives of the Lac du Puy wetland (Corent, Fr.) Catena (Giessen) 195: 104908.

Lemus-Lauzon, I., Bhiry, N., Arseneault, D., Woollett, J., and Delwaide, A. (2018) Tree-ring evidence of changes in the sub-Arctic forest cover linked to human disturbances in northern Labrador (Canada). *Écoscience* 25(2): 135-151.

Lennartsson, T., Westin, A., Crumley, C.L. (2017) *Issues and concepts in historical ecology. In* The past and future of landscapes and regions. Cambridge University Press, Cambridge.

Lewontin, R.C. (1983) *Gene, organism, and environment. In* D.S. Bendall (ed), Evolution from molecules to men, pp. 273-285. Cambridge, UK: Cambridge University Press.

Lindroth, C.H. (1961) *The ground beetles (Carabidae, excl.* Cicindellidae*) of Canada and Alaska*, Part 2. Opuscula Entomologica Supplementum 20: 1-200.

Lindroth, C.H. (1963a) *The faunal history of Newfoundland illustrated by carabid beetles*. Opuscula Entomologica Supplementum 23: 1-112.

Lindroth, C.H. (1963b) *The ground beetles (Carabidae, excl.* Cicindellidae*) of Canada and Alaska, Part 3*. Opuscula Entomologica Supplementum 24: 201-408.

Lindroth, C.H. (1966) *The ground beetles (Carabidae, excl.* Cicindellidae*) of Canada and Alaska, Part 4*. Opuscula Entomologica Supplementum 29: 409-648.

Lindroth, C.H. (1968) *The ground beetles (Carabidae, excl.* Cicindellidae*) of Canada and Alaska, Part 5*. Opuscula Entomologica Supplementum 33: 649-944.

Lindroth, C.H. (1969a) *The ground beetles (Carabidae, excl.* Cicindellidae*) of Canada and Alaska, Part 1*. Opuscula Entomologica Supplementum 35: 1-48.

Lindroth, C.H. (1969b) *The ground beetles (Carabidae, excl.* Cicindellidae*) of Canada and Alaska, Part 6*. Opuscula Entomologica Supplementum 34: 945-1192.

Lohse, G.A., Klimaszewski, J., and Smetana, A. (1990) Revision of Arctic Aleocharinae of North America (Coleoptera: Staphylinidae). *The Coleopterists Bulletin* 44(2): 212-202.

Loring, S. (1992) Princes and princesses or ragged fame: Innu archaeology and ethnohistory in Labrador. *Doctoral dissertation*, University of Massachusetts, Amherst, MA.

Loring, S., McCaffrey, M.T., Armitage, P., and Ashini, D. (2003) The archaeology and ethnohistory of a drowned land: Innu nation research along the former Michikamats Lake shore in Nitassinan (interior Labrador). *Archaeology of Eastern North America* 31: 45-72.

Lozny, L.R. (2006) *Landscapes under pressure: Theory and practice of cultural heritage research and preservation*. Springer, New York.

Lozny, L.R. & McGovern, T.H. (eds) (2019) *Global perspectives on long-term community resource management*. Springer, Co Bern Switzerland.

Lutz, H.J. (1951) The concentration of certain chemical elements in the soils of Alaskan archaeological sites. *American Journal of Science* 249(12): 925-928.

MacEachern, A. & Turkel, W.J. (eds) (2009) *Method & meaning in Canadian environmental history*. Nelson Education. The University of Western Ontario. 336 p.

Majka, C.G., Anderson, R.S., McAlpine, D.F., and Webster, R.P. (2007) The weevils (Coleoptera: Curculionoidea) of the Maritime Provinces of Canada, I: New records from New Brunswick. *The Canadian Entomologist* 139(3): 378-396.

Mann, C.C. (2005) *1491: new revelations of the Americas before Columbus*. New York, NY: Knopf Press.

Marsh, G.P. (1864) *Man and nature*. Lowenthal, D. (ed) (1965) Harvard University Press.

Matthews, J.V. (1983) A method for comparison of northern fossil insect assemblages. *Géographie physique et Quaternaire* 37(3): 297-306.

Mayewski, P.A., Meeker, L.D., Whitlow, S., Twickler, M.S., Morrison, M.C., Bloomfield, P., Bond, G.C., Alley, R.B., Gow, A.J., Grootes, P.M., Meese, D.A., Ram, M., Taylor, K.C., and Wumkes, W. (1994) Changes in the atmospheric circulation and ocean ice cover over the North Atlantic during the last 41, 000 years. *Science* 263 (5154): 1747-1751.

Maxwell, M.S. (1985) *Prehistory of Eastern Arctic.* Academic, Orlando, Florida.

McCartney, N.G. (1979) Effects of Thule Eskimo on soils and vegetation at Silumiut, N.W.T. *Thule Eskimo Culture*: 495-527.

McGhee, R. (2000) Radiocarbon dating and timing of the Thule migration. *In* Identities and cultural contacts in the Arctic. *Proceedings from a conference at the Danish National Museum, Copenhagen, November 20 to December 2, 1999.* M. Appelt., J. Berglund, and H.-C. Gulløv (eds). Copenhagen Danish Polar Center: 181-191.

