

**Convergent Adaptive Strategies During the Transitional Holocene: A Case Study from the Alpena-
Amberley Ridge in the Great Lakes Region**

by

Brendan Sean Nash

A dissertation submitted in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy
(Anthropology)
in the University of Michigan
2025

Doctoral Committee:

Professor John M. O'Shea, Chair
Professor Daneil C. Fisher
Associate Professor Ashley K. Lemke, University of Wisconsin–Milwaukee
Associate Professor Brian A. Stewart
Professor Henry T. Wright

Brendan S. Nash

nashbs@umich.edu

ORCID iD: [0000-0003-4956-5910](https://orcid.org/0000-0003-4956-5910)

© Brendan S. Nash 2025

Dedication

This dissertation is dedicated to my family for their endless support in my journey to earn a Ph.D.

Acknowledgements

I would like to acknowledge the years of work and dedication to exploration and research on the Alpena-Amberley Ridge by Professors John O'Shea and Ashley Lemke. Also, Jamie Anderson from Michigan Technical University for operating the autonomous underwater vehicle that was used to gather sonar data and build an acoustic image of the Gap Locality and the South Gap site. And Tyler Shultz from Michigan Adventure Diving in Milan Michigan who served as our dive master and guided the scuba team in collecting sediment samples from the bottom of the lake.

Table of Contents

Dedication	ii
Acknowledgements	iii
List of Tables	xi
List of Figures	xiii
List of Appendices	xvii
Abstract	xviii
Chapter 1 Introduction	1
1.1 Introduction	1
1.2 Organization	3
1.3 The scientific process	5
1.4 Notes about dates	6
Chapter 2 Paleoecology and Archaeology of the Great Lakes Region during the Pleistocene-Holocene Transition: Cultural and Environmental Background	7
2.1 Introduction	7
2.2 Great Lakes environment and lake levels during the Pleistocene-Holocene transition	9
2.3 The local environment of the Alpena-Amberley Ridge during Lake Stanelly	13
2.4 Physiographic regions surrounding the Great Lakes	14
2.4.1 Eastern Woodlands	14
2.4.2 Northern Plains	15
2.4.3 Interior Lowlands	16
2.5 Technologies of the Great Lakes Region and surrounding areas	16

2.5.1 Hi-Lo.....	18
2.5.2 Kirk corner notched	20
2.5.3 LeCroy bifurcates.....	22
2.5.4 Plano	23
2.5.5 Microlithic technology.....	25
2.6 Discussion	26
2.7 Conclusion	27
Chapter 3 Small Tools Around the Globe: A Survey of Small Tools Through Time	29
3.1 Introduction.....	29
3.2 Global survey	30
3.2.1 South Africa	31
3.2.2 Howiesons Poort	32
3.2.3 Post Howiesons Poort	33
3.2.4 Robberg.....	33
3.2.5 Oakhurst.....	33
3.2.6 Wilton	34
3.2.7 Europe	35
3.2.8 Aurignacian and Proto Aurignacian.....	35
3.2.9 Gravettian.....	36
3.2.10 Solutrean	37
3.2.11 Magdalenian.....	37
3.2.12 Mesolithic	38
3.2.13 Northern Europe.....	38
3.2.14 Central and Southern Europe	39
3.2.15 Asia	40

3.2.16 Discussion of Yubetsu and wedge-shaped core microblade technology	40
3.2.17 Northeast China	41
3.2.18 Siberia	42
3.2.19 North America: Alaska	43
3.2.20 Canada.....	45
3.2.21 Discussion about the spread of microlithic technologies from Asia into the Americas and the Great Lakes	46
3.3 Conclusions.....	46
Chapter 4 Introduction to the Early Holocene Adaptations Foraging Model	48
4.1 Introduction.....	48
4.2 Theoretical background for the global phenomenon of convergent foraging strategies during the PHT.....	49
4.3 A Synthesized model to account for the global phenomenon.....	54
4.4 Four domains of the EHA model	54
4.4.1 Technology: miniaturized stone tool industry	54
4.4.2 Mobility and provisioning	55
4.4.3 Cultural niche construction and hunting architecture	56
4.4.4 Social networks.....	57
4.5 Applying the EHA model to the submerged landscape of the Alpena-Amberley Ridge .	58
4.6 Specific expectations for the EHA model on the AAR	60
4.7 Conclusions.....	63
Chapter 5 Testing of the Early Holocene Adaptation Foraging Model at Multiple Scales: An Analysis of the Cultural Landscape of the Alpena Amberley Ridge.....	65
5.1 Introduction.....	65
5.2 Testing the EHA Model.....	66
5.3 Regional expectations and variables for the EHA model	67

5.4 Materials	70
5.4.1 Data for stone tools	70
5.4.2 Data for stone constructions.....	73
5.4.3 Data for sediment samples	76
5.5 Methods.....	77
5.5.1 How the EHA model will be critically applied.....	77
5.6 Test results for technology.....	80
5.6.1 Expectation a.....	80
5.6.2 Testing expectation a	80
5.6.3 Results for expectation a.....	80
5.6.4 Expectation b	82
5.6.5 Testing expectation b	82
5.6.6 Results for expectation b.....	83
5.7 Test results for mobility	89
5.7.1 Expectation c.....	89
5.7.2 Testing expectation c	89
5.7.3 Results for expectation c.....	89
5.7.4 Expectation d	93
5.7.5 Testing expectation d	93
5.7.6 Results for expectation d.....	94
5.7.7 Expectation e.....	98
5.7.8 Testing expectation e	98
5.7.9 Results for expectation e.....	98
5.8 Test results for cultural niche construction.....	103
5.8.1 Expectation f.....	103

5.8.2 Testing expectation f.....	103
5.8.3 Results for expectation f	103
5.9 Test results for social networks.....	108
5.9.1 Expectation g	108
5.9.2 Testing expectation g	108
5.9.3 Results for expectation g.....	108
5.10 Discussion of results for the regional model tests	111
5.11 Conclusions.....	115
Chapter 6 Critically Applying the Diachronic Expectations of the Early Holocene Adaptation Foraging Model to Sites on the AAR	117
6.1 Introduction.....	117
6.2 Background for select sites	118
6.2.1 The Dragon Site (20AA230).....	118
6.2.2 The Drop 45 Site (20AL104).....	119
6.2.3 The South Gap Site (20AA232).....	119
6.2.4 The Funnel Site (20AA231).....	120
6.3 Diachronic expectations of the EHA model	120
6.4 Test results for the diachronic expectation of the EHA model related to technology	123
6.4.1 Expectation 1	123
6.4.2 Testing expectation 1	123
6.4.3 Results for expectation 1.....	123
6.5 Test results for the diachronic expectation of the EHA model related to mobility	128
6.5.1 Expectation 2	128
6.5.2 Testing expectation 2	128
6.5.3 Results for expectation 2.....	129

6.6 Test results for the diachronic expectation of the EHA model related to cultural niche construction.....	130
6.6.1 Expectation 3	130
6.6.2 Testing expectation 3	131
6.6.3 Results for expectation 3.....	131
6.6.4 Count.....	131
6.6.5 Variety.....	132
6.6.6 Complexity.....	133
6.7 Discussion of the diachronic expectation tests	137
6.8 Conclusions.....	138
Chapter 7 South Gap Site Investigation.....	139
7.1 Introduction.....	139
7.2 Background	141
7.2.1 Previous research at South Gap	141
7.2.2 New research at South Gap.....	145
7.3 Methods and materials	146
7.3.1 Sonar mapping with an automated underwater vehicle	146
7.3.2 Sonar mapping with sector scan	149
7.3.3 Sonar guided sampling via scuba.....	150
7.3.4 Laboratory sample processing procedures.....	154
7.4 Analysis and results	155
7.5 Spatial analysis.....	155
7.5.1 Natural advantageous setting	155
7.5.2 Cultural modification to the site and the central drive area	157
7.5.3 The western portion of the site.....	157
7.6 Analysis of South Gap site lithic assemblage	160

7.6.1 Function	160
7.6.2 Context.....	166
7.7 Conclusions.....	166
Chapter 8 Concluding Discussions	168
8.1 Introduction.....	168
8.2 An assessment of foraging strategies on the AAR.....	170
8.2.1 The Drop 45 site (20AL104).....	172
8.2.2 The Dragon site (20AA230)	173
8.2.3 The South Gap site (20AA232)	174
8.2.4 The Funnel site (20AA231)	175
8.2.5 Summary of evidence from the four sites	176
8.3 A terrestrial example of Holocene caribou hunting from the southwest Yukon	177
8.3.1 Archaic hunting technology in the southwest Yukon	180
8.4 Discussion of the potential North America interaction zone	182
8.5 After the AAR and the proliferation of Small Tool cultures	184
8.6 Implications for the peopling of North America.....	185
8.7 Conclusions.....	186
8.8 Reflections and recommendations for future directions	187
Appendices.....	190
Bibliography	207

List of Tables

Table 2.1 Lake stages, time frames, water level, and predominant vegetation in the Lake Huron Basin.	9
Table 2.2 Summarizes the water level changes and associated time periods within the Lake Stanley lowstand.	14
Table 2.3 List of regions surrounding the GLR during the PHT with associated technologies and their dates and references for the environment.	17
Table 3.1 List of South African industries Since the Late Middle Stone Age.....	32
Table 3.2 Shows the succession of major technological industries in Western Europe highlighting when microlithic technology is a prominent component of lithic tool kits.....	35
Table 3.3 Succession of industries documented from Alaska.	44
Table 4.1 Summary of Early Holocene Adaptations model expectations and how they will be tested.	61
Table 4.2 Shows the diachronic expectations of the Early Holocene Adaptations model for individual sites on the AAR along the four Domains.	63
Table 5.1 Summary of EHA model expectations.	67
Table 5.2 List of the three data categories and very brief description of the materials.	70
Table 5.3 Lists the data collected from each of the stone tools that are needed to test the expectations of the Early Holocene Adaptations foraging model.	71
Table 5.4 List reduction strategies identified on the AAR.	72
Table 5.5 List of categories for potential stone construction identified on the AAR.	75
Table 5.6 List of topographic classes for sites on the AAR.....	76
Table 5.7 List of sediment samples used for testing expectation a.....	77
Table 5.8 Scales of analysis.	78

Table 5.9 Shows weights of select sediment samples in four fractions, with the addition of the maximum dimension and weight of the largest chert specimen in the sample, and the percent of 1/4 in. material that is chert.....	81
Table 5.10 Shows data related sites on the AAR in terms of number of sites with hunting structures, artifacts related to hunting and animal processing, and samples.	104
Table 5.11 List of sites with the total number of hunting structures and artifacts with the total volume of recovered sediment, and the density of artifacts per liter of sediment for each site..	105
Table 5.12 Compares the volume of sediment recovered for sites with and without tools.	106
Table 5.13 Data from three sites on Adak Island in Alaska including artifact density, and calibrated c14 dates from (Wilmerding & Kay 2011).	107
Table 5.14 Lists the three artifacts made from non-local materials, and their direction and distance from the source.	109
Table 6.1 Shows the diachronic expectations for individual sites on the AAR along three domains of the EHA model.....	121
Table 6.2 List of raw materials for artifacts recovered from the AAR, including the site(s) where they occur, and their quality. For certain tool types, quartzite is considered a high-quality material.	124
Table 6.3 Results for the diachronic expectation tests relating to cultural niche construction..	136
Table 7.1 Number of samples taken from the South Gap before 2020 with dates.	142
Table 7.2 Types and counts of stone structures identified at the South Gap site before 2020. ..	143
Table 7.3 Stone tools recovered from the South Gap site before 2020.	143
Table 7.4 Table of samples collected during the South Gap site investigation.	153
Table 7.5 List of artifacts recovered from the South Gap site after 2020.....	155
Table 8.1 Shows data for the four sites under consideration here used to discuss differences in foraging behavior.	176
Table 8.2 Shows the number of microblades and microblade fragments recovered from the Drop 45, South Gap, and Dragon sites.	177

List of Figures

Figure 2.1 Map of the physiographic regions surrounding the Great Lakes during the Pleistocene - Holocene transition ca. 11,000 Cal. B.P.....	8
Figure 2.2 Shows the extent of the Laurentian Ice sheet in the Great Lakes region from about 14,000 - 12,000 Cal. B.P and associated proglacial lake Algonquin. (after Lemke 2016).....	10
Figure 2.3 Shows the extent of the Laurentian Ice Sheet in the Great Lakes region from about 10,500 - 8,300 Cal. B.P and associated low level lake stands including lake Stanley in the Lake Huron Basin.....	11
Figure 2.4 Shows water levels during the high stand of Lake Nipissing stage from about 7,500 - 4,000 Cal. B.P.....	12
Figure 2.5 Shows two Hi-Lo points from the Great Lakes Region. Photo Credit to the Michigan Archaeological Society.....	19
Figure 2.6 Shows the core range for techno-complexes in and surrounding the GLR during the PHT.....	20
Figure 2.7 Image of two Kirk Corner Notched points. Photo credit to the Michigan Archaeological Society.....	21
Figure 2.8 Image of two LeCroy Bifurcate points from the GLR. Photo Credit to the Michigan Archaeological Society.....	23
Figure 2.9 Image of Cody Complex points Photo credit to David Nix and Meagan Schoenfelder and the State Historical Society of North Dakota.....	24
Figure 3.1 Map of the globe with key sites and dates for the occurrence of microlithic technology around the world from Asia to the Americas.....	31
Figure 3.2 A technical diagram of the basic reduction strategy for Yubetsu technology which is often referred to as wedge-shaped cores in central and northeast Asia modified from Hirasawa and Holmes (2017: 106).....	41
Figure 4.1 Bathymetric map of the Lake Huron Basin.....	59
Figure 5.1 Shows Areas 1, 2 and 3 with the smaller scales of analysis including the locations of the six site clusters/ localities and the 31 sites within them.....	79

Figure 5.2 Shows the four primary reduction strategies –and one ground stone– for tools on the AAR at the four nested scales.	84
Figure 5.3 A wedge likely produced from a bipolar reduction method from the Drop 45 site, showing macroscopic use-wear with a heavily battered end and an end that was polished from use as a wedge.....	86
Figure 5.4 Shows the only artifact recovered from Area 2 from three different angles. It is a scraper (265-1) made with a bipolar reduction method from local cobbles. The solid line indicated the edge that functioned as a scraper, and the dashed line indicates a modified edge..	87
Figure 5.5 Small, white, edge retouch flake (138-4) from three angles. The curved black line indicates the platform of the flake.	88
Figure 5.6 Shows tools (with debitage removed) recovered from the AAR that were likely to be used for multiple tasks at four different scales. Red bars indicate the tools that were likely used for multiple functions, while blue bars indicate single-use tools.....	90
Figure 5.7 Shows a multi-functioning small tool: specimen 131-1, a “thumbnail” scraper with a potential graver on Bayport Chert recovered from the Drop 45 site.	92
Figure 5.8 Shows a multi-functioning small tool (299-1) with its remnant scraper edge indicated with a curved line and its burinated edge indicated with a straight line.	93
Figure 5.9 Shows the number of structures at each site plotted against the average elevation of the structures for each site. The graph shows a strong clustering of sites between about 30 and 35 meters below the modern lake surface, suggesting a single major phase.	95
Figure 5.10 Top) Shows the depth (elevation in meters) of structures at site from certain topographical settings, and Bottom) shows the number of different types of structures for each topographical setting.	97
Figure 5.11 Shows the occurrence of local and imported lithologies for artifacts recovered from the AAR at the four scales.	99
Figure 5.12 Two of the larger tools from the Dragon site a) diorite ground stone tool (299-2) b) quartzite chopper (299-8).....	100
Figure 5.13 Obsidian flakes from a biface, recovered from the South Gap site.....	101
Figure 5.14 Show tools on imported material from the AAR, and their source location.	110
Figure 5.15 Shows a scraping tool (324-2) made from a relatively large local chert cobble, and it has a bifacial edge that would have produced flakes classified here as derived from bifacial reduction.	112
Figure 5.16 Map showing AAR sites with non-hunting features including rectangular enclosures and stone rings.	114