McGovern, T.H. (2012) *Introduction: the long-term global human ecodynamics conference. In* Surviving sudden environmental change: lessons from archaeology. J. Cooper & P. Sheets (eds). University of Colorado Press, Boulder.

McGovern, T.H. (2014) *North Atlantic human ecodynamics research: Looking forward from the past. In* Long-term human ecodynamics in the North Atlantic: an archaeological study. R. Harrison & R. Maher (eds). Lexington Publishers, Lanham, Maryland.

McGovern, T.H. (2018a) What is it all for? Archaeology and global change research. Society for American archaeology president's forum, *SAA Archaeological Record*: 33-36.

McGovern, T.H. (2018b) Burning libraries: A community response. *Conservation and Management of Archaeological Sites* 20(4): 165-174.

McGovern, T.H., Vésteinsson, O., Friðriksson, A., Church, M., Lawson, I., Simpson, I.A., Einarsson, Á., Dugmore, A., Cook, G., Perdikaris, S., Edwards, K.J., Thomson, A.M., Adderley, W.P., Newton, A., Lucas, G., Edvardsson, R., Aldred, O. and Dunbar, E. (2007) Landscapes and settlement in Northern Iceland: Historical ecology of human impacts and climate fluctuation on the millennial scale. *American Anthropologist* 109(1): 27-51.

McGovern, T.H., Harrison, R. and Smiarowski, K. (2014) *Sorting sheep and goats in medieval Iceland and Greenland: Local subsistence or world system? In* Long-term human ecodynamics in the North Atlantic: An archaeological study. R. Harrison & R. Maher (eds). Lexington Publishers, Lanham, Maryland.

McManus, G.E. & Wood, C.H. (1991) *Atlas of Newfoundland and Labrador*. Breakwater, St. John's, NL.

Meese, D.A., Alley, R.B., Gow, A.J., Grootes, P., Mayewski, P.A., Ram, M., Taylor, K.C., Waddington, E.D., and Zeilinski, G. (1994) The accumulation record of the GISP2 core and an indicator of climate change throughout the Holocene. *Science* 266(5191): 1680-1682.

Michelutti, N., McCleary, K.M., Antoniades, D., Sutherland, P., Blais, J.M., Douglas, M.S.V., and Smol, J.P. (2013) Using paleolimnology to track the impacts of Early Arctic people on Freshwater ecosystems from southern Baffin Island, Nunavut. *Quaternary Science Reviews* 76: 82-95.

Mihoub, J.-B., Henle, K., Titeux, N., Brotons, L., Brummitt, N.A. and Schmeller, D.S. (2017) Setting temporal baselines for biodiversity: The limits of available monitoring data for capture the full impact of anthropogenic pressures. *Nature Scientific Reports* 7.

Millard, A.R. (2014) Conventions for Reporting Radiocarbon Determinations. *Radiocarbon* 56 (2): 555-559.

Moran, E.F. (2010) Environmental social science: Human-environment interactions and sustainability. Wiley-Blackwell publication, Oxford.

Moore, T.R. (1986) The spatial variability of soil properties and its application to archaeology. *The Canadian Geographer/Le Géographe Canadien* 30(1): 80-82.

Moore, T.R. & Denton, D. (1988) The role of soils in interpretation of archaeological sites in northern Québec. In *Conceptual issues in environmental archaeology,* edited by J.L. Bintliff, Donald, A. Davidson, and Eric G. Grant, pp. 25-37. University Press, Edinburgh, UK.

Murray, M.S. (1999) Local heroes. The long-term effects of short-term prosperity: An example from the Canadian Arctic. *World Archaeology* 30: 466-487.

Nelson, M.C. Ingram, S.E., Dugmore, A.J., Streeter, R., Peeples, M.A., McGovern, T.H., Hegmon, M., Arneborg, J., Kintigh, K.W., Brewington, S., Spielmann, K.A., Simpson, I.A., Strawhacker, C., Comeau, L.E.I., Torvinen, A., Koch-Madsen, C., Hambrecht, G., and Smiarowski, K. (2016) Climate challenges, vulnerabilities, and food security. *PNAS* 113(2): 298-303.

Nunatsiavut Government (2021) About Nunatsiavut Government. *Nunatsiavut Government.*

Nyyssönen, J., Salmi, A.-K., Madison, W. (2013) Towards a multiangled study of reindeer agency, overlapping environments, and human-animal relationships. *Arctic Anthropology* 50(2): 40-51.

Oberndorfer, E., Winters, N., Gear, C., Ljubicic, G., and Lundholm, J. (2017) Plants in a "sea of relationships": Networks of plants and fishing in Makkovik, Nunatsiavut (Labrador, Canada). *Journal of Ethnobiology* 37(3): 458-477.

Oberndorfer, E., Broomfield, T., Lundholm, J., and Ljubicic, G. (2020) Inuit cultural practices increase local-scale biodiversity and create novel vegetation communities in Nunatsiavut (Labrador, Canada). *Biodiversity and Conservation* 29(4): 1205-1240.