Figure 6.1 Honey colored chert cobble that was cut in half to reveal that it is actually a high-quality grey chert.	126
Figure 6.2 Pie charts showing the proportions of flaked artifacts that are on high, medium, and low-quality chert quartzite, and obsidian from Dragon, Drop 45, and South Gap.	127
Figure 6.3 Show the weight of tools for each site with the function of large outliers labeled. Horizontal lines not attached to boxplots represent artifacts in cases where there are not enough at a site to create quartiles and calculate outliers.	129
Figure 6.4 Bar graph showing the total count of documented plausible structures for each site on the AAR.	132
Figure 6.5 Bar graph shows the total count of structure types out of six different classes for each site on the AAR.	133
Figure 6.6 Dragon site acoustic map showing the natural escarpment that directs animals along a predictable path.	134
Figure 6.7 (After O’Shea et al. 2014) Functional diagram of the Drop 45 site drive lane complex including hunting blinds and a couple examples of associated tools in their find locations (left), and the original sector scan sonar data showing the drive lane, and blinds (right).	135
Figure 6.8 The Funnel site complex. Diagram of cultural stone features above, and a photograph of the complex below After: O’Shea (2015).	136
Figure 7.1 Map of the Huron Basin during the Lake Stanely period showing the location of the South Gap site within Area 3.	140
Figure 7.2 A map showing the find location of the obsidian flakes in Lake Huron and its geological source at Wagonfire in central Oregon. After (O’Shea et al. 2021).	144
Figure 7.3 Two AUV sonar maps with transects in perpendicular directions at the Gap Locality. A) AUV map of the Gap locality with transects running north-south. B) AUV sonar map of the Gap locality with transects running east-west with one swath missing.	148
Figure 7.4 Sector scan acoustic images of two of the V shaped blinds on the east side of the esker at South Gap A) Rockpile Cairn, and B) TV Blind.	149
Figure 7.5 Show diver Tyler Shultz filling a lift back attached to a sediment sample to bring it to the surface. Photo credit John O’Shea.	151
Figure 7.6 Map of sample locations at the South Gap drive area, and the location of previous samples.	152
Figure 7.7 Shows the esker leading to the South Gap site and the central drive area at the center of the South Gap site, including the series of three V-shaped blinds, the drive lane leading to	

them, sample DA-1 (sample that contained the two obsidian flakes), and the natural esker that serves as a barrier to migrating animals.....	156
Figure 7.8 Sonar map showing the esker at the South Gap site and the complex of hunting structures surrounding it. It also shows the location of the obsidian flakes, and several potential hunting blinds.....	159
Figure 7.9 Microblade assembled from the South Gap site. The dashed line on specimen 324-1 indicates modification along the edge.....	161
Figure 7.10 Core assemblage from South Gap. The arrows indicate the direction of flake removals, and the dashed line represents a modified edge potentially used as a scraper or chopper.....	162
Figure 7.11 Shows the scraper (234-2) from South Gap. Dashed lines indicate the visibly abraded and smoothed edge from use as a scraper.	163
Figure 7.12 Assemblage of flakes from a bifacial edge South Gap.....	164
Figure 7.13 Potential net sinker from the South Gap site.	165
Figure 8.1 Map of the four relatively well studied sites discussed in this chapter.	171
Figure 8.2 Photo of the hunting structures at the Friday Creek Ice Patch site from Boyer (2011: 175).	179
Figure 8.3 Shows an image from Hare et al. (2004: 266) of a bone dart point slotted for inset microblade use from the Yukon dated to 7,310 +/- 50 ¹⁴ C. yr B.P [ca.8,022 Cal. B.P.].	181
Figure 8.4 Map of North America showing the extent of the northern (habitual microlithic tools users) and southern foraging traditions (emphasis on bifacial technologies with limited use of microlithic tools) and where they overlap during the PHT. Note the similarity to map figure 9.5 in Lemke & O'Shea 2019: 167, that shows a schematic of later Pleistocene technological traditions.	183

List of Appendices

Appendix 1: Lithic Specimens.....	190
Appendix 2: Stone Constructions	195
Appendix 3: Sediment Samples	200

Abstract

The Pleistocene-Holocene Transition (PHT) (13,000–8,000 years ago) was a period of pronounced climatic and landscape change that affected every continent. Along with retreating glaciers, rising sea levels produced dramatic effects on landscapes around the world. In response, foraging groups from different portions of the globe developed convergent adaptive strategies, including miniaturized stone tool industries, niche construction, increased mobility, and far-reaching social networks. This dissertation investigates the global phenomenon of convergent adaptive strategies during the PHT through a case study from the Alpena-Amberley Ridge (AAR). The AAR is a limestone and dolomite landform that crosses the Lake Huron Basin from northwest to southeast, forming a causeway that connects both sides. The landform served as a land bridge that caribou likely used on seasonal migration routes and that ancient foragers used for seasonal hunting. The AAR is currently underwater and was only traversable, dry land during the Lake Stanley lowstand between about 11,000 and 8,000 years ago. The submerged context of the AAR has preserved archaeological data, including organic remains and landscape modifications such as hunting blinds and drive lines, from disturbance by modern development. This makes it an ideal location for investigating hunter-gatherer adaptations to new and changing conditions at the onset of the Holocene. The results of this investigation show that foraging strategies on the AAR resemble global patterns but also exhibit unique expressions strongly influenced by the local environment. These adaptations most closely resemble those documented from northern post-Arctic landscapes in western Canada.

Chapter 1 Introduction

1.1 Introduction

The Alpena-Amberley Ridge (AAR) is a now submerged limestone and dolomite landform that bisects the Lake Huron Basin. Between about 11,200 - 7,500 Cal. B.P., a low water stand referred to as Lake Stanley exposed the landform as dry land. This created a continuous causeway crossing the basin from northwest to southeast that migrating animals such as caribou could use on seasonal migrations. The inundated and largely preserved landscape of the AAR offers a unique opportunity to model human adaptation during the Pleistocene-Holocene transition (PHT) on what was a newly exposed and rapidly changing area. These conditions are unique and offer a chance to apply and test a body of theory related to foraging on new and unknown landscapes during the PHT in a novel case study.

This dissertation compiles and synthesizes all available data collected from the AAR project between 2008 and 2022, including sediment samples, recovered artifacts, and documented constructed stone features. The core of this dissertation rests heavily on data and insights produced by the principal investigators of the AAR project, Professors John O'Shea and Ashley Lemke, whose foundational research over the last decade and a half has made this systematic analysis of cultural landscape of the AAR possible.

The primary goal of this dissertation is to synthesize the existing data into a cohesive foraging model –referred to as the Early Holocene Adaptations model (EHA)– that describes how people during the PHT structured their behaviors to subsist within the unique environmental and ecological conditions of AAR. The strategies identified while creating and critically applying the EHA model to AAR data will be compared to other strategies in North America and around the globe during this same time period to identify similar patterns that may suggest cultural antecedents or extended social networks.

In 2021 there was a call by Dr. Andrew White for researchers working on the AAR to engage more with the terrestrial archaeological record and try to help situate the data in the broader context of Early Holocene North America (White 2021). The dissertation presented here

sets out to accomplish just this. However, it is important to contextualize the scale and scope of this project. Since its inception in 2008, research on the AAR has been conducted by a small team of two primary researchers; Dr. John O'Shea, Dr. Ashley Lemke, and a few professional divers. Fieldwork conducted by this small crew has utilized on one 25-foot research vessel and a single remotely operated vehicle (ROV), to conduct surveys and data recovery in an environment where sites lie in an average of 100+ feet below the water surface and 30-50 miles offshore. Despite these considerable logistical challenges, the data collection and publication output of the project is both substantial and significant, demonstrating the productivity and impact of this focused effort.

Data collection on the AAR has largely concentrated on the documentation of constructed stone features (O'Shea & Meadows 2009; O'Shea *et al.* 2013; O'Shea *et al.* 2014; O'Shea 2015a; Lemke & O'Shea 2017; Lemke 2021, 2022), the recovery of artifacts and sediment samples through scuba-based methods (Lemke 2015a; O'Shea *et al.* 2021), palaeoecological modeling (Sonnenburg 2015; Sonnenburg & O'Shea 2017), and bathymetric mapping of the lake bottom using sonar. This dissertation builds on these results by constructing the comprehensive EHA foraging model using these data. Through comparison of the EHA model to foraging strategies documents in other regions, this dissertation seeks to answer fundamental questions about who may have used the AAR, where these groups might have originated, and what social connections they may have had with other groups in North America and beyond.

A particularly intriguing aspect of the archaeological record of the AAR is its divergence from contemporary terrestrial sites in the Great Lakes Region (GLR). One notable difference is a strong focus on small and expedient tools with a conspicuous absence of bifaces or biface fragments, which are traditionally used as cultural diagnostics for Early Holocene societies in North America. However, there are a few retouch flakes from the edge of bifacial tools. The lack of diagnostic bifaces complicates efforts to determine cultural affinity for AAR foragers. However, by examining the foraging system used by the inhabitants of the AAR—including technological organization, social networks, mobility patterns, and niche construction strategies—this dissertation searches for patterns and similarities with known foraging systems in other regions of North America. The goal is to identify whether comparable foraging adaptations elsewhere might reflect an extended social network or cultural affinity with groups in North America. Although subsistence strategies are not definitive evidence of shared ancestry or direct

interaction, they do provide meaningful pathways for exploring potential long-term, generationally transmitted subsistence strategies and lifeways.

The EHA model draws on a body of theory pertaining to foraging strategies employed by people in newly exposed landscapes following the Last Glacial Maximum (LGM). This includes consideration of human movement into deglaciated northern latitudes and the subsequent abandonment of now-submerged coastal regions due to rising sea levels. Building on this body of theory, this dissertation proposes and critically applies the four-part EHA foraging model to describe the strategies employed by foragers on the AAR.

Across eight chapters, this dissertation undertakes a comprehensive analysis of Early Holocene foraging adaptations on the now submerged landscape of the AAR. By integrating multiple lines of archaeological evidence, it seeks to contribute to broader discussions about cultural connectivity, mobility, and adaptation in the dynamic post-glacial environments of North America. Lastly, the progressive stages of research and subsequent analysis of data described in this report can serve as a road map for future investigations that aim to recover and analyze material from a submerged context. This research considers multiple scales of analysis on the AAR but also focuses on one site in detail, the South Gap site (20AA232). Investigation at Gap focused on creating a high-resolution site map utilizing an autonomous underwater vehicle. Along with facilitating precise sampling, the sonar map produced during this project was instrumental for understanding the social and environmental context of the stone tool industry on the AAR and the complex of constructed hunting features at the South Gap site.

1.2 Organization

Chapter 2 discusses the paleoecology and archaeology of the GLR during the PHT. The chapter highlights three physiographic regions surrounding the GLR including, the woodlands to the east, the Midwestern lowlands to the south, and the Plains to the west. Each of these regions has a unique ecology that experienced a series of changes from the Late Pleistocene to the Early Holocene. These dynamic environments provide the setting for the foraging societies during the PHT in GLR. This chapter emphasizes the distinct archaeological signatures of the three physiographic regions surrounding the GLR, proposing them as potential cultural traditions that may have been socially connected to AAR users.

Chapter 3 provides a survey of microlithic tool technologies from around the world and through time emphasizing their repeated emergence as adaptive responses to environmental change and associated uncertainty. Special attention is given to the Yubetsu microblade technique associated with the Dyuktai culture, whose spread into Alaska and subsequently British Columbia and Alberta signals long-distance cultural networks that may have influenced tool use on the AAR. Finally, the chapter highlights an interaction zone centered in the Pacific northwest around the American and Canadian border where Plano and microlithic technologies were often found together. It is then suggested that this pattern most closely matches the technological organization identified on the AAR.

Chapter 4 introduces the EHA model, a new interpretive framework built around four domains –technology, mobility, niche construction, and social networks– and outlines ten testable expectations for how foraging strategies should shift in response to post-glacial ecological changes. The first seven expectations apply to all of the sites on the AAR in aggregate and predict patterns that are expected to be identifiable at the regional scale. The remaining three expectations are diachronic in character and are expected to be testable only at a subset of sites that experienced more frequent visitation.

Chapter 5 tests the seven regional scale expectations of the EHA model outlined in Chapter 4 and utilizes three categories of data collected between 2010 - 2022, including every identified lithic artifact, constructed stone features and sediment samples. This chapter presents both the methodology and the results of the model testing and offers a critical assessment of whether the empirical data supports the theoretical expectations and if the model requires refinement.

Chapter 6 tests the three diachronic expectations of the EHA model presented in Chapter 4. These expectations are predicted to be observed only at a subset of sites that likely experienced repeated use, and elaboration of stone constructions. This chapter presents both the methodology and results of the model tests and offers a critical assessment of whether the empirical data support the theoretical expectations and if the model requires refinement.

Chapter 7 details a new field research project conducted at the South Gap site between 2020 and 2022. The project used the sites as a case study for caribou hunting that includes constructed stone blinds and drive lanes oriented for seasonal use. The recovered lithic assemblage confirms its function as a hunting and processing site. The field research included

the use of side-scan and sector-scan sonar imaging to map and document submerged features and scuba-based sampling to target sediment in and around cultural and natural features. The chapter also includes an analysis of site function that focuses on the spatial arrangement of natural and cultural site features that make up hunting complex at its core. Where people used multiple structures in tandem to facilitate communal caribou hunting.

Chapter 8 concludes the dissertation with a discussion about how the AAR fits into the mosaic of Early Holocene cultures in North America. It begins with a discussion of four well-documented AAR sites; South Gap, Drop 45, Dragon, and Funnel. The discussion highlights differences in function and seasonality among the four sites; and provides insights into the temporal and behavioral variability in foraging adaptations across the AAR. This foraging system is then compared to an Arctic caribou hunting site in the Yukon to demonstrate the existence of shared foraging strategies stretching across the ecological zone of the Canadian Interior Plains. This highlights the position of the AAR at the eastern edge of a nearly continent-wide interaction zone where people accustomed to using microlithic technologies moved south, while people who predominantly use bifacial tools moved north. The chapter will conclude with a reflection on my experiences conducting archaeology underwater and provide advice for future directions.

1.3 The scientific process

This dissertation represents a theory building exercise that takes into account all of the artifactual and sample data collected from the AAR over the past decade and a half. These data were used to create the four-part EHA foraging model that represents a theory of how people subsisted on the AAR. The model includes ten specific expectations that were created with the existing data gathered between 2008 and 2019. New data gathered during the course of this investigation (2020 - 2022) is combined with the existing data and is used to test each expectation. Based on the results, the expectations will either be supported as is or augmented. After a few more seasons of data collection, the expectations developed here could be tested against the new data from the AAR. The results of that investigation would be used to further refine the model. This process arrives at a better understanding of foraging lifeways with iteration and represents the successful application of the scientific method to archaeological modeling and analysis.

1.4 Notes about dates

Cited dates are presented as they appear in the literature, however uncalibrated dates - often from works before the 1970's when the calibration curves were established- are calibrated using OxCal IntCal20. The calibrated dates are presented in parentheses next to the published, uncalibrated dates. This becomes particularly important for Chapters 2 and 3 that describe the previous research on the use of microlithic tools, and the archaeology of the Pleistocene-Holocene transition in North America. Much of the cited research was published before the wide-spread adoption of calibrated dates.

Chapter 2 Paleoecology and Archaeology of the Great Lakes Region during the Pleistocene-Holocene Transition: Cultural and Environmental Background

2.1 Introduction

Late Pleistocene occupations in North America are predominantly characterized by technological systems centered around the creation and use of fluted points, triangular end-scrapers, and modified flake tools (13,100 - 11,000 Cal. B.P) (Bradley *et al.* 2010; Waters 2019; Gingerich 2019; Smith & Goebel 2018; Waters *et al.* 2011; Haynes 2002; Talbot *et al.* 2021; Nash *et al.* 2024). These versatile stone tools were utilized for resource extraction including hunting, scavenging, and processing of plants and animals across the continent. As the Pleistocene-Holocene Transition (PHT) unfolded however, there was a notable diversification in lithic technologies across North America, with regional variations arising and conforming to major physiographic settings. The Great Lakes Region (GLR) is in the interior of the continent and borders three distinct geographic regions; the incipient woodlands to the east, the Northern Plains to the northwest, and the midwestern lowlands to the south (figure 2.1). Within each of these habitable regions a unique succession of stone tool industries in the Early Holocene arises following the Late Pleistocene fluted point traditions. The Laurentide ice sheet still covers land directly north of the GLR during the PHT (figure 2.1).

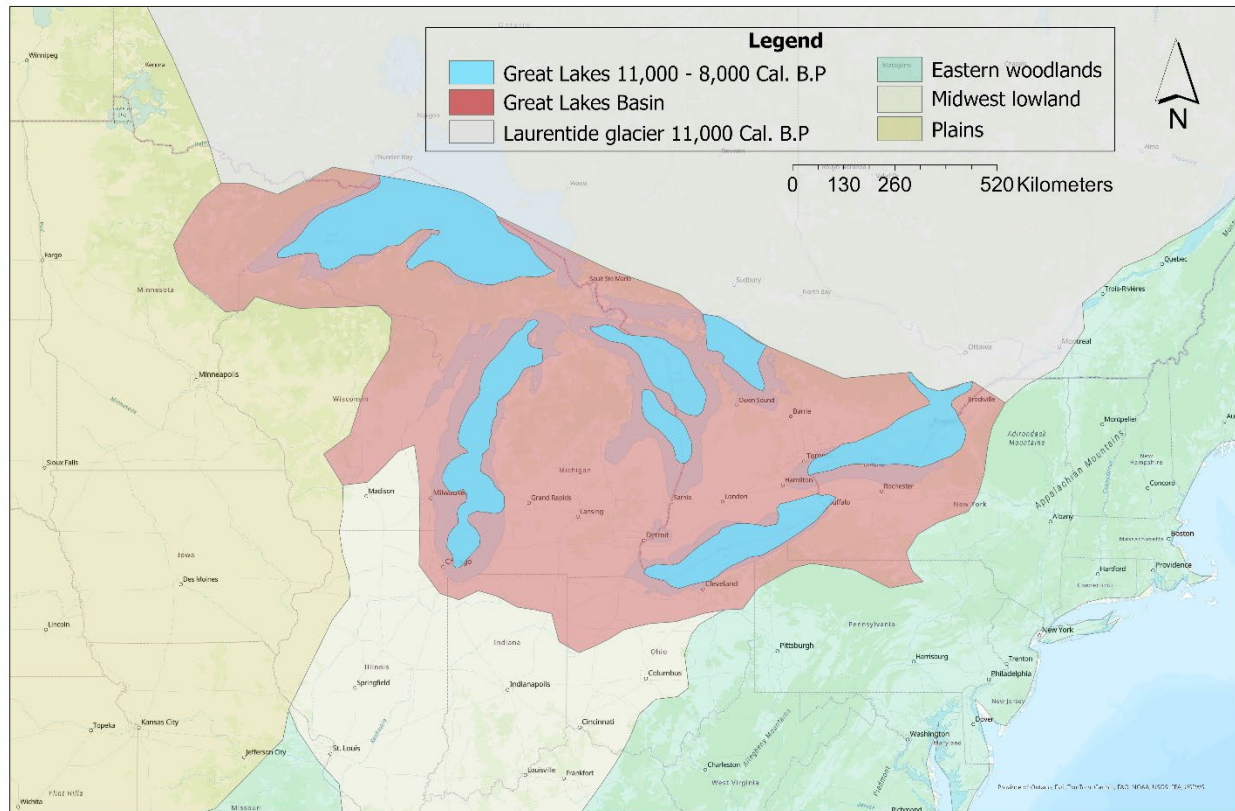


Figure 2.1 Map of the physiographic regions surrounding the Great Lakes during the Pleistocene - Holocene transition ca. 11,000 Cal. B.P.

Due to its central location, the GLR contains evidence for each of the early Holocene technologies found in the neighboring regions. This reality makes it difficult to formulate a model of cultural and technological diversity and to describe the succession of early Holocene technologies in the GLR itself, as different people and materials are moving into the region from different areas using different technologies. There was no technology specific to the GLR in the Early Holocene period (Justice & Kudlaty 2001). To accurately characterize the culture history and mosaic of occupations in the GLR, a broader model is needed that takes into account each of the physiographic regions east of the Rocky's and south of the Arctic.

The complex nature of the early Holocene occupation of the GLR makes it difficult to determine who exploited the AAR and where they may have had social ties; given the absence of recovered diagnostic bifaces to date. This chapter will review each of the unique physiographic regions abutting the GLR, and their associated technological industries. This will include a brief description of the ecologies and how they evolved from the Late Pleistocene into the Early

Holocene, and the succession of technological industries for each region. Creating this model is critical for determining who may have been exploiting the AAR and from where. In subsequent chapters, data from the AAR will be compared with the descriptions of technologies and ecologies from surrounding regions presented here address this important outstanding question.

2.2 Great Lakes environment and lake levels during the Pleistocene-Holocene transition

As the Laurentide ice sheet withdrew at the end of the Pleistocene, much of the water flowed into the Great Lakes basin creating the highwater stand of Lake Algonquin between about 14,000 -11,200 Cal. B.P (Lewis 2016; Lewis 2005) (figure 2.2) (table 2.1). This high stand co-occurs with the Younger Dryas climatic interval, which was a reversal to cold and dry Ice Age conditions during the otherwise general warming at the end of the Pleistocene from about 12,900 - 11,500 Cal. B.P (e.g. Ellis *et al.* 2011; Meltzer & Holliday 2010; Broecker *et al.* 2010; Peteet 1995). In the northern GLR, periodic re-advances of the icesheet served to prolong existing tundra and spruce dominate environmental conditions, including in the Lake Huron Basin (Ellis *et al.* 2011; Larson & Kincare 2009; Lemke 2016: 95; Dalton *et al.* 2020; Sonnenburg & O'Shea 2017).

Table 2.1 Lake stages, time frames, water level, and predominant vegetation in the Lake Huron Basin.

Time Period	Elevation above Mean Sea Level	Lake Stage	Major vegetation
ca. 14,000 - 11,200 Cal. B.P.	ca. 184 m	Lake Algonquin	Spruce dominated parkland
ca. 11,200 - 7,500 Cal. B.P.	ca. 55- 95 m	Lake Stanely	Red and white pine boreal forest, spruce, sedge swamp
ca. 7,500 - 4,000 Cal. B.P.	ca. 160 m	Lake Nipissing	Mixed hemlock, maple, beech forest

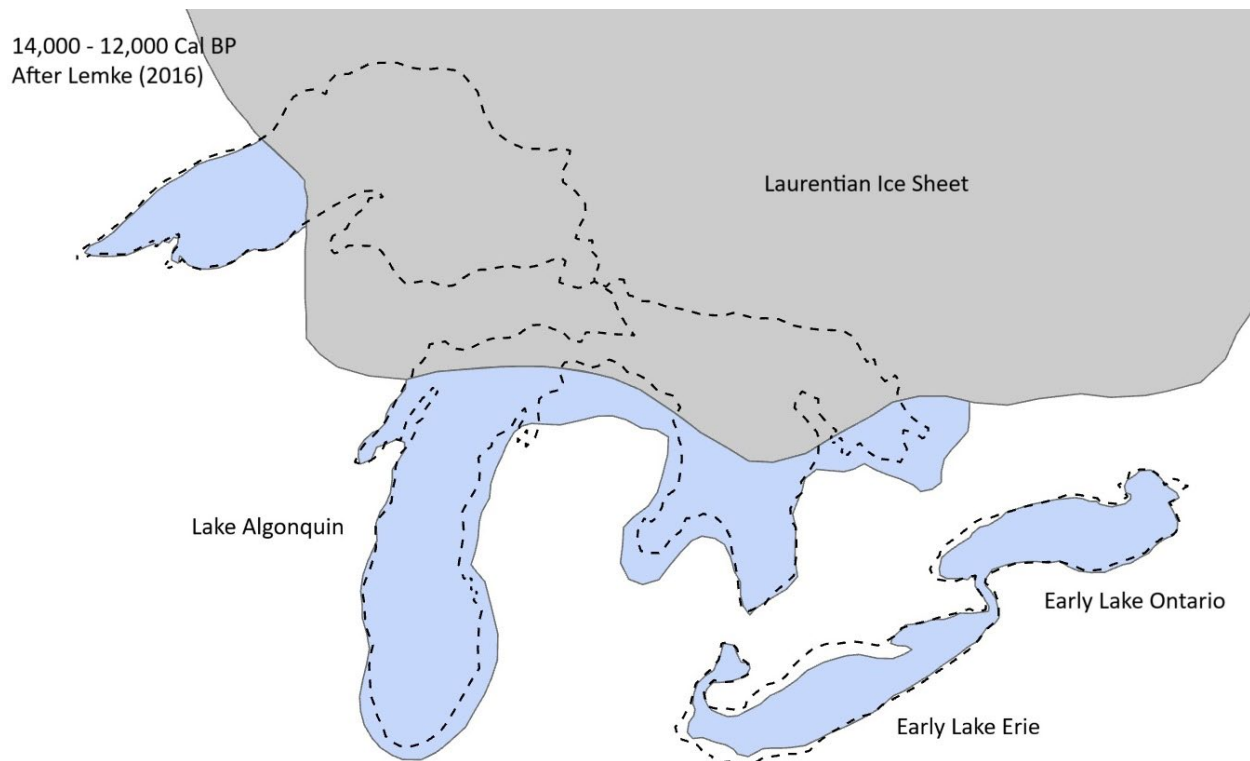


Figure 2.2 Shows the extent of the Laurentian Ice sheet in the Great Lakes region from about 14,000 - 12,000 Cal. B.P and associated proglacial lake Algonquin. (after Lemke 2016).

As the glaciers continued to retreat after the Younger Dryas, new water outlets were exposed that drained much of Lake Algonquin (Larson & Kincare 2009; Lewis *et al.* 2005). Additionally, increased aridity in the early Holocene Great Lakes caused by stronger and more prevalent air masses from the Pacific and Arctic also contributed to a negative water budget, and together led to lake levels lowering significantly (Lewis *et al.* 2005: 205; McCarthy *et al.* 2015: Lemke 2016: 103; Sonnenburg *et al.* 2013). When meltwater from the Laurentide ice sheet was diverted north of the upper Great Lakes through the North Bay outlet around ca. 11,500 Cal. B.P. (Eschman & Karrow 1985; Larson & Kincare 2009; Larson & Schaetzl 2001; Lewis *et al.* 2005; Lewis *et al.* 1994), a drastic decline in lake levels occurred creating more than 50,000 km² of newly exposed land in the GLR (Lewis *et al.* 2005), and forming the isolated and hydrologically closed Lake Stanley in the Huron Basin and Lake Chippewa in the Lake Michigan Basin (Lemke 2016: 102; Lewis 2016; Lewis *et al.* 2005) (table 2.1) (figure 2.3).

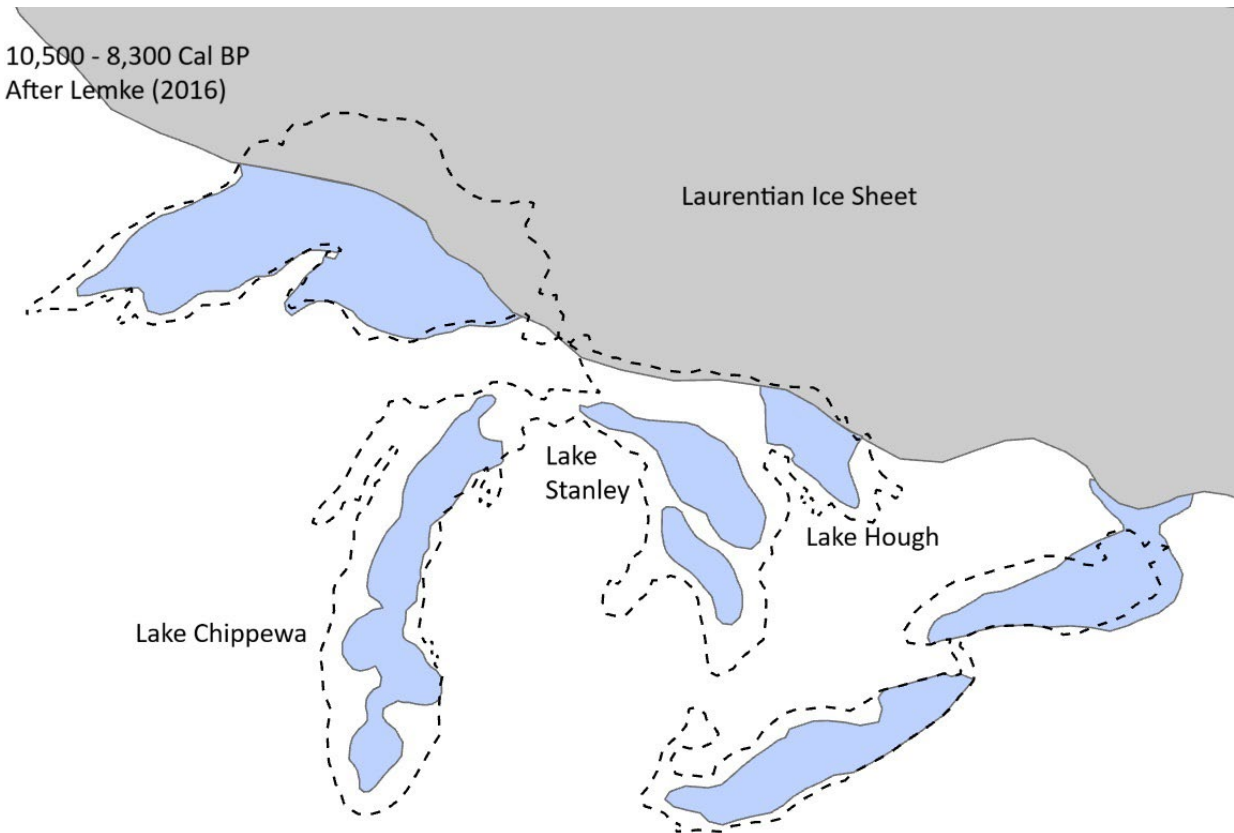


Figure 2.3 Shows the extent of the Laurentian Ice Sheet in the Great Lakes region from about 10,500 - 8,300 Cal. B.P and associated low level lake stands including lake Stanley in the Lake Huron Basin.