Odling-Smee, F.J., Feldman, M.W. and Laland, K.N. (2013) *Niche construction: The neglected process in Evolution* (MPB-37). Princeton University Press, Princeton, NJ.

Ojala, M., Cunsolo, A., Ogunbode, C.A. and Middleton, J. (2021) Anxiety, worry, and grief in a time of environmental and climate crisis: A narrative review. *Annual Reviews of Environment and Resources* 46: 35-58.

O'Brien, C.W. (1970) A taxonomic revision of the weevil genus Dorytomus in North America (Coleoptera: Curculionidae). *University of California Publications in Entomology* 60: 1-69.

O'Connor, T. (2013) *Animals as neighbors: The past and present of commensal species*. East Lansing: Michigan State University Press.

Odess, D. (2005) One of these things is not like the other: Typology, chronology, and the concept of Middle Dorset. In *Contributions of the Study of the Dorset Palaeo-Eskimos*, edited by Patricia Sutherland, ppr. 81-92. Mercury Series Archaeological Survey of Canada no. 167. Canadian Museum of Civilization, Gatineau, Québec.

Ohlson, M. & Tryterud E. (2000) Interpretation of the charcoal record in forest soils: forest fires and their production and deposition of macroscopic charcoal. *The Holocene* 10: 519-525.

Onalik, L. (2006) Report on the 2006 Parks Canada trip to Black Island, Nutak and Okkak. Nunatsiavut Government, Torngâsok Cultural Centre.

Oswalt, W.H. (1992) *Bashful no longer: An Alaskan Eskimo ethnohistory*, 1778-1988. Norman: University of Oklahoma Press.

Panagiotakopulu, E. (2001a) New records for ancient pests: Archaeoentomology in Egypt. *Journal of Archaeological Science* 28: 1235-1246.

Panagiotakopulu, E. (2001b) 'Fleas from Pharaonic Amarna'. *Antiquity* 75: 499-500.

Panagiotakopulu, E. & Buchan, A. (2015) Present and Norse hayfields in southwest Greenland – Insect assemblages, taphonomy, and biogeography. *Holocene* 25(6): 921-931.

Panagiotakopulu, E. & Buckland, P.C. (2013) Late Holocene insect faunas from Tasiusaq, Southwest Greenland. *Boreas* 42(1): 160-172.

Panagiotakopulu, E. & Buckland, P.C. (2017) A thousand bites – Insect introductions and the late Holocene environments. *Quaternary Science Reviews* 156: 23-35.

Panagiotakopulu, E., Skidmore, P., and Buckland, P.C. (2007) Fossil insect evidence for the end of the Western settlement in Greenland. *Naturwissenschaften* 94: 300-306.

Panagiotakopulu, E., Buckland, P.C., Day, P.M., Sarpaki, A.A. & Doumas, C. (1995) 'Natural Insecticides and Insect Repellents in Antiquity: A Review of the Evidence'. *Journal of Archaeological Science* 22: 705-710.

Panagiotakopulu, E., Buckland, P.C., Kemp, B.J. (2010) 'Underneath Ranefer's Floors – Urban Environments on the Desert Edge'. *Journal of Archaeological Science* 37: 474-481.

Panagiotakopulu, E., Buckland, P.C., Wickler, S.H., and John, P. (2018) Is there anybody in there? Entomological evidence from a boat burial at Øksnes in Vesterålen, northern Norway, *PloS one* 13(7): doi: 10.13.71/journal.pone.0200545.

Panagiotakopulu, E., Schofield, E.J., Vickers, K., Edwards, K.J., and Buckland, P.C. (2020) Thule Inuit environmental impacts on Kangeq, southwest Greenland. *Quaternary International* 549: 176-190.

Park, R.W. (2016) The Dorset-Thule transition. In *The Oxford handbook of the prehistoric Arctic*. Friesen & Mason (eds), pp. 807-826, Oxford University Press, Oxford.

Perdikaris, S. & McGovern, T.H. (2008) Codfish and kings, seals, and subsistence: Norse marine resources use in the North Atlantic. *In* Human impacts on marine environments. R. Torben and J. Erlandson (eds). *UCLA Press Historical Ecology series*: 157-190.

Podmore, C. (1998) *The Moravian church in England 1728-1760*. Oxford: Clarendon Press: 228-265.

Ramsden, P., & Rankin, L.K. (2013) Thule radiocarbon chronology and its implications for Early Inuit-European interaction in Labrador. In *Exploring Atlantic transitions: Archaeologists of transience and permanence in New found Lands,* edited by Pope, P.E. and Lewis-Simpson, S. pp. 299-309. The Boydell Press, Woodbridge, Suffolk.

Rankin, L.K. (2008) Native people from the Ice Age to the extinction of the Beothuk (c. 9000 years ago to AD 1829). In *A shorty history of Newfoundland and Labrador*. Edited by S. Lewis-Simpson, pp. 1-22. Boulder Publications, St. John's, NL.

Rankin, L.K. (2009) *An archaeological view of the Thule-Inuit occupations of Labrador*. Memorial University of Newfoundland, St. John's, NL.

Rankin, L.K. (2015) Identity markers: Interpreting sod-house occupation in Sandwich Bay, Labrador. *Études/Inuit/Studies* 39(1): 91-116.

Real, L.A. & Levin, S.A. (1991) Theoretical advances: the role of theory in the rise of modern ecology. *In Foundations of ecology: classic papers with commentaries*, (eds) L.A. Real and J.H. Brown. Chicago: University of Chicago Press, pp. 177-191.

Redman, C. L. (1999) Human impact on ancient environments. Tucson: University of Arizona Press.

Redman, C. L. (2005) Resilience theory in archaeology. *American Anthropologist* 107(1): 70-77.

Reimer, P.J., Austin, W.E.N., Bard, E., Bayliss, A., Blackwell, P.G., Ramsey, C.B., Butzin, M., Cheng, H., Edwards, R.L., Friedrich, M., Grootes, P.M., Guilderson, T.P., Hajdas, I., Heaton, T.J., Hogg, A.J., Hughen, K.A., Kromer, B., Manning, S.W., Muscheler, R., Palmer, J.G., Pearson, C., Van der Plitcht, J., Reimer, R.W., Richards, D.A., Scott, E.M., Southon, J.R., Turney, C.S.M., Wacker, L., Adolphi, F., Büntgen, U., Capano, M., Fahrni, S.M., Foftmann-Schulz, A., Friedrich, R., Kölher, P., Kudsk, A., Miyaje, F., Olsen, J., Reining, F., Sakamoto, M., Sookdeo, A., and Talamo, S. (2020) The IntCal20 Northern hemisphere radiocarbon age calibration curve (0-55 cal Kbp*). Radiocarbon* 64(4): 725-757.

Renfrew, C. & Bahn, P. (2008) *Archaeology: Theories, methods, and practice.* 5th edition. Thames & Hudson, New York.

Renouf, M.A.P. (2003) Palaeoeskimo dwelling structures in Newfoundland and Labrador: A review. *Études/Inuit/Studies* 27(1-2):375-416.

Renouf, M.A.P., Bell, T., and Macpherson, J. (2009) Hunter-gatherer impact on subarctic vegetation: Amerindian and Palaeoeskimo occupations of Port au Choix, Northwestern Newfoundland. *Arctic Anthropology* 46(1-2): 176-190.

Roberts, E. (2009) *Foreword. In* Rollmann, H. (ed) Moravian beginnings in Labrador: Papers from a Symposium held in Makkovik and Hopedale. *Newfoundland and Labrador Studies* 2.

Rockman, M. & Maase, J. (2017) *Every place has a climate story: Finding and sharing climate change stories with cultural heritage. In* Public archaeology and climate change. Oxbow Books, Oxford.

Rollmann, H. (2009) (ed) Moravian beginnings in Labrador: Papers from a Symposium held in Makkovik and Hopedale. *Newfoundland and Labrador Studies* 2.

Root, R.B. (1967) The niche exploitation pattern of the blue-grey gnatcatcher. *Ecology Monogr.* 37: 317-349.

Roy, N. (2010) *Évolution du paysage naturel et occupation humaine à Dog Island au nord du Labrador*. Université Laval, Québec, QC.

Roy, N., Bhiry, N., and Woollett, J. (2012) Environmental change and terrestrial resource use by the Thule and Inuit of Labrador, Canada. *Geoarchaeology: An International Journal* 27: 18-33.

Roy, N., Woollett, J. and Bhiry, N. (2015) Palaeoecological perspectives on landscape history and anthropogenic impacts at Uivak Point, Labrador, since AD 1400. *The Holocene*: 1742-1755.

Roy, N., Woollett, J., Bhiry, N., Lemus-Lauzon, I., Delwaide, A., and Marguerie, D. (2021) Anthropogenic and climate impacts on sub-Arctic forests in Nain region, Nunatsiavut: Dendroecological approaches and historical approaches. *Écoscience*: 1-16.

Ryan, K. (2016) The "Dorset problem" revisited: The transitional and early and Middle Dorset periods in the Eastern Arctic. In *The Oxford handbook of the prehistoric Arctic*. Friesen & Mason (eds)Oxford University Press, Oxford.

Sassaman, K.E. (2004) Complex hunter-gatherers in evolution and history: A North American perspective. *Journal of Archaeological Research* 12(3): 227-280.

Scheffer, M., Carpenter, S., Foley, J.A., Folke, C., and Walker, B. (2001) Catastrophic shifts in Ecosystems. *Nature* 413 (6856): 591-596.

Schoener, T.W. (1989) The ecological niche. *In Ecological concepts* (eds) J.M. Cherrett. Oxford: Blackwell, pp. 79-113.

Scott, A. C., & Damblon, F. (2010) Charcoal: taphonomy and significance in geology, botany, and archaeology. *Palaeogeography, Palaeoclimatology, and Palaeoecology* 291(1-2): 1-10.

Serreze, M.C. & Barry, R.G. (2005) *The Arctic climate system*. Cambridge Atmospheric and Space Science Series. Cambridge University Press, Cambridge.