Pollen data associated with Lake Stanley period (11,200 - 7,500 Cal. B.P) in the upper GLR show an ecosystem involving a pine (*Pinus*) dominated woodland with additional birch (*Betula*), oak (*Quercus*), elm (*Ulmus*), maple (*Acer*), and spruce trees (*Picea*) (McCarthy *et al.* 2015). More broadly, this indicates a mosaic of paleoenvironments during Lake Stanley, including patches of open subarctic spruce taiga, and pine-dominated, mixed forests (McCarthy *et al.* 2015). This provides a broader picture of environments surrounding the AAR, which has been characterized as an open, sub-arctic spruce/sedge environment (Sonnenburg & O'Shea 2017) (see Local Environment of the Alpena-Amberley Ridge During Lake Stanley section below).

Following the Lake Stanley lowstand, the ice sheet fully retreated from the GLR resulting in isostatic rebound that uplifted the landmass and closed water outlets that drained Lake Stanley. Water levels ultimately rose to a little over modern levels but less than proglacial lake

Algonquin, forming the post glacial Lake Nipissing, ca. 7,500 - 4,000 Cal. B.P (Lewis 1970; Larsen 1985; Monaghan *et al.* 2005; Lewis *et al.* 2005; Lemke 2016: 91-94) (table 2.1) (figure 2.4). The Lake Nipissing period is correlated with the mid-Holocene Altithermal characterized by warmer and wetter climates in the GLR (McCarthy *et al.* 2015; Eyles *et al.* 2015). Preserved cedar (*Cedrus*), pine (*Pinus*), spruce (*Picea*), hemlock (*Conium*), and ash (*Fraxinus*) tree stumps in south Lake Huron provide firm evidence that middle Holocene environments in the basin could be described as mixed deciduous hemlock, beech, and maple forests, within a more variable but slightly warmer climate than today (Hunter *et al.* 2006). Modern lake levels were reached in the Great Lakes by the end of the middle Holocene around 4,000 Cal. B.P (Larsen 1987).



Figure 2.4 Shows water levels during the high stand of Lake Nipissing stage from about 7,500 - 4,000 Cal. B.P.

2.3 The local environment of the Alpena-Amberley Ridge during Lake Stanley

The newly exposed land during the lowstand of Lake Stanley that comprises the AAR was part of the ancient lakebed of Lake Algonquin. This wet and sediment rich land was highly productive for the cold climate and supported the development of sedge swamps with scattered spruce trees that were eventually accompanied by pine and other conifers as the ecosystem developed throughout the Early Holocene (McCarthy *et al.* 2015). These new areas would have supported ungulates such as caribou with its open landscape and emerging vegetation regimes (Lemke 2016: 101-106). Moreover, that the landform forms a continuous causeway across the Lake Huron Basin from the northwest to the southeast provides a land bridge for migrating animals to cross the basin on yearly migratory routes.

A robust environmental reconstruction of the local environment on the AAR was conducted by Sonnenburg and O'Shea (2017). Over 60 sediment samples from the AAR were analyzed for properties including size, sorting, morphology, and sources to help characterize the depositional environment to help assess site formation and taphonomic processes. The authors also examine organic and carbonate content from the sediment samples, including testate amoebae, and organic materials. These environmental indicators considered alongside macro-botanical remains such as trees still rooted on the bottom of the lake, and charcoal samples recovered by scuba divers, confirm that the AAR had a boggy, sub-arctic climate, with scattered conifer trees during the Lake Stanley lowstand. A strong lake effect from water bodies on both sides of the AAR contributed to the relatively colder and more snowy climate on the AAR than other portions of the GLR during this period (see Griggs *et al.* 2022; Davis *et al.* 2000; Wright *et al.* 2013).

The earliest portion of Lake Stanley experienced the most drastic drop in lake levels reaching a low of 55-80 meters above modern sea levels (table 2.2). This would have exposed the largest surface area of land that included the AAR and a large mass of land in the northern portion of the Lake Huron Basin. This land could have been exploited by Late Pleistocene hunter gatherers in the GLR using relatively early technologies, such as Hi-Lo. The Middle Lake Stanley period saw higher water levels and would have left the AAR as a narrow land bridge running northwest to southeast across the Huron Basin. The later period of Lake Stanley saw relatively stable water levels that eventually rose drastically to usher in the end of Lake Stanley and represents the last time the AAR was exposed as traversable dry land.

Table 2.2 Summarizes the water level changes and associated time periods within the Lake Stanley lowstand.

Low water stage	Date (Cal. B.P.)	Elevation above mean sea level
Early Lake Stanley	ca. 11,200 - 10,000	55 - 80 m
Middle Lake Stanley	ca. 10,000 - 8,500	85 - 100 m
Late Lake Stanley	ca. 8,500 - 7,500	90 - 95 m

2.4 Physiographic regions surrounding the Great Lakes

Regional paleoenvironmental conditions surrounding the GLR at the end of the Pleistocene and into the Holocene were marked by diverse and dynamic ecological transformations. Though the changes were distinct for each surrounding physiographic region, they were also deeply interconnected and created a complex environmental mosaic that shaped the context for early human settlement. The Eastern Woodlands, Northern Plains, and Central lowlands each experienced unique vegetation transitions in response to deglaciation and climate change, yet all reflect broader patterns of post-glacial ecological succession. Palaeoecological data—including pollen records, sediment cores, and fossil assemblages—show shifting vegetation regimes across millennial timescales. These transitions offer context for understanding how deglaciated environments were recolonized by flora and fauna and, ultimately, by human populations. By comparing these regions, it is possible to trace the pace and direction of forest migration as well as the timing of the emergence of key arboreal communities. These environmental changes not only transformed local ecologies but also influenced the resources and habitats available to early foragers in the region.

2.4.1 *Eastern Woodlands*

The northern portion of the Eastern Woodlands, spanning from Pennsylvania to Maine, shares its eastern boundary with the GLR. Recent pollen records from the Twin Lakes sediment core in Vermont align with temperature proxies from oxygen isotope analysis, revealing that the Late Pleistocene (13,000 - 12,000 Cal. B.P) experienced a cold climate and vegetation conditions

resembling modern boreal forests and taiga in eastern and midcontinental Canada (Grigg *et al.* 2021: 194; Shuman *et al.* 2002; Webb 1987). Following these conditions, the pollen record indicates centennial-scale changes during the terminal Pleistocene (11,600 - 10,800 Cal. B.P), indicating a rapid transition from mixed conifer forest to shrub birch and finally to pine/oak forest (Grigg *et al.* 2021: 200). The Early Holocene (10,800 - 9,000 Cal. B.P) is characterized by increased pollen diversity from arboreal taxa, featuring the first significant appearances of *Tsuga Canadensis*, *Acer*, *Ostrya/Carpinus*, and *Ulmus* (Grigg *et al.* 2021: 194). Despite this diversity, the pollen records suggest *Pinus* dominance (40% - 50%) during this period, with a decline in *Betula* pollen to 10% and a corresponding increase in *Quercus* pollen up to 25% (Grigg *et al.* 2021: 194; Oswald *et al.* 2018; Yu 2003; Foster *et al.* 2006; Whitlock *et al.* 1993; Bernabo & Webb 1977).

2.4.2 Northern Plains

The expansive Northern Plains stretch from the Dakotas to Manitoba and Saskatchewan, bordering the western edge of the GLR. This region was largely covered by the Laurentide Ice Sheet during the late-Wisconsinan glaciation (ca. 35,000 - 18,000 Cal. B.P) (Dyke & Prest 1987; Peterson 1986; Person *et al.* 2007). This resulted in an upland glacial till plain, characterized by large shallow lacustrine basins that were once glacial lakes which serve as significant repositories of paleontological evidence in the form of plant and animal fossils of Late-Pleistocene and Holocene age (Yansa 2006; Holliday *et al.* 2002). These data from buried spruce logs, coeval paleosols, and mammoth fossils support the reconstruction of an open spruce parkland environment that was composed of an assemblage of prairie, parkland, and boreal environments (Yansa 2006: 277). This interpretation is supported by Grimm *et al.* (2001a) who examined sediments containing pollen and macrofossils from spruce from the Northern Plains. Grimm *et al.* (2001a) describes a substantial decline in spruce abundance, occurred between about 13,200 and 11,000 Cal. B.P, and led to a relatively brief interval characterized by a deciduous forest environment, that ultimately transitioned to a predominantly treeless grasslands after about 11,500 - 10,000 Cal. B.P (Mason *et al.* 2008: 1774).

The informative study by Yansa (2006) models the northern migration of Spruce taxa and serves to describe the timing for the spread of spruce parkland environments into the recently deglaciated areas of the Northern Plains. The model holds that white Spruce existed on the South

Dakota - Nebraska border, immediately south of the Late-Wisconsinan glacial limit around 15,000 Cal. B.P. The onset of spruce migration into deglaciated South Dakota is poorly dated. However, by 15,020 -14,300 Cal. B.P white spruce had reached northern South Dakota. By 12,930 Cal. B.P it had arrived in central North Dakota, and by 12,100 Cal. B.P it had migrated to southern Saskatchewan, and sometime before about 10,930 Cal. B.P, reached southern Manitoba near the northwest portion of the GLR (Yansa 2006: 278).

2.4.3 Interior Lowlands

Filling the space between the Woodlands to the East and the Plains to the West is the interior lowlands of the Midwest, abutting the GLR to the south. This large, multi-lobed shallow basin spanning from central Illinois to eastern Ohio and was carved out by successive glaciation events over the past few hundred thousand years. The most recent glaciation of this area reached a maximum extent around 17,500 Cal. B.P or so and covered the northern $\frac{3}{4}$ of Ohio and Indiana (Dalton *et al.* 2020). The succession of vegetation is similar to the neighboring Eastern Woodlands, where Spruce forests covered the Interior Lowlands at the end of the Pleistocene before declining rapidly around 11,500 Cal. B.P (Grimm *et al.* 2001b). Glover *et al.* (2011) reports the transition from a Spruce to hardwood forest at about 11,240 Cal. B.P, from sediment cores in central Ohio and eastern Indiana. Additionally, pollen records from lake sediment from Pretty Lake in Northeastern Indiana show that by 11,000 Cal. B.P the area was briefly dominated by a pine forest before quickly giving way to a mixed deciduous forest by 10,000 Cal. B.P (Grimm *et al.* 2001b: 339; Counts *et al.* 2015: 75). As in the other North American regions, the change in vegetation is seen as a consequence of the transition to warmer climates (Glover *et al.* 2011).

2.5 Technologies of the Great Lakes Region and surrounding areas

Each of these neighboring regions described above has its own archaeological expression during the PHT that includes diagnostic bifacial projectile point forms (table 2.3). People on the Northern Plains abutting the GLR to the west were using Plano technology defined by its distinctive comedial flaking pattern (Knell 2007: 129-232). Additionally, a microblade industry associated with the Late Denali complex often co-occurs with plano technology on the western

portion of the northern plains, primarily in British Columbia and Alberta (Magne *et al.* 2020; Wilson *et al.* 2011; Younie *et al.* 2010; Le Blanc & Ives 1986; Sanger 1968). The woodlands to the east and southeast of the GLR exhibit early corner notched bifacial points often referred to as Kirk technology (Ellis *et al.* 1991), while in the midwestern lowlands to the south, a bifurcate base point technology is prevalent (Hickson *et al.* 2008; Mohow 1987; Fitting 1964).

Table 2.3 List of regions surrounding the GLR during the PHT with associated technologies and their dates and references for the environment.

Calibrated Dates (Cal. B.P.)	Technology (Radiocarbon Dates)	Region	Environment	References for the environment
12,000 - 6,000	Microblade	Northern Plains	Upland glacial till plain with large shallow lacustrine basins	Yansa (2006); Holliday <i>et al.</i> (2002); Grimm <i>et al.</i> (2001a); Mason <i>et al.</i> (2008)
12,040 - 10,115	Hi-Lo (10,400–9,000 ¹⁴ C yr B.P.)	Eastern Woodlands	Pine-dominated mixed forest	Fitting (1963); Ellis (2004); Morse (1997a, 1997b); White (2013, 2016); Koldehoff & Walthall (2009); Lothrop <i>et al.</i> (2016); Ellis & Deller (1982)
12,040 - 10,115	Hi-Lo (10,400–9,000 ¹⁴ C yr B.P.)	Interior Lowlands	Hardwood forest	Grimm <i>et al.</i> (2001b); Glover <i>et al.</i> (2011); Counts <i>et al.</i> (2015)
11,146 - 9,009	Kirk (9,800–8,000 ¹⁴ C yr B.P.)	Eastern Woodlands	Pine-dominated mixed forest	Fitting (1963); Ellis (2004); Morse (1997a, 1997b); White (2013, 2016); Koldehoff & Walthall (2009); Lothrop <i>et al.</i> (2016); Ellis & Deller (1982)
10,645 - 8,191	Plano (9,500–7,500 ¹⁴ C yr B.P.)	Northern Plains	Upland glacial till plain with large shallow lacustrine basins	Yansa (2006); Holliday <i>et al.</i> (2002); Grimm <i>et al.</i> (2001a); Mason <i>et al.</i> (2008)
9,437 - 8,005	Le Croy (8,500–7,300 ¹⁴ C yr B.P.)	Interior Lowlands	Hardwood forest	Grimm <i>et al.</i> (2001b); Glover <i>et al.</i> (2011); Counts <i>et al.</i> (2015)

It is important to note the nearly complete absence of radiocarbon dates for sites in the GLR during the Late Pleistocene period and the very limited dates for the PHT. This has led to a model of cultural diversity for the GLR that is based on analogy and the dating of similar lithic technologies in neighboring regions, rather than one built with data from sites within the GLR (Ellis *et al.* 2011; Justice & Kudlaty 2001; Morrow 2005; Ellis & Deller 1990). The mosaic of overlapping culture patterns that we see during the PHT in the GLR is markedly different from the preceding Late Pleistocene periods where fluted point technology was widespread (Ellis *et al.* 2011; Justice & Kudlaty 2001). Accompanying the use of fluted points in the preceding periods was the employment of an embedded lithic procurement strategy where an intimate knowledge of the landscape allowed people to regularly visit sources of high-quality stone that occurred in large packages (Ellis *et al.* 2011). This is in contrast to observations on the AAR, where recent work suggests a unique cultural expression within the novel ecological niche (Lemke & O'Shea 2019). This research will provide data to help integrate the submerged record of the Lake Huron Basin with contemporary sites and materials on land.

2.5.1 Hi-Lo

A few different technologies/styles of bifacial points occur in the GLR and surrounding physiographic regions during the PHT. The earliest are Hi-lo points that are considered to be a midwestern variant of the Late Paleoindian Dalton technology that occurred throughout North America west of the Rockies (Ellis 2004; Koldehoff & Walthall 2009; White 2013: 84; Lothrop *et al.* 2016: 209). After being first reported by Fitting (1963), isolated finds of Hi-lo points have been reported across the southern GLR from Minnesota, Wisconsin and into Illinois (Ellis 2004: 58). Although several sub-types have been proposed (Ellis 2004: 63-64), in general, Hi-lo points are relatively thick with a moderate basal concavity, short end-thinning facets, heavy grinding of the lateral and basal edges, pronounced ears, while lacking the parallel co-medial flaking seen in Plano technology on the Plains (Jackson & Hinshelwood 2004; Ellis 2004: 62) (figure 2.5). Like most other bifacial technology at this time, they are often beveled, reworked, and likely served as multi-function tools (Ellis 2004; Ellis & Deller 1982; Mason 1981: 111-139). The Hi-lo occupation of the GLR seems to represent small groups and short occupations as there is no evidence of cemeteries, formalized exchange, or large base camps such as those associated with the broader Dalton phase in other regions (Morse 1997a,b; White 2012).



Figure 2.5 Shows two Hi-Lo points from the Great Lakes Region. Photo Credit to the Michigan Archaeological Society.

Although Hi-lo points have not been directly dated in the GLR, Ellis (2004: 69) suggests that they overlap with Plano in Ontario. This fits with the dating of morphologically similar points in Texas and the Southeast referred to as San Patrice, found just above Dalton points in Texas and have been dated to between 10,400 - 9,000 ^{14}C . yr B.P [12,040 - 10,115 Cal. B.P] (Anderson & Smith 2003; Bousman *et al.* 2004; Lopinot *et al.* 1998, 2000; Jennings 2010). The occurrence of Hi-lo points forms a continuous distribution with San Patrice points from the South and Southeast, that extends up through the Midwest and into the GLR, where they are fairly common (Ellis & Deller 1982), particularly Southern Ontario, Michigan, and Northern Illinois (Dickson 2011) (figure 2.6). In Ontario, archaeologists have recovered Holcombe, Hi-Lo, and Plano points on the bed of Lake Algonquin, demonstrating that these biface forms must postdate the draining of Lake Algonquin (Lothrop *et al.* 2016: 207).

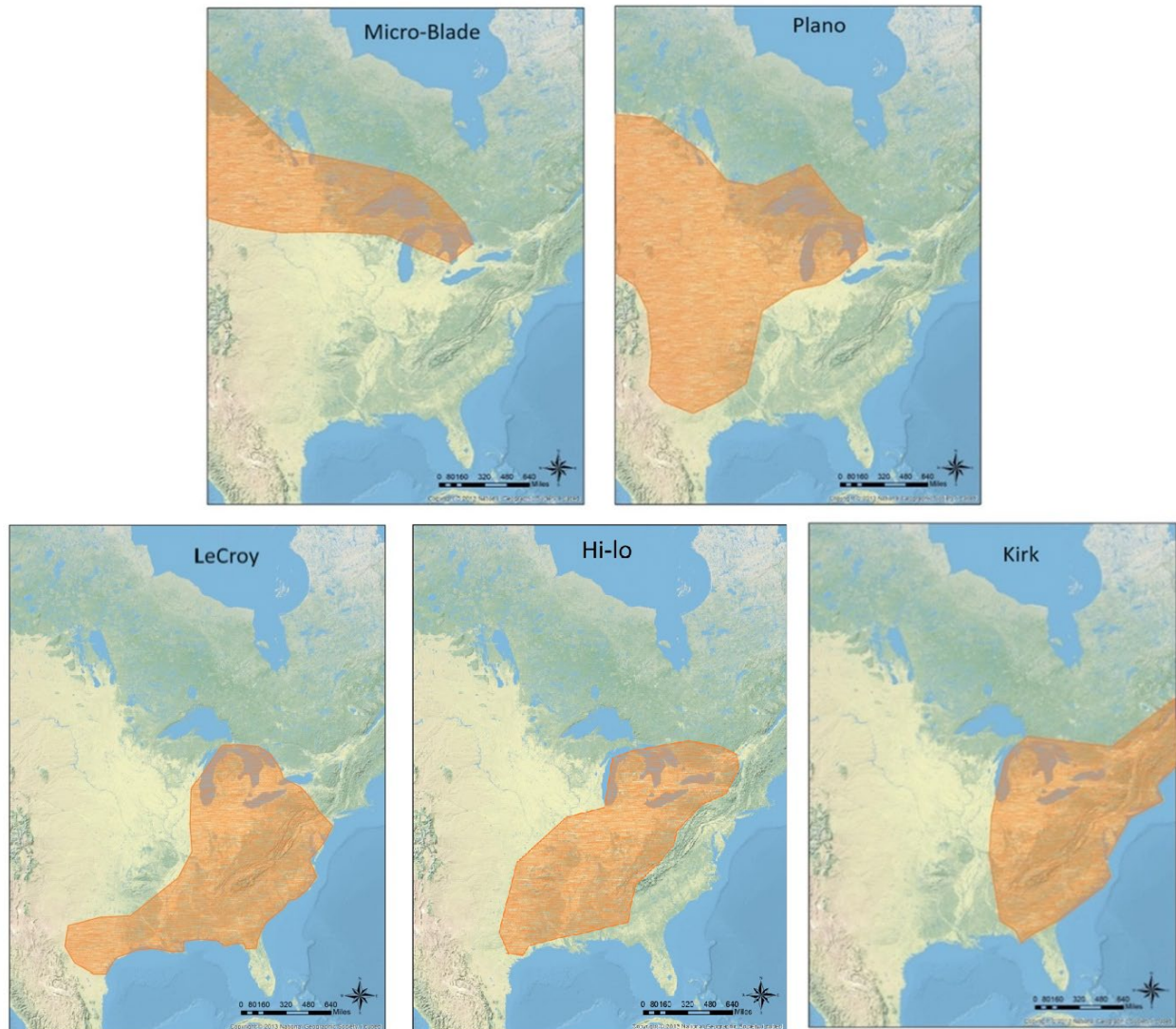


Figure 2.6 Shows the core range for techno-complexes in and surrounding the GLR during the PHT.

2.5.2 *Kirk corner notched*

Following Hi-Lo points in the GLR are early corner notched points referred to as Kirk points (figure 2.7). Although these points have not been directly dated in the GLR, Kirk style points have been recovered in stratified and dated context at many sites in the southeastern Woodlands including, the Topper site in South Carolina (Anderson *et al.* 2016), and at series of sites along the lower Little Tennessee river valley (Chapman 1977: 161-163). Dust Cave in northern Alabama also contained early corner notched Kirk points in stratified context, where researchers date them to between about 9,000 ^{14}C . yr B.P [ca. 11,146 Cal. B.P] and 8,000 ^{14}C . yr

B.P [ca. 9,009 Cal. B.P] based on dates derived from above and below the component containing the points (Driskell 1994: 26).



Figure 2.7 Image of two Kirk Corner Notched points. Photo credit to the Michigan Archaeological Society.

In the Midwest, the St. Albans Site in Kanawha County West Virginia has yielded some of the best stratified Early Archaic data. Researchers at the site recorded a broad sequence of Early Archaic bifacial forms with a series of associated radiocarbon dates. The sequence begins with side notched points dating to about 7,900 $\pm$ 500 B.C.) [ca.10,162 Cal. B.P]. Next, Kirk corner notched points of varying sizes overlay the side notched points and date to between 6,900 $\pm$ 320 to 6,850 $\pm$ 320 B.C. [ca. 9,264 - 9,130 Cal. B.P]. Above the Kirk points were a series of bifurcate stem forms dating between 6900 $\pm$ 320 to 6300 $\pm$ 100 B.C [ca. 9,264 - 9,085 Cal. B.P] (Lennox 1993: 56; Broyles 1971: 49).

Additionally, at the Longworth-Gick Site in the Falls of the Ohio region in Kentucky, discrete Early Archaic deposits contained small Kirk corner notch points were associated with radiocarbon dates of 7816 $\pm$ 237 B.C. [ca. 10,560 Cal. B.P] and 6735 $\pm$ 391 B.C. [ca. 9,402

Cal. B.P], and larger Kirk corner notched bifaces were recovered from an overlying deposit with an associated date of 6,732 +/- 128 B.C. [ca. 9,540 Cal. B.P] (Collins 1979a; Mohow 1987: 65).

In New Jersey, at the West Creek site (28OC45) researchers discovered evidence of "pockets" of calcined human bone fragments. Associated with these cremation burials were Kirk-Corner notched points and a very small number of scrapers. One of these features produced a carbon sample which dated to 9,850 +/- 160 ¹⁴C. yr B.P [ca. 10,755 Cal. B.P]. Kirk points were found in the pockets and in the soil above the pockets in the same locus, indicating that this is an early date for Kirk at the site (Stanzeski 1998: 42-43).

At each site where early corner notched points occur in stratigraphic context in the southeast and Midwest, they are found below early split stem LeCroy points, and above Dalton or side notched associated with Hi-lo technology. Dates from these sites indicate an age of between about 9,500 ¹⁴C. yr B.P [ca 10,560 Cal. B.P] to 8,500 ¹⁴C. yr B.P [ca. 9,261 Cal. B.P] (see Ellis *et al.* 1998: 161). Although Kirk corner notched points have not been found in stratified context in the GLR, they occur commonly in Michigan and Ontario with the Nettling site in Southwest Ontario being a notable example (Ellis *et al.* 1991).

2.5.3 *LeCroy bifurcates*

LeCroy is a bifacial, early split-stem technology (figure 2.8) that occurs in deposits overlaying early corner notched Kirk technology at several sites in the Midwest, including at the St. Albans site reviewed above and Eastern Woodlands from Michigan to Texas where it is referred to as Gower. The dates and stratigraphic position of LeCroy in the GLR and the Midwest align well with what we know about the dating of Gower in Texas (Oksanen 2008; Williams 2018; Collins 2004). It appears that there is a continuous occurrence of this technology throughout the Eastern Woodlands, including at the Topper site in South Carolina (Goodyear *et al.* 2019), and the Midwest extending from GLR to central and east Texas (figure 2.6). Dating from the Deep Shelter (Dorwin & Warholic 1970) and Longworth-Gick sites (Collins 1979b; Morow 1987:65) in Kentucky align well dating of LeCroy from the St. Albans site and are reported as 6,570 +/- 470 - 5,290 +/- 550 B.C. [ca. 9,079 - 7,574 Cal. B.P] , and to 6,715 +/- 113 B.C. [ca. 9,537 Cal. B.P] respectively. In the GLR the Kassel and Blue Dart sites in Ontario are the best excavated examples of this technology and are associated with a C14 date on white pine

charcoal from a cultural feature dating to 8320 +/- 60 ¹⁴C. yr B.P [ca. 9,130 Cal. B.P] (Lennox 1993: 20).



Figure 2.8 Image of two LeCroy Bifurcate points from the GLR. Photo Credit to the Michigan Archaeological Society.

2.5.4 Plano

Plano technology is part of the larger Cody complex and consists of characteristic co-medial, parallel flaked, lanceolate to slightly stemmed, bifaces with a prominent central ridge where flakes from each edge terminate, often in a patterned fashion (figure 2.9). Most researchers accept that Plano biface varieties in the GLR include Agate Basin and Eden/St. Anne-Varney forms, and are intrusive from the High Plains (Lothrop *et al.* 2016: 208). Plano technology is wide-spread with its core area on the Plains spanning as far south as central Texas where they are referred to as Scotts Bluff (Bousman *et al.* 2004: 74), all the way north to Alberta and British Columbia (Magne *et al.* 2020).



Figure 2.9 Image of Cody Complex points Photo credit to David Nix and Meagan Schoenfelder and the State Historical Society of North Dakota.

The term Scottsbluff comes from a location in western Nebraska where the point was first identified and dated (see Neuman 1967). They also occur commonly in the on the GLR from the north shore of Lake Superior as part of the Lakehead Paleoindian complex (Fox 1975, 1977; Dawson 1983; Julig 1984, 1994; Julig *et al.* 1990), and on Manitoulin Island at the Sheguiandah

site (Julig 2002a,b; Lee 2013), to the Eastern GLR and into New England Maritime area (Lothrop *et al.* 2016: 208). Plano is the first well dated technology in the GLR. Both the Cummins and Sheguiandah sites have associated dates that support the idea that Plano in the GLR is contemporary with Plano on the Plains. A fragmentary cremation burial from the Cummins site of the Lakehead complex was dated to 8,480 +/- 390 ¹⁴C. yr B.P [9,005 Cal. B.P] and occupations at the site across several other localities date to between 9,500 - 7,500 ¹⁴C yr B.P [ca.10,500 - 8,150 Cal. B.P] (Julig *et al.* 1990: 42-44). Initial occupation at Sheguiandah has also been dated to around 9,500 ¹⁴C yr B.P [ca. 10,550 Cal. B.P] and ending around 7,000 ¹⁴C yr B.P [ca. 7,700 Cal. B.P] (Julig & Mahaney 2002: 120-134).

2.5.5 Microlithic technology

The microlithic tradition in the Americas begins in Alaska, where micro-blades become prominent around 14,000 Cal. B.P as evidenced by Yubetsu technology at the Swan Point site and others in the Tanana River Valley (Hirasawa & Holmes 2017; Coutouly & Holmes 2018). In Alaska, this technology is commonly attributed to caribou hunting societies (Magne *et al.* 2020). The technology involves creating microblades by removing slivers of stone from the edge of a bifacial core, rather than from a conical or irregular shaped core. In earlier periods this technology had spread across eastern Siberia and northeast Asia beginning at the end of the last glacial maximum around 18,000 Cal. B.P (see Chapter 2). The spread of this technology is thought to represent the recolonization of northern latitudes in Asia as the icesheets retreated, and Holocene habitats took root (Holmes 2001: 156). The Yubetsu microcore technology is replaced by the more diverse microcore forms associated with the Denali complex dating to between 12,000 - 6000 Cal. B.P (Potter 2008a: 184). However, the basics of Yubetsu technology including removing microblades from the edge of a bifacial core remains a common feature of Denali toolkits (Magen *et al.* 2020: 89).

Further south across the northern Plains, from British Columbia to Manitoba, microblade technology spanned the PHT, and often occurs in association with Plano technology (Magne & Fedje 2007; Potter 2008b; Wilson *et al.* 2011; Magen *et al.* 2020: 89). The microblade technology from Alberta and the northwestern Plains is characterized by wedge-shaped, Yubetsu like, core types. Magen *et al.* (2020: 90) link this technology to the early Holocene phases of the Denali complex in Alaska. They point out that by 11,000 - 10,000 Cal. B.P, the Denali and Plano

cultural complexes were both arriving in the deglaciated corridor from their respective directions as the landscape was evolving into a broad northern Plains grassy parkland (Beaudoin *et al.* 1996).

2.6 Discussion

As Holocene environments took hold in North America, the late glacial landscapes of spruce parklands and pine forests gradually transitioned into more hospitable mixed forests. These new environments provided a greater variety of foods and raw materials (Fredlund *et al.* 1996; Grimm & Jacobson 2004). This likely resulted in an increase in available, more easily obtainable calories across the landscape that could support higher birth rates and contribute to the expansion of hunter-gatherer populations following the Late Pleistocene (see Kelly 1995: 137-165; Binford 1980: 5-7; Warden *et al.* 2017).

Accompanying these changes is a major shift in prey species availability with deer largely replacing caribou in the GLR (Lemke 2015b). In response to these environmental and demographic changes, foraging strategies likely shifted not only because of the redistribution of resources, but also in response to changes in the social landscape. As competition for resources increased with higher population densities, less mobile communities effectively create “interaction spheres” (Caldwell 1964; Wolf 1982; Sutton 1989) or “communities of practice” (Lave & Wenger 1991; Wenger 1999; Knappett & Van Der Leeuw 2014). These groups may have become increasingly socially distinct, leading to diversification in stone tool technologies as knowledge transmission became more localized and socially bounded within communities.

Stone sourcing patterns from the Midwest and Northeast provide evidence that supports these changes and show that predominantly north - south movement of materials (over distances of about 300 km) during the Late Pleistocene transitions to often shorter but sometimes longer east - west patterns in later periods (Ellis 2011). This suggests a broader shift from wide-ranging seasonal migrations to more localized settlement patterns, with increased reliance on nearby stone sources and expanded trade for non-local materials. Additionally, increasing population densities and reduced mobility may be the driver for the proliferation of cemeteries during the Early Archaic period. The earliest known cemetery in the Americas is the Slone-Dalton site in Arkansas, dating to around 11,500 Cal. B.P (Smallwood *et al.* 2018; Morse 2017; Walthall 1998). This site contained approximately 20 clusters of calcined human bone along with grave

goods such as intact Dalton points (related to Hi-Lo types), adzes, and scrapers that demonstrate cremation burial practices (Morse 2017).