Smiarowski, K., Harrison, R., Brewington, S., Hicks, M., Feeley, F., Dupont-Hébert, C., Hambrecht, G., Woollett, J., and McGovern, T.H. (2017) *Zooarchaeology of the Scandinavian settlements in Iceland and Greenland: diverging pathways. In* U. Albarella, M., Rizzetto, H. Russ, K. Vickers, and S. Viner-Daniels (eds). Oxford Handbook of Zooarchaeology.

Smith, B.D. (2007) The ultimate ecosystem engineers. *Science* 315: 1797-1798.

Smith, D.N. (2012) *Insects in the city: An archaeoentomological perspective on London's past.* British Archaeological Reports, British Series 561. Archaeopress, Oxford.

Speight, M.R., Hunter, M.D. and Watt, A.D. (1999) *Ecology of insects: Concepts and applications.* Blackwell Science Ltd., Oxford. 350 p.

Speller, J. & Forbes, V. (2022) On the role of peat bogs as components of Indigenous cultural landscapes in northern North America. *Arctic, Antarctic, and Alpine Research* 54(1): 96-110.

Stopp, M.P. (2002a) Ethnohistoric analogues for storage as an adaptive strategy in Northeaster subarctic prehistory. *Journal of Anthropological Archaeology* 21(3): 301-328.

Stopp, M.P. (2002b) Reconstructing Inuit presence in southern Labrador. *Études/Inuit/Studies* 26(2): 71-106.

Sutton, D., Hood, B. and Fitzhugh, W.W. (1981) In quest of Dorset subsistence strategies: 1980 excavations at Okak-1 and No-Name Island, Labrador. In Archaeology in Newfoundland and Labrador (1980), vol. Annual Report 1, Thomson, J.S. and Ransom, B. (eds) pp. 48-57.

Taylor, G. (1974) Labrador Inuit settlements of the early contact period. *Ethnology* (9), National Museum of Man, Ottawa.

Taylor, J.G. & Taylor, H. (1977) Inuit land use and occupancy in the Okak region: 1776-1830. *In* Our footprints are everywhere: Inuit land use and occupancy in Labrador. C. Brice-Bennett (ed) Nain: Labrador Inuit Association.

Thomas, C.D. (2020) The development of Anthropocene biotas. *Philosophical transactions Royal Society B* 375: 1-9.

Toft, P.A. (2016) Moravian and Inuit encounters: Transculturation of landscapes and material culture in West Greenland. *Arctic* 69(1): 1-13.

Todd, Z. (2014) Fish pluralities: Human-animal relations and sites of engagement in Paulatuuq, Arctic Canada. *Études/Inuit/Studies* 38(1-2): 217-238.

Todd, Z. (2016) *'You never go hungry': Fish-pluralities, human-fish relationships, Indigenous legal orders, and colonialism in Paulatuuq*, Canada. ProQuest Dissertations Publishing.

Todd, Z., Nagy, M., Rodon, T., and Laugrand, F. (2014) Fish-pluralities: Human-animal relations and sites of engagement in Paulatuuq, Arctic Canada. *Études/Inuit/Studies* 38(1/2): 217-238.

Viveiros de Castro, E. (1998) Cosmological deixis and Amerindian perspectivism. *The Journal of the Royal Anthropological Institute* 4(3): 469-488.

Walker, B., Holling, C.S., Carpenter, S.R., and Kinzig, A. (2004) Resilience, adaptability, and transformability in social-ecological systems. *Ecology and Society* 9(2): 5.

Whitridge, P. (2008) Reimagining the Iglu: Modernity and the challenge of the 18th century Labrador Inuit winter house. *Archaeologies* 4(2): 213-250.

Whitridge, P. (2012) Invented places: environmental imaginaries and the Inuit colonization of Labrador. In Settlement, subsistence, and change among the Labrador Inuit, edited by D.C. Natcher, L. Felt, and A. Procter, pp. 43-60. University of Manitoba Press, Winnipeg, MB.

Whitridge, P. (2016) *"Classic Thule": Precontact Inuit,* In *The Oxford handbook of the prehistoric Arctic*. Friesen & Mason (eds). Oxford University Press, Oxford.

Whitridge, P. (2018) Archaeological Investigations at Kivalekh (Okak-1; HjCl-01), Northern Labrador, July-August 2018. *Provincial Archaeology Office 2018 Archaeology Review*: 250-261.

Whyte, I.D. (2002) *Landscape and history: since 1500*. Reaktion Books, London.

Williamson, M.H. (1972) *The analysis of biological populations*. London: Edward Arnold.

Woollett, J.M. (1999) Living in the Narrows: Subsistence economy and culture change in Labrador Inuit society during the contact period. *World Archaeology* 30(3): 370-387.

Woollett, J.M. (2003) An historical ecology of Labrador Inuit culture-change. *Ph.D. thesis*, The City University of New York.

Woollett, J. (2008) Labrador Inuit subsistence in the context of environmental change: An initial landscape history perspective. *American Anthropologist* 109(1): 69-84.