Continuing this pattern, Early Archaic cremation burials associated with Kirk-style projectile points were recorded at the Weast Creek Site (28OC45) in New Jersey. Clusters of calcined bone fragments were recovered from pit features resembling those at Slone. Material from one of these features was radiocarbon dated to 9,850 $\pm$ 160 ^{14}C . yr B.P [ca. 10,755 Cal. B.P] (Stanzaski 1998: 42-43). The presence of Kirk corner notched points both within and above the burial layer indicates repeated use of the site by groups employing the Kirk technology. This suggests not only continuity of occupation but a deliberate return to a specific landscape marked by ancestral burials; an early indication of territoriality and land claims through burial practices (see Rowley-Conwy & Piper 2016; Winter-Livneh *et al.* 2012; Saxe 1970; Chapmen 1981). Moreover, a single cremation burial at the Cummings Site on the northwest shore of Lake Superior was associated with Angostura/Agate Basin and Plano-style points, dating to approximately 6,530 $\pm$ 390 B.C. [ca. 8,555 Cal. B.P] (Julig 1984; Julig 2002a,b; Dawson 1983). This burial, tied to the Lakehead Complex near Thunder Bay in Ontario, was located on an abandoned beach from the Lake Minong high-water phase of the Superior basin, which ended around 9,500 ^{14}C . yr B.P [ca. 10,550 Cal. B.P] (Clayton & Teller 1983; Julig 1984).

Interestingly, microlithic tools were recovered at the edge of one Early Archaic locus at the Weast Creek Site in an area where no projectile points or fragments were found (Stanzaski 1998: 42). This pattern suggests that microlithic tool use extended to the Atlantic coast of New Jersey during the Early Archaic. Such evidence aligns with the broader trend of microlithic technology diffusing from the Northwest to the Southeast during the Holocene, as noted by Magne (2023). Alternatively, the presence of these tools might indicate contact or overlap between groups from different regions; another potential marker of growing intergroup competition and the need to assert territorial claims through land use and burial.

2.7 Conclusion

Taken together, the increased regionalization of biface technology during the Early Holocene in North America –marked notably by the invention and spread of stemmed and notched projectile point bases– reflects a broader diversification of technological strategies. This stands in contrast to the preceding Late Pleistocene period, when populations across the

continent commonly employed similar lanceolate-shaped and fluted projectile points. Alongside these technological shifts, we also see the emergence of new cultural expressions, such as cremation burials and formal cemeteries. These practices suggest a reduction in residential mobility and a rise in territorial behavior, possibly reflecting more stable, regionally bound communities.

When considering who may have utilized the AAR and constructed hunting structures on it during the Early Holocene, the diversity of technological strategies in and around the GLR - that are shared across adjacent physiographic zones- offers both challenges and opportunities for interpretation. If the technological strategies found on the AAR are more similar those of a specific neighboring region, this may offer evidence about the identity or social affiliations of the groups using the landscape.

It is plausible that a resident population based primarily in the GLR was responsible for exploiting the AAR. However, the possibility remains that, at this point in the Early Holocene, the region was used primarily by seasonal visitors. In either scenario, determining the origins or social affiliations of AAR users is complicated by the lack of distinct, region-specific technologies. Instead, the technological systems documented across the Early Holocene show broad distributions that extend into the GLR but are not exclusive to it. A detailed examination of the subsistence strategies employed on the AAR –and a comparison with similar patterns elsewhere– may help illuminate where such practices originated and, by extension, the cultural affiliations of those who used them.

Chapter 3 Small Tools Around the Globe: A Survey of Small Tools Through Time

3.1 Introduction

Some of the earliest technologies associated solely with modern *Homo-sapiens* are industries that involve microlithic tools. These were dubbed “mode 5” technologies by J.D Clark in (1969) in his famous book *World Prehistory: A New Outline*. These industries involve creating small, sharp pieces of stone that are often inset into organic hafts to create cutting edges for composite hunting and processing tools, including harpoons, dart points, knives, scrapers, and burins. Historically, the use of small tools is discussed as a strategy of mitigating resource uncertainty, often due to large-scale environmental change (Ambrose 2002; Elston & Brantingham 2002; Kuhn & Elston 2002; Jochim 1989, 1996; Pazan *et al.* 2023). The transition from cold Pleistocene climates to warmer Holocene environments represented a major global change for foragers and seems to coincide with widespread adoption of microlithic tool kits around the globe, especially in areas that were recently deglaciated, as discussed in chapter 4. However, the use of small tools is not limited to these conditions. They were in use by some of the earliest anatomically modern humans in Arica and since then, have disappeared and reappeared at several points in human prehistory, in a multitude of geographies. This indicates that microlithic industries, as a global phenomenon for foraging societies, did not require direct cultural transmission to arise in the archaeological record.

This leads to the question of whether the seemingly out of place microlithic industry identified on the AAR is a produce of cultural transmission or an independent solution to similar foraging situations. In total, the technology observed on the Alpena-Amberley Ridge (AAR) shows a diversity of strategies that includes both the traditional bifacial tools commonly found in the Great Lakes Region (GLR), but more often exhibits *ad hoc* production of microlithic tools (see Chapter 5). Although similar strategies are commonly reported in Alaska and British Columbia, they have never been reported as a primary technologic strategy from the GLR. The review provided here will track the occurrence of microlithic technology around the globe with

the aim of determining whether any identified industries are potentially ancestral to the AAR assemblage bases on location, timing and trends in the direction of movement through time.

This chapter will begin with a global survey of microlithic tool use through time as observed in the archaeological record. The survey will describe the succession of technological changes including the periodic adoption of microlithic tools and other varied technological strategies through time in several key areas including South Africa, Europe, northeast Asia, and western Canada. Authors have largely linked changes in technological organization as adaptive changes to resource redistribution associated with large-scale environmental shifts such as stages of glacial cycles. Along these lines, the role of the distinctive Yubetsu microblade technology associated with the spread of Dyuktai culture across Asia and into the Americas after the Last Glacial Maximum (LGM) will be highlighted. The distribution of this technology reflects a broad cultural network during the Upper Paleolithic that spanned the two continents (Goebel 1999, 2002; Vasil'ev *et al.* 2002). The earliest known occurrence of this technology in the Americas occurs in central Alaska by 14,200 Cal. B.P (Reuther *et al.* 2023; Holmes 2001, 2011). However, by about 10,000 Cal. B.P, the Yubetsu technique has spread along the recently deglaciated zone west and east of the Cordilleran icesheet into central and southern British Columbia and Alberta (Magne *et al.* 2020; Magne 2023). It will be suggested that foragers on the AAR likely had social connections to this region, and the presence of obsidian sourcing to central Oregon (O'Shea *et al.* 2021) provides evidence to back up this interpretation.

3.2 Global survey

The following sections will briefly describe a generalized succession of technological industries through time in a few key areas that serve to track on a very macro scale the occurrence of microlithic technology around the world, including South Africa, Europe, Northeast Asia, and northern North America, highlighting when microlithic technology occurs and its environmental context (figure 3.1).

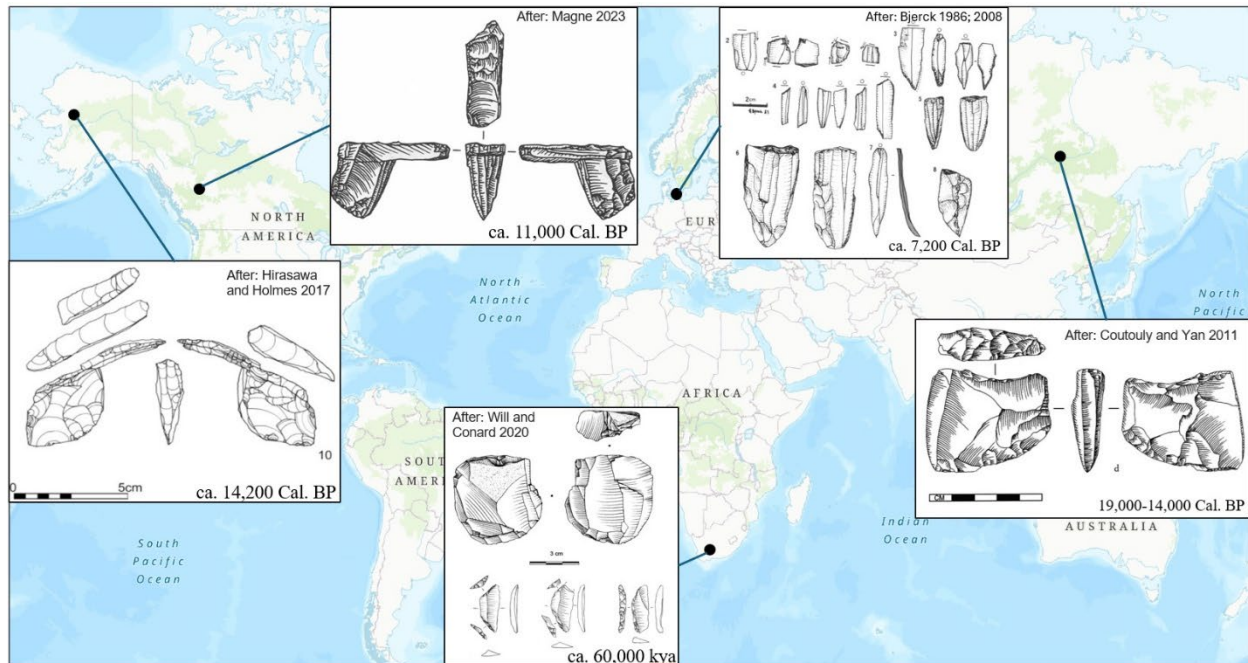


Figure 3.1 Map of the globe with key sites and dates for the occurrence of microlithic technology around the world from Asia to the Americas.

3.2.1 South Africa

South Africa has long been known as the cradle of humankind (Dart 1929: 649) and has preserved in the caves of its karstic environments an amazing archaeological record spanning the entirety of human existence (Stratford *et al.* 2021). Not lost in the voluminous history is the periodic intensification of small tool use. The later stone age (LSA) in Africa is partly characterized by the shift from larger all-purpose tools, such as the bi-pointed bifaces of the Still Bay industry (see Villa *et al.* 2009; Wadley 2007) to include more specialized micro-lithic tools as a component of lithic toolkits. However, the adoption of microlithic technology occurred by at least the end of the middle stone age (MSA) around 70,000 years ago in southern and eastern African (Ambros 2002: 21) but likely began sometime between 94,000 and 82,000 years ago in southern Africa (Millard 2006; Tribolo *et al.* 2009). The first well established use of a microlithic industry with a microlithic component is represented by the Howiesons Poort industry of southern Africa where it shows up as a component of toolkits (table 3.1).

Table 3.1 List of South African industries Since the Late Middle Stone Age.

Period	Technology	Date
Stillbay	Bi-pointed or elliptical based bifaces with curved, convex sides, and irregular center lines.	ca. 75,000 kya
Howiesons Port (microlithic component)	Combinations of MSA style points and cores alongside LSA style backed microliths, and small blades.	65,000 - 60,000 kya
Post Howiesons port	Unifacial and scraping tools, irregular core and blank production.	55,000 - 30,000 kya
Robberg (microlithic component)	Microblade, bipolar cores, small flakes, borers, and scrapers.	22,000 -12,000 kya
Oakhurst	large retouched flakes, small flakes, cores and very few other formal tools.	13,700 - 7,700 kya
Wilton (microlithic component)	formal microlithic tools, including backed microliths and small convex end scrapers	8,700 - 3,000 kya

3.2.2 Howiesons Poort

Howiesons Poort layers –usually found in South African caves– have combinations of MSA style points and cores alongside LSA style backed microliths, and small blades that dominate the assemblage. These backed microliths would have been hafted into organic handles in a variety of ways to create composite tools with several different functions (Wurz 1999; Lombard 2011; Igreja & Porraz 2013; Dusseldorp 2014: 317-318; McCall & Thomas 2012: 19-20). Dating from several sites on the southern coast indicate that Howiesons Poort assemblages are associated with the marine isotope stage 4 glacial period of the last ice age, dating to between about 65,000 and 60,000 years ago (Jacobs *et al.* 2008; Dusseldorp 2014).

3.2.3 Post Howiesons Poort

The transition from Howiesons Poort to the post-Howiesons Poort assemblages is characterized by the disappearance of backed microliths, and less standardized core reduction producing more irregular and informal blanks (Villa *et al.* 2005; Soriano *et al.* 2007; Cochrane 2008a). Formal tools associated with post Howiesons Poort assemblages are dominated by scrapers and unifacial points (Wurz 2002; Lombard & Parsons 2011; Mackay 2011; Lombard *et al.* 2012; Porraz *et al.* 2013; Dusseldorp 2014: 317-318). The transition from more formal tools made with inset backed microliths to a more expedient industry has been interpreted to reflect a change in foraging behavior potentially linked to changes in the nature and distribution of resources in an area (McCall 2007; Ambrose 2006). The Howiesons Poort technological system is interpreted to reflect the targeted logistical exploitation of resources in an environment of relatively low resource density, but relatively high resource predictability. Whereas the post Howiesons Poort industries are thought to reflect high residential mobility and the exploitation of rich but unpredictable resources (Ambrose & Lorenz 1990; McCall 2007; McCall & Thomas 2012; Dusseldorp 2014: 321). These are thought to be versatile tools that have relatively low manufacture costs and can be easily maintained by resharpening while hafted, supporting high residential mobility (McCall 2007; Mackay 2009; McCall & Thomas 2012).

3.2.4 Robberg

From about 22,000 - 12,000 Cal. B.P a microlithic industry referred to as the Robberg industry, characterized by microblades, bipolar cores, small flakes, borers, and scrapers (Pazan *et al.* 2023; Cochrane 2008b; Ambrose & Lorenz 1990; Deacon 1984). Pazan *et al.* (2023) argue that the accelerated implementation and standardization of bladelet technology during this period was the consequence of modifying and expanding existing technologies to function in a high-stakes LGM environment. Further, it is thought to be a response to increased risk to foragers in a temperate highland grassland during the LGM, by focusing on a reliable yet flexible technology (Pazan *et al.* 2023: 14).

3.2.5 Oakhurst

Following the Robberg Industry at several sites in South Africa, including Nelsons Bay Cave, Matjes River Rock Shelter, and Bloompaa Cave, Oakhurst Shelter, as well as others

(Ryano *et al.* 2017: 115; Deacon 1978; Deacon 1979) is a lithic industry referred to as Oakhurst or Albany (12,000 - 7,000 ^{14}C . yr B.P) [ca. 13,700 - 7,700 Cal. B.P] (Orton 2006), which is characterized as a simple expedient method for stone tool production (Ryano *et al.* 2017: 115). This is a non-microlithic and bladelet-poor industry, dominated by large irregular retouched flakes, small flakes, large and medium scrapers, and cores (Deacon 1982; Wadley 1993; Deacon & Deacon 1999; Lombard *et al.* 2012; Ryano *et al.* 2017: 95). These tools are often made from large local cobbles of quartzite and hornfels (Deacon 1982; Wadley 1993; Ryano *et al.* 2017: 95). This period coincides with the Younger Dryas period in South Africa which was a return to colder conditions associated with the end of the Pleistocene at the onset of the Holocene (Ryano *et al.* 2017). This came with a change in resource abundance and distribution, and it is thought that the Oakhurst industry is a response to this change as its expedient technology is designed to be used for immediate needs, without anticipation of future tasks, and are often discarded without refurbishment (Deacon 1979; Bamforth 1986; Ryano *et al.* 2017: 116). This may be a reflection of foraging in a less certain environment where people encounter resources opportunistically and use local lithic resources to harvest/process them.

3.2.6 Wilton

Flowing the Oakhurst/Albany technological pattern during the Early, Middle, and Later Holocene in southern Africa, dating from about 8,000 - 3,000 ^{14}C . yr B.P [ca. 8,700-3,000 Cal. B.P], are the Wilton phase technologies. The technocomplexes within this phase vary regionally but is largely characterized by backed blades, scrapers, including small “thumbnail” scrapers, and adzes (Wadley 2000; Ambros 2002; Deacon 1984; Deacon & Deacon 1999). The “Classic Wilton” phase during the middle Holocene contains a high proportion of both formal microlithic tools and fine-grained raw materials (Deacon 1984; Humphreys 1972; Ambros 2002: 13).

The reappearance of microlithic technology at several points in time in South Africa coincides with changing environmental conditions over the entire span of human history, making it a particularly informative case. Lithic industries are thought to have shifted to and from the use of microlithic tools as a reaction to changing environmental conditions. These include the onset of glacial conditions that rearrange and often remove resources from an area, to rising sea levels that cause changes to resource distribution and abundance, as well as other causes. Together this

suggests that changes to technological organization and the adoption of microlithic technology can occur in response to a number of circumstances.

3.2.7 Europe

A generalized succession of major technological industries associated with the initial colonization of Europe by modern homo-sapiens through the neolithic can be described: at the most macro scale, technology in Europe can be seen to alternate from microlithic tools to larger blade and bifacial tools a few times in the occupational history (table 3.2). These chronologies suffer from incongruities in data collection and reporting, as many significant European sites were excavated before the 1960's and did not employ fine screening, or absolute dating before 1955.

Table 3.2 Shows the succession of major technological industries in Western Europe highlighting when microlithic technology is a prominent component of lithic tool kits.

Period	Technology	Dates
Proto-Aurignacian	Prominent microlithic component	42,000 - 40,000 Cal. B.P.
Aurignacian	Large blades	40,000 - 35,000 Cal. B.P.
Gravettian	Microlithic component	35,000 - 25,000 Cal. B.P.
Solutrean	Large Bifaces	25,000 - 17,000 Cal. B.P.
Magdalenian	Microlithic component	17,500 - 14,000 Cal. B.P.
Mesolithic	Almost entirely microlithic	12,000 - 6,000 Cal. B.P.

3.2.8 Aurignacian and Proto Aurignacian

In Europe, the spread of anatomically modern humans is traditionally associated with the spread of the Aurignacian culture pattern (Bailey *et al.* 2009; Benazzi *et al.* 2015; Higham *et al.* 2011a) and is characterized by a diversity of stone tools including scrapers, burins, (Hays & Lucas 2000), large blades, flake tools, and bifaces (Churchill & Smith 2000; Kuhn 2002). Although the timing of the spread of Aurignacian culture is not consistent throughout the continent, it seems to begin replacing Mousterian technology from around 40,000 Cal B.P before

becoming ubiquitous by about 35,000 Cal. B.P (Barshay-Szmidt *et al.* 2018; Higham *et al.* 2011b; Szmidt *et al.* 2010; Djindjian *et al.* 2003). However, there is an early appearance of microlithic technology that coincides with the latter portion of the late Mousterian in southern Europe (Spain, Italy, and Austria), referred to as the proto-Aurignacian (Banks *et al.* 2013a,b; Kuhn 2002; Bischoff *et al.* 1989; Soler & Fullola 1996). This industry is partly characterized by the production of small bladelets often with fine marginal retouch on one or both faces (Falcucci *et al.* 2017; Banks *et al.* 2013a,b; Kuhn 2002: 83-85). These assemblages typically occur in layers stratified above the late Mousterian, sometimes separated by evidence of an occupational hiatus or mixed layer (Kuhn 2002:85). Careful dating of these assemblages from several sites indicates that the Proto-Aurignacian occurs between 41,500 Cal. B.P and 39,900 Cal. B.P and the Early Aurignacian between 39,800 Cal. B.P and 37,900 Cal. B.P (Banks *et al.* 2013a,b; Bischoff *et al.* 1989; Soler & Fullola 1996).

3.2.9 Gravettian

Broadly, following the Aurignacian culture pattern in Europe is the Gravettian (Anghelinu *et al.* 2021; Händel *et al.* 2021; Kozłowski 2015; Marreiros & Bicho 2013: 93; Gamble 1986). This period is partly known for its distinctive ivory and stone Venus figurines and distinctive stone tools kits revolving around the use of large, long blades, backed microblades, end-scrapers, bruins, and slender points with retouch down one edge (Gamble 1982:183). Bone and antler tools including barbed harpoons and bladelets are hallmarks of Gravettian assemblages (Gamble 1986). Two Gravettian sites from Southern Iberia, Vale Boi (Manne 2010; Belmiro *et al.* 2021; Cascalheira *et al.* 2017) and Cueva de Cendres (Villaverde & Román 2004; Román & Villaverde 2006) provide a good window into the timing and nature of lithic assemblages during this period (Marreiros & Bicho 2013). At the site of Vale Boi, two unmixed, Early Gravettian layers dated from 32,000 Cal. B.P and 30,000 Cal. B.P (Marreiros & Bicho 2013: 93). Gravettian technology from Vale Boi was mainly characterized by flake and bladelet exploitation, including many backed and pointed bladelets (Marreiros & Bicho 2013: 95). At the site of Cueva de Cendres (Alicante), Gravettian lithic assemblage was studied and published by (Villaverde & Román 2004; Román & Villaverde 2006), dated from 28,000 to 30,000 Cal. B.P (Marreiros & Bicho 2013: 93). This assemblage also contains many backed, and

pointed micro-blades, as well as end-scrapers, sidescrapers, denticulate, and splintered pieces derived from blade production (Marreiros & Bicho 2013: 95; Villaverde *et al.* 2019).

3.2.10 Solutrean

Following the Gravettian period in western Europe is the Solutrean culture pattern, associated with the LGM. This transition in culture patterns represents a change in the patterns of small tools and blade use to one that utilizes large bifaces and bifacial, shouldered projectile points, end-scrapers, side scrapers, (Gamble 1986; Straus *et al.* 1977; Straus 2000, 2015, 2016; Schmidt 2015). This change in technologies is seen as a cultural response to the LGM crisis when glaciers covered Scandinavia, most of Britain, Russia and northern Ukraine, forcing people southward to more favorable areas (Straus 2000: 46-48). The LGM also brought depressed temperatures and increased aridity which caused a reorganization of flora and fauna. People responded to this situation by regrouping in areas that still had fodder for game, shelter, and lithic raw materials (Straus 2000: 46).

3.2.11 Magdalenian

The Magdalenian period represents the end of the Paleolithic in Europe coinciding with the retreat of the glaciers after the LGM, and near the end of the Pleistocene (Reade *et al.* 2021; Panagiotopoulou *et al.* 2025; Gameiro *et al.* 2020). It has been well dated from more than a dozen sites in southern France to about 17,500-14,00 Cal. B.P (Langlais *et al.* 2012: 141). This period in western Europe is characterized by variable Late Glacial environments and drastic changes to flora and fauna that would have greatly influenced foraging behavior. At about 19,500 Cal. B.P there is a reduction in forested environments and the expansion of steppe biomes consisting of grasses and *Artemisia* shrubs. These open landscapes persisted until at least 12,000 Cal. B.P (Langlais *et al.* 2012: 140-141). Pleistocene step fauna came to dominate these areas and Middle Magdalenian hunting practices essentially focused on large ungulate herds (Langlais *et al.* 2012: 142). In southwestern France saiga antelope, and reindeer typically dominate faunal assemblages, while horse and bovids are common additions (Langlais *et al.* 2012: 142).

Lithic technology in the Magdalenian is characterized by reorganization of lithic technology from the larger bifacial tools of the Solutrean back to blade tools and microlithic

backed blade segments, often prismatic or triangular in cross section (Gambel 1986: 208, 220; Fisher 2006; Fontes 2016; Solheim *et al.* 2020; Gauvrit 2022). Typically, these assemblages also included end-scrapers, burins, retouched flakes, small denticulates, and borers made from blade blanks (Gambel 1986:208, 220; Solheim *et al.* 2020; Hartz *et al.* 2010; Kuhn 2002:8). In the latter part of the Magdalenian, quantities of microlithic tools, especially backed bladelets, increase (Gambel 1986: 220). Extensive use of bone and antler tools are also characteristic of this time (Gamble 1986: 221). These tools are varied in the form and function, are often decorated (Langlais *et al.* 2012: 143; Pétillon, 2006).

3.2.12 Mesolithic

The Mesolithic represents the final period of ubiquitous hunter-gatherer societies in Europe. The earliest Mesolithic assemblages in Europe date from ca. 9,500 ¹⁴C. yr B.P [ca.10,600 Cal. B.P], while the end of the Mesolithic is marked by the introduction of agriculture between about 6,000 and 5,000 ¹⁴C. yr B.P [ca. 6,300 Cal. B.P] (Price 1991: 216; Davison *et al.* 2009; Warden *et al.* 2017), although there is no firm date for the end of the Mesolithic because agricultural transitions occurred at different times in different regions throughout the European continent (Crombé & Robinson 2014). In this period, blades and microblades were the principal blanks for producing retouched and unretouched tools (Kozłowski 2009: 26). Additionally, peat bog development in the Early Holocene led to the preservation of organic artifacts that point to the use of the bow and arrow, domesticated hunting dogs, watercraft in the form of canoes, and a variety of fishing tools including line, nets, hooks, weirs, and traps (Price 1991: 216; Robson *et al.* 2018; McQuade & O'Donnell 2007; Groß *et al.* 2019; Janssens *et al.* 2018).

3.2.13 Northern Europe

Following the retreat of the ice, and the continuous warming of the late Pleistocene around 10,000 ¹⁴C. yr B.P [ca. 11,300 Cal. B.P], most of northern Europe was left covered with glacial sediments, primarily outwash sand and glacial till and moraine (Van der Wateren 1999; Price 1991: 213-214). At this time, sea levels were more than 60 meters lower than they are today (Busschers *et al.* 2007: 3217-3221; Price 1991:215), however as Pleistocene glaciers continue to melt, sea levels slowly rose, eventually reaching modern levels by 5,000 ¹⁴C. yr B.P

(Busschers *et al.* 2007: 3217-3221; Price 1991: 215). As this process took place the land surface of northern Europe has been rebounding due to isostatic rise after the enormous weight of the Pleistocene ice had been removed (Uścińowicz 2003; Price 1991: 215). As a result of this dynamic interplay of forces on the coastline of Lake Pleistocene and Early Holocene European coastlines, Mesolithic sites in some areas are submerged beneath the sea (Boldreel *et al.* 2025; Flatman 2014; Price 1991: 215).

In Northern Europe, technological organization changes markedly from the Paleolithic of the Late Pleistocene to the Mesolithic of the Transitional Pleistocene and Early Holocene, where the size of artifacts trends toward smaller and more geometric tools (Cooper *et al.* 2017; Sørensen *et al.* 2013; Jochim 2011; Straus 2002: 128-130; Price 1991: 216; Gabel 1958). For sites in northern Germany and Poland, large blade industries shift toward smaller cores of lower-quality flint in the Mesolithic (Cooper *et al.* 2017; Price 1991: 216). In northeastern Europe, very standardized (consistent in morphology) microblades were produced using pressure flaking of ‘pencil-shaped’ cores throughout the Mesolithic period (Kozłowski 2009: 26). In southern Scandinavia, a similar change in technology is reported where industries shift from focusing on large, standardized blades of the Bromme period, to smaller tanged points and various microliths of the early Mesolithic Maglemosian period (Sørensen 2012; Riede 2008; Fisher 2006; Price 1991: 216). These new microlithic industries were designed to take advantage of lithic material – small chert cobbles – in the glacial that came to cover these areas after the LGM (Svoboda 2008: 228-229).

3.2.14 Central and Southern Europe

In central and southern Europe, from France to Poland and south to Greece, a series of changes to microlithic technology took place. Early in the early part of the Mesolithic people are using discoidal cores that produce irregular, short but broad microblades (Kozłowski 2009: 35). In the middle part of the Mesolithic people had largely switched to using conical cores to produce standardized narrow blades (Kozłowski 2009: 35). Near the end of the Mesolithic, larger keeled cores were used to create larger standardized blades that were often retouched for use as knives and/or broken into sections to create trapezoidal segments that could be shaped into a point or used as inset microblades in composite tools (Kozłowski 2009: 35). This technology

spread broadly in central Europe including north of the Balkans and the Black Sea (Kozłowski 2009: 35).

3.2.15 Asia

Following the initial colonization of the Asian continent by upper paleolithic people about 45,000 Cal. B.P, the wide-spread adoption of microlithic technology in Asia dates to around 29,000-26,000 Cal. B.P (Song *et al.* 2019; Bae 2010; Lee 2004; Choi *et al.* 2001; Chun 1984). Although the exact timing is unclear, most of central, eastern, and northern Asia seem to have experienced a similar progression of blade technology where a sequence of irregular and variable core forms dominates assemblages up until the LGM around 18,000 Cal. BP. After this time, wedge-shaped cores, often referred to as Yubetsu technology associated with Dyuktai culture becomes prominent. Researchers working in the area suggest that the spread of Yubetsu technology represents the recolonization of the northern latitudes of Asia after the LGM, when climate in Northern Asia become conducive to widespread human occupation (Zhao *et al.* 2023; Guan *et al.* 2020; Goebel 2002: 122; Vasil'ev *et al.* 2002; Goebel 1999).

3.2.16 Discussion of Yubetsu and wedge-shaped core microblade technology

Yubetsu microblade technology was named after a site in Hokkaido Japan and is technologically equivalent to the “wedge-shaped” cores that came to dominate central and northeast Asia after the LGM (Nakazawa & Akai 2017, 2020; Chang 2013; Chin-Yee 1980: 1-9; Morlan 1976). The technique involves creating an ovate, bi-pointed biface that will serve as a core (Kimura & Gurya 2016; Nakazawa *et al.* 2005; Nakazawa *et al.* 2007; Inizan *et al.* 1992a,b) (figure 3.2). The early-stage bifacial cores can be up to 30 cm long and are initially prepared by removing one of the bifacial edges with a longitudinal spall referred to as a “ski-shaped-spall” (Kimura & Gurya 2016; Nakazawa *et al.* 2005; Inizan *et al.* 1992a,b). These long flakes are commonly recovered as debitage where this technology is manufactured and are diagnostic of this specific technique. After an edge is removed, a second spall is removed from the joining edge to make a platform of the correct angle. From here, microblades can be removed in succession down the length of the biface until it is exhausted (figure 3.2). The Yubetsu biface

cores and microblade technique is an intrinsic component of the Dyuktai material culture from Siberia and northeast Asia (Mochanov 1980; Coutouly & Holmes 2018; Hirasawa & Holmes 2017; Coutouly 2016).