Woollett, JM (2010) Oakes Bay 1: A preliminary reconstruction of a Labrador Inuit seal hunting economy in the context of climate change. *Geografisk Tidsskrift-Danish Journal of Geography* 110: 245-260.

Woollett, JM (2011) Dog days at Uivak Point: Zooarchaeological perspectives on Inuit dog team management. In: *Society of American Archaeology Meetings*, Sacramento, CA.

Woollett, J., Henshaw, A.S., and Wake, C.P. (2000) Palaeoecology implication of archaeological seal bon assemblages: Case studies from Labrador and Baffin Island. *Arctic* 53: 395-420.

Wu, J. & Loucks, O. (1995) From balance of nature to hierarchical patch dynamics: a paradigm shift in ecology. *Q Rev Biol* 70: 439-66.

Zutter, C. (2009) Paleoethnobotanical contributions to 18th- century Inuit economy: An example from Uivak, Labrador. Journal of the North Atlantic, special volume 1: 23-32.

Zutter, C. (2012) The shrubs in the forest: The use of woody species by 18th-century Labrador Inuit. *Études/Inuit/Studies* 36(1): 139-155.

APPENDICES

Appendix 1 – Cores samples and matrix descriptions for each location tested (Coffin Island, Green Island, and Okak Islands [Kivalekh]). In order to find a suitable sampling location, the matrix had to be organic (peat, silt) with enough depth to allow the insertion of the monolith tin. These descriptions were found in the field notebook from 2019 (Carlson 2019) and transcribed herein.

Coffin Island (July 15, 2019)
Core samples & Matrix description

Core samples#	Depth below ground level (cm)	Matrix description
1	1-30	Silt, organic, brown; the very top is peaty (humus) vegetation.
	30-45	Organic silty; a little bit of sand near the bottom, refusal on bedrock.
2	1-30	Similar as previous one; organic (humus) silty brown peat, with rootlets.
	30-47	Similar as above; brown organic silt with light brown strip around ~33 cm, refusal on bedrock.
3	1-30	Organic brown silt with peat matrix on top.
	30-38	Brown organic silt before refusal on bedrock.
4	1-27	Brown organic silt; refusal on bedrock.
5	1-30	Top 10 cm: browner (decay of organic matter); ~7-10 cm: organic brown silt.
	30-40	More organic silt.
6	1-30	Humid silt; dark brown with organic decay (more present on top layers); 1 more cm before reaching refusal on permafrost.
7	1-30	Limestone silt; dark brown.
	30-38	Brown organic silt; refusal on permafrost.
8	1-26	Gray-brown organic silt; refusal on permafrost.
9	1-30	Humid silt; dark brown; refusal on permafrost.
10	1-30	Silt with gravel.
11	1-7	Humus; peaty silt.

Green Island (July 16, 2019)
Core samples & Matrix description

Core samples#	Depth below ground level (cm)	Matrix description
1	1-30	Peaty silt; dark brown to dark; more vegetation throughout than Coffin; sandy towards 30 cm.
	30-57	Strong dark brown ~37 cm; brown sandy layer, then lighter brown, wet and silty sediment.
	57-70	Silty wet organic matter brighter orange; refusal on permafrost.
2	1-30	Few cm of peat followed by 27 cm sandy soil with some organic decay.
	30-37	Sandy sediments; some organic decay; dark brown with large twigs; macrofossils present; refusal on bedrock or permafrost.
3	1-30	Organic sediment.
	30-58	Sandy with some organic matter; coarse sand; bedrock or permafrost.
4	1-30	Peaty top 5-8 cm; dark brown; progressively sandy with brown organic strip of clay.
	30-58	Humus sandy sediment; lighter and coarser in the bottom.
	58-63	Wet sand with some organic sediment.
5	1-30	Tiny layer of peat and dark sand.
	30-65	Dark silty sandy sediment with very decayed organic matter.

Okak Island (Kivalekh) (July 16, 2019)
Core samples & Matrix description

Core samples#	Depth below ground level (cm)	Matrix description
1	1-30	Thin layer of peat (1-3 cm) followed by light coarse brown sandy sediment.
	30-43	Coarse sandy sediment.
2	1-25	Peaty decayed organic matter; dark brown; refusal on bedrock.
3	1-30	Peat layer (1-20 cm); dark brown followed by sandy sediment; refusal on permafrost.
4	1-30	Top ~7-8 cm very peaty with coarse sandy sediment; refusal on permafrost.
5	1-15	Dark black peat; refusal on bedrock.
6	1-15	Dark black peat; refusal on bedrock.
7	1-5	'blanket' of dark peat; refusal on bedrock.
8	1-15	Humous silt (peat); dark brown peat; refusal on bedrock.
9	1-20	Humus silt (peat); silt progressively wetter; bedrock or permafrost.
10	1-25	Poorly decayed organic matter; moss down to permafrost.
11	1-30	Dark reddish-brown humous (silty peat).
	30-40	Dark silty sand with little bit of organic matter; refusal on permafrost.
12	1-30	Peat from ~23 cm; then sand.
	30-40	Cold dark brown sandy silt; refusal on permafrost.
13	1-30	Peaty humous; silt (1-25 cm); silty sediment; wet and cold until 30 cm; refusal on permafrost.
14	1-25	Humous silt (peat); cold at bottom; refusal on permafrost.
15	1-30	Humous silt (peat) from 1-25 cm; then silty sediment from 25-30 cm.
	30-45	Sandy silt; organic matter; refusal on permafrost.
16	1-30	Peaty highly organic matter.
	30-45 cm	Peat to sandy matter towards 40 cm; refusal on permafrost.

Appendix 2 – Loss-on-ignition (LOI) results presented in percentages (%). Samples from #22 (28-29 cm) to #33 (38-39 cm) [**bold numbers**] varies between 70.98% and 86.38%. This does not result in a sharp lithological change, and globally the soil matrix from the monolith is highly organic in nature.

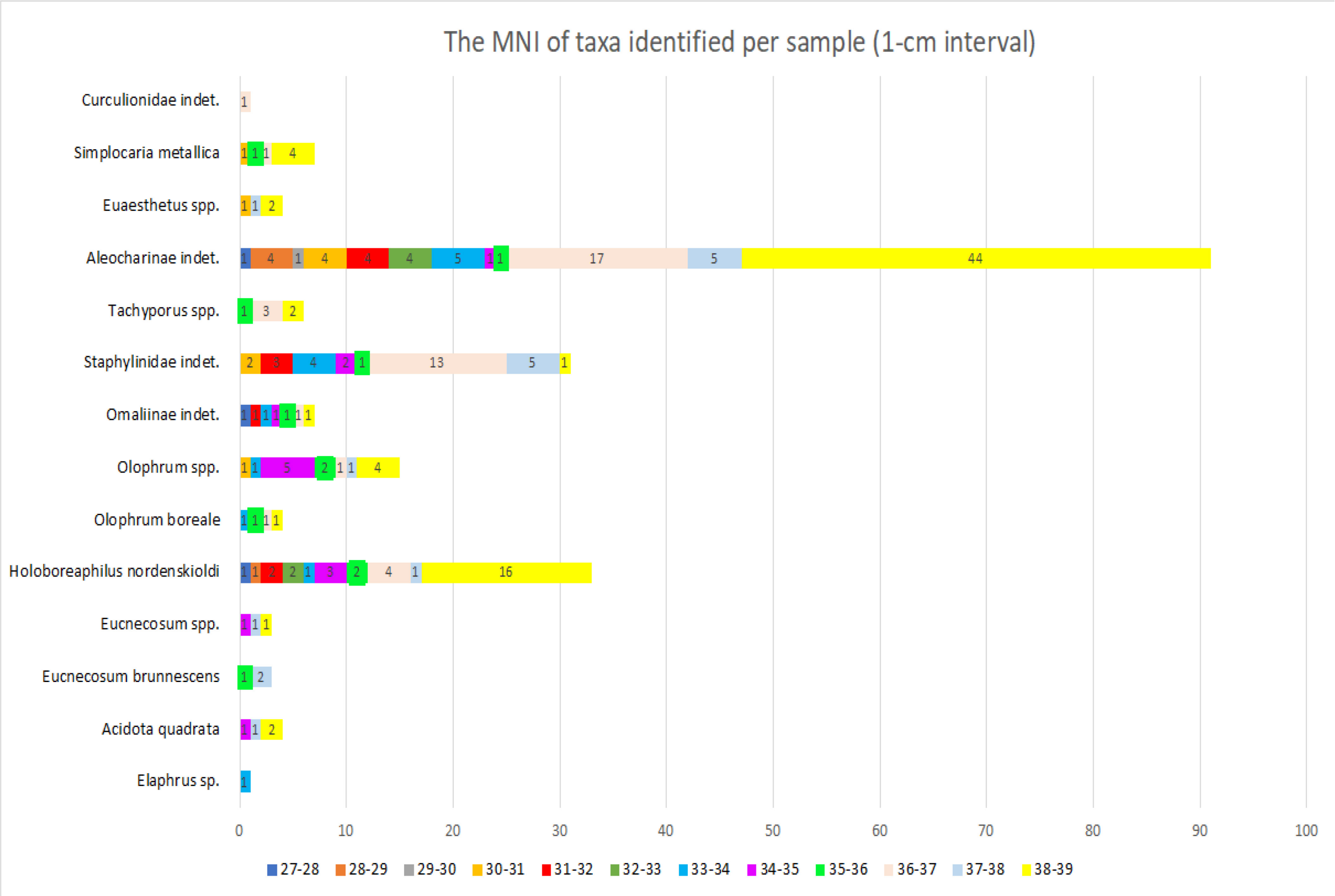
Sample #	Depth (cm)	Crucible #	Crucible weight (g)	Wet weight (g)	Dry weight (g)	Ashed weight (g) *post-ignition @ 550°C*	% LOI
1	6-7 cm	1	8.7260	10.0031	8.9549	8.7750	78.5933
2	7-8 cm	2	7.7702	9.1306	7.9925	7.8180	78.4975
3	8-9 cm	3	6.9524	9.6488	7.3503	7.0437	77.0545
4	9-10 cm	4	7.0449	9.2275	7.3652	7.1224	75.8039
5	10-11 cm	5	7.4814	9.7610	7.8108	7.5378	82.8780
6	11-12 cm	6	7.5374	9.5096	7.7446	7.5620	88.1274
7	12-13 cm	7	8.3458	10.7869	8.5636	8.3659	90.7713
8	13-14 cm	8	7.3149	9.4101	7.4948	7.3334	89.7165
9	14-15 cm	9	7.6033	10.1997	7.8169	7.6276	88.6236
10	15-16 cm	10	7.1313	9.9195	7.3972	7.1564	90.5604
11	16-17 cm	11	7.5959	9.5132	7.7813	7.6194	87.3247
12	17-18 cm	12	8.8711	11.4535	9.1027	8.8936	90.2850
13	18-19 cm	13	7.6264	10.6267	7.8903	7.6497	91.1709
14	19-20 cm	14	7.0550	9.8969	7.2967	7.0808	89.3256
15	20-21 cm	15	7.3883	9.4905	7.5543	7.4048	90.0602
16	21-22 cm	16	7.9704	9.3659	8.1474	7.9950	86.1017
17	22-23 cm	17	7.4360	9.5960	7.6783	7.4681	86.7520
18	23-24 cm	18	7.6686	9.8418	7.9031	7.6974	87.7186
19	24-25 cm	19	8.1507	10.3196	8.5630	8.2229	82.4885
20	25-26 cm	20	7.6817	10.0163	8.0146	7.7443	81.1956
21	26-27 cm	21	7.9610	10.0177	8.3547	8.0831	68.9865
22	27-28 cm	22	7.0900	9.9840	7.6550	7.2022	**80.1416**
23	28-29 cm	23	7.6280	9.7582	8.1701	7.7853	**70.9832**
24	29-30 cm	24	6.5382	9.6982	7.1463	6.6830	**76.1881**
25	30-31 cm	25	6.9525	9.2116	7.3788	7.0548	**76.0028**
26	31-32 cm	26	8.1929	10.7440	8.6900	8.3134	**75.7594**
27	32-33 cm	27	7.1790	9.8469	7.5656	7.2424	**83.6006**
28	33-34 cm	28	7.0018	9.3688	7.4136	7.0712	**83.1472**
29	34-35 cm	29	7.0571	9.3893	7.3604	7.0987	**86.2842**
30	35-36 cm	30	7.9127	10.1187	8.2980	7.9983	**77.7835**

31	36-37 cm	31	7.1993	10.2810	7.8305	8.2732	**79.3093**
32	37-38 cm	32	7.7062	10.4841	8.2757	7.8234	**79.4205**
33	38-39 cm	33	8.1423	10.9389	8.7351	7.3286	**77.6147**

Appendix 3 – Table of the Minimum Number of Individuals (MNI) of the specimens recovered and identified from Kivalekh's samples (depth range in cm per volume (ml) analyzed).

Depth range (cm)	**27-28**	**28-29**	**29-30**	**30-31**	**31-32**	**32-33**	**33-34**	**34-35**	**35-36**	**36-37**	**37-38**	**38-39**
Midpoint (cm)	27.5	28.5	29.5	30.5	31.5	32.5	33.5	34.5	35.5	36.5	37.5	38.5
Total Coleoptera MNI	3	5	1	9	10	6	14	14	11	42	17	78
Elaphrus sp.	0	0	0	0	0	0	1	0	0	0	0	0
Acidota quadrata	0	0	0	0	0	0	0	1	0	0	1	2
Eucnecosum brunnescens	0	0	0	0	0	0	0	0	1	0	2	0
Eucnecosum spp.	0	0	0	0	0	0	0	1	0	0	1	1
Holoboreaphilus nordenskioeldi	1	1	0	0	2	2	1	3	2	4	1	16
Olophrum boreale	0	0	0	0	0	0	1	0	1	1	0	1
Olophrum spp.	0	0	0	1	0	0	1	5	2	1	1	4
Omaliinae indet.	1	0	0	0	1	0	1	1	1	1	0	1
Staphylinidae indet.	0	0	0	2	3	0	4	2	1	13	5	1
Tachyporus spp.	0	0	0	0	0	0	0	0	1	3	0	2
Aleocharinae indet.	1	4	1	4	4	4	5	1	1	17	5	44
Euaesthetus spp.	0	0	0	1	0	0	0	0	0	0	1	2
Simplocaria metallica	0	0	0	1	0	0	0	0	1	1	0	4
Curculionidae indet.	0	0	0	0	0	0	0	0	0	1	0	0
Volume (litres)	0,05	0,05	0,05	0,05	0,05	0,05	0,05	0,057	0,057	0,057	0,057	0,557

Appendix 4 – Histogram of the Minimum Number of Individuals (MNI) of the specimens recovered and identified from Kivalekh's samples (depth range in cm per volume).


The MNI of taxa identified per sample (1-cm interval)