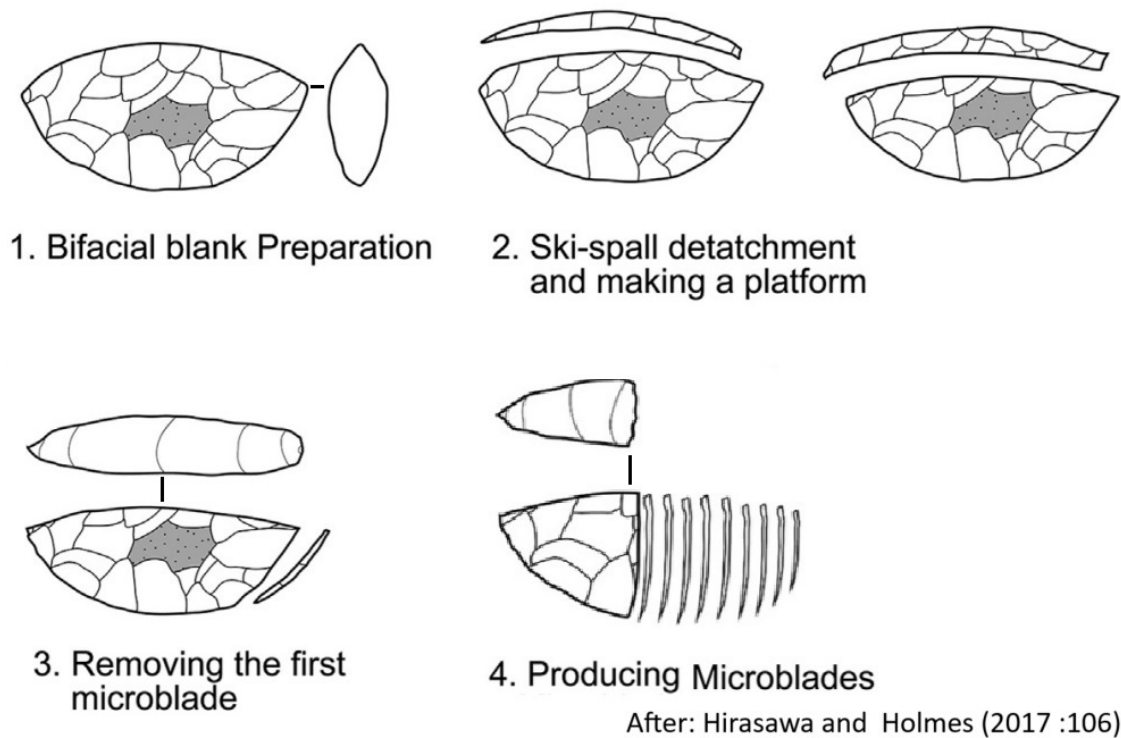


Figure 3.2 A technical diagram of the basic reduction strategy for Yubetsu technology which is often referred to as wedge-shaped cores in central and northeast Asia modified from Hirasawa and Holmes (2017: 106).

3.2.17 Northeast China

Zhao *et al.* (2023) surveyed the literature for early microblade sites in Northern China and created a generalized succession of microlithic technologic development for the periods before the LGM, consisting of three phases: Phase one (ca. 27,000 - 26,000 Cal. B.P) blade remains begin to form a considerable proportion of the total lithic assemblage (Guan *et al.* 2020; Song *et al.* 2017). Most of the microblade cores were only coarsely pre-shaped and there is much variation in the size and morphology of these cores; Phase two (ca. 26,500 - 24,500 Cal. B.P), exhibits smaller microliths and core forms are more regular, showing stylized procedures of core pre-shaping in different modes. Semi-conical cores are prevalent at a couple sites; Phase three

(ca. 25,000 - 20,000 Cal. B.P) contains the short boat-shaped microblade cores that became ubiquitous around Aisa during this period. By this time, large blade assemblages have almost completely disappeared from lithic inventories, and the blades became smaller in size. These patterns clearly show a trend of miniaturized microblade production (Zhao *et al.* 2023) in the Pleistocene. Phase three is also a period when microblade technology diffused from the middle and eastern part of North China to the west (Zhao *et al.* 2023).

After phase 3, archaeologists recognize a chronological gap in microblade assemblages during the middle LGM, between roughly 22,000 - 18,000 Cal. B.P (Guan *et al.* 2020: 39; Goebel 2002). Following this hiatus, the new, more standardized core technology often referred to as “wedge-shaped” or Yubetsu cores become prominent (Seong 1998). These assemblages are ascribed to a new, intrusive population that recolonizes the northern latitudes of Asia after the ice sheets retreat and a more amenable climate takes hold (Guan *et al.* 2020: 44-45). A similar hiatus (ca. 23,000 - 21,000 Cal. B.P) and subsequent adoption of wedge-shaped cores in the neighboring archaeological record of northern Mongolia (Rybin *et al.* 2016).

3.2.18 Siberia

Researchers working in neighboring Siberia recognize the same cultural hiatus associated with the LGM, between about 24,000 - 18,000 Cal. B.P as researchers in its neighboring regions of Northern China and Mongolia (Rybin *et al.* 2016; Goebel 2002; Guan *et al.* 2020). Moreover, the spread of microblade technology between about 18,000 - 11,000 Cal. B.P likely represents the recolonization of Siberia by modern humans following the LGM (Goebel 2002: 122).

Although, researchers have argued that the first microblades in Siberia appear around 20,000 years ago, they do not become prominent until the wedged-shaped cores, associated with Dyuktai culture first appears in the southern Lake Baikal region –about the same time that it appears in northern China– roughly following the close of the (LGM) about at 18,000 ¹⁴C. yr B.P. [ca. 21,000 Cal. B.P] (Guan *et al.* 2020: 38-39; Goebel *et al.*, 2000; Goebel 2002). Shortly after this, between about 16,000 - 14,000 Cal. B.P, Yubetsu technology and Dyuktai culture appeared in the Yenisei region to the west, the Amur region to the east, and the Yakutia to the north (Hoffecker *et al.* 1993; Goebel 2002: 122; Vasil'ev *et al.* 2002).

Radiocarbon dating of the early layers of the Khayrgas site in central Yakutia in central Siberia associated with the Dyuktai culture, established the early beginning of this complex date

to the LGM around 21,000 Cal. BP (Kuzmin *et al.* 2017). However, the lowest cultural zone contains a few wedge-shaped cores and microblades. More items directly related to microblade technology are found in the overlying zone dated to about 16,000 Cal. B.P. Thus, the earliest accepted evidence of Dyuktai microblade production at Yakutia is established ca. 20,700 Cal. B.P but is in full swing in Siberia by 16,000 Cal. BP (Keates *et al.* 2019: 396; Goebel 2002: 118-122).

3.2.19 North America: Alaska

After spreading to northeast Siberia from central Asia, microblade technology appeared in Beringia around 15,000 Cal. B.P, before spreading across Alaska and northwest Canada in the early Holocene (Hoffecker *et al.* 1993; Goebel 2002: 122; Magne *et al.* 2020, Magne 2023). The oldest microlithic assemblage in Alaska is found at the Swan Point site in the Tanana River Valley and is radiocarbon dated to about 14,200 Cal. B.P, also making it the oldest dated component with microblades in all of North America (Reuther *et al.* 2023; Hirasawa & Holmes 2017:105). Technologically, they are associated with the wedge-shaped core tradition sometimes referred to as the Yubetsu method often associated with the Dyuktai culture pattern of central, and northeast Asia, reviewed above (Hirasawa & Holmes 2017; West 1975).

There are two main archaeological complexes following the Swan Point's Yubetsu assemblage in central Alaska; the Nenana (13,500 - 13,000 Cal. B.P), and Denali (12,600 - 10,000 Cal. B.P) (Graf *et al.* 2020; Gore & Graf 2018). The former contains distinctive Chindadn sub-triangular bifacial points, and the latter has microblades and cores including diagnostic wedge-shaped cores (Hirasawa & Holmes 2017:105). Although the origin of the Denali complex in Alaska remains under debate, most assume –based on similarities in their technologies– that the Dyuktai microblade component at Swan Point is ancestral to the Denali complex technologies (Holmes 2011: 183; Wygal 2018: 294; Coutouly 2012; Magne 2023: 123-124). The occurrence of the Denali technology in eastern Beringia is evidenced by the number and their wide-spread distribution throughout central Alaska (Wygal 2018: 285, 288, 290-291). The Denali complex spread into northern and southern Alaska during the Early Holocene and it continued into the middle Holocene where it has been referred to as the late Denali complex (Dixon 1985; Mason *et al.* 2001: 526; Mobley 1991; Esdale 2008: 6; Wygal 2018: 285).

In Alaska during the middle Holocene (7,000 - 5000 Cal. B.P), a widespread birch-spruce woodland covered the landscape (Holmes 2008: 71). Within this warmer ecological setting, an archaeological period referred to as the Northern Arctic is characterized by a reduction in microlithic technology and the appearance of notched dart points (Holmes 2008). Following this warmer period, a neoglacial cycle began that was characterized by decreasing temperatures and the reappearance of glaciers in the Arctic after they largely disappeared at the end of the Pleistocene (Briner *et al.* 2018). This coincides with the appearance of the Arctic Small Tool tradition dating between about 3,000 to 5,000 Cal. B.P in the circumpolar regions of Asia and North America (Dumond 2005; Davis & Knecht 2005; Tremayne 2015a).

In Alaska, as in other regions of the world, there is an oscillation between microblade and biface traditions which is linked to the changing ecologies and subsistence (table 3.3). The arrival of Yubetsu technology from eastern Asia represents the first microlithic industry in the Americas. The subsequent use of prominent use of bifacial technology in alternating periods is yet another example of the oscillation between bifacial and microlithic technology in response to changing ecological conditions. Together the South African, European, and Alaskan cases point to a global social phenomenon not linked to direct cultural transmission, rather to convergent responses to similar ecological changes.

Table 3.3 Succession of industries documented from Alaska.

Industry	Technology	Date
Swan Point Yubetsu	Microlithic	ca. 14,200 Cal. B.P.
Nenana	Largely Bifacial	13,500 -13,000 Cal. B.P.
Denali	Largely Microlithic	12,600 - 10,000 Cal. B.P.
late Denali	Largely Microlithic	10,000 - 8,000 Cal. B.P.
Northern Arctic	Mixed Microlithic and Bifacial	7,000 - 5000 Cal. B.P.
Arctic Small Tools	Largely Microlithic	5,000 - 3,000 Cal. B.P.

3.2.20 Canada

As an extension of the microlithic tradition in Alaska, those in Canada also seems to be principally derived from the assemblage at Swan Point and it's Dyuktai predecessors of eastern Russia, which existed from about 30,000 to 12,000 Cal. B.P (Goebel 2002; Derevianko & Rybin 2003; Coutouly 2011; Magne 2023: 123). As mentioned above, this complex is often referred to as Denali in Alaska and Canada and can be found throughout the early Holocene, concentrated principally in British Columbia, the Yukon, and Alaska with fewer occurrences in the Northwest Territories and Alberta (Magne 2023). In a review of dated microlithic sites across western Canada, Magne (2023: 122) reports that the earliest dated site south of Alaska is the Vermilion Lakes site in southern Alberta at 11,400 Cal. B.P (see Fedje *et al.* 1995), followed by Tse'K'wa (Charlie Lake Cave) in northeast British Columbia at 10,800 Cal. B.P (Driver *et al.* 1996: 272; Fladmark 1996). These dates are reliably earlier than the earliest reported microlithic sites from the northwest coast of Canada and are contemporary with early sites in southeast Alaska such as Shuká Káa Cave dating to 10,500 Cal. B.P (Lee 2007; Magne 2023: 120-124). This suggests that the microlithic tradition spread from Alaska down through western Canada, overland southeast through what is left of a now very wide ice-free corridor. In fact, Carlson (1979, 1998) first proposed that the microlithic industries in Canada represent a unified tradition that spans the Holocene epoch and shows pattern of moving southeast over time (Magne 2023). A pattern that has been substantiated with the review by Magne (2023).

Recently, a series of reported sites from central to southern British Columbia and Alberta demonstrate that wedge-shaped core technology continued to spread along post-glacial ecological settings, this time south along recently deglaciated areas east and west of the Cordilleran ice sheet (Magne *et al.* 2020; Magne 2023). Here, a series of sites with wedge shaped cores very similar to the Yubetsu technique, often referred to as campus cores, have been recovered from sites dating from about 11,500 - 7,000 Cal. B.P and have been associated with Denali technology (Fedje *et al.* 1995; Clark & Gotthardt 1999; Mason *et al.* 2001; Magne 2023). Moreover, an interesting pattern of Denali microlithic tools and Cody complex bifacial tools are found in associations with one another at several sites in southern British Columbia, Washington, and Southern Alberta (Magne 2023; Magne *et al.* 2020). This has important implications for understanding the occupation of the Northern Plains and how early interactions among different

groups as users of Cody complex users moved northward after deglaciation while people with microblade technology were moving southward (Magne *et al.* 2020: 90; Magne 2023).

3.2.21 Discussion about the spread of microlithic technologies from Asia into the Americas and the Great Lakes

The spread of microlithic technology in North America did not terminate in southern British Columbia and Alberta, rather continued eastward along the post-glacial ecological zone of the Canadian central lowlands, eventually reaching the GLR and the AAR. The use of a microlithic toolkit for at least the initial exploitation of the AAR was previously suggested by Lemke and O'Shea (2019: 165-167), based on the recovery of microlithic tools including a “thumbnail” scraper from the Drop 45 site. Additionally, the two obsidian flakes from the South Gap site that sourced to central Oregon (O'Shea *et al.* 2021), indicate long-distance social networks stretching from the GLR to the Pacific Northwest. These data support the interpretation that foragers using microlithic technologies and exotic obsidians on the AAR had connections to the far west and may have included both Plano and late Denali technology users.

At the southern margin of Denali microblade technology, particularly in Washington, Oregon, Idaho, archaeological evidence demonstrates interaction between Late Denali microblade users and Plano biface toolmakers on the Northern Plains (Magne 2023; Fedje *et al.* 1995). Moreover, the two obsidian flakes from the AAR, which originate from this interaction zone and are similar in age and technology to Plano materials, further suggest that AAR foragers had social connections to groups from that area. Significantly, the AAR seems to represent the southeasternmost extent of this interaction zone and global scale strategy of using small tools to facilitate highly mobile caribou hunting end of the Last Glacial Maximum.

3.3 Conclusions

The global review of microlithic technologies presented here has identified several key patterns regarding the widespread distribution and repeated emergence of microlithic tool kits across diverse environments over time. Since their earliest appearance in Africa around 80,000 years ago, microlithic tools have served as a lightweight alternative to larger, heavier stone tools, enabling more flexible mobility strategies tailored to the specific distribution and availability of

resources on different landscapes. Because technology is so closely tied to resource extraction, changes to the environment are often closely linked to shifts in technological strategies.

A final consideration is that microlithic tools can be manufactured from smaller raw materials, which are more abundant and accessible, especially in glacial gravels found in recently deglaciated regions. This helps explain why the use of microlithic technologies is frequently associated with the post-glacial foraging and recolonization of northern latitudes around the world following the LGM. Lastly, the appearance of microlithic tools in the GLR may represent the last phase of this global expansion, spanning from central Asia across the Beringian landmass into Alaska and western Canada, and ultimately across the northern Plains into the GLR, where it was identified on the AAR.

Chapter 4 Introduction to the Early Holocene Adaptations Foraging Model

4.1 Introduction

The Pleistocene-Holocene Transition (PHT) (13,000 - 8,000 Cal. B.P) is a period of pronounced climatic and landscape change that affected every continent. Along with retreating glaciers and isostatic rebound, fluctuating sea levels had dramatic effects on landscapes around the world (Roberts 2013; Lambeck 2001, 2004; Baichtal *et al.* 2021; Stocchi *et al.* 2005). In some regions that experienced relatively subtle environmental shifts, there is evidence for cultural continuity on both sides of the PHT, while regions that experienced more drastic transformations see sweeping changes in cultural expressions (Straus 1996: 6). Despite the diversity of changes around the globe caused by dramatic transformation of ecosystems associated with the onset of the Holocene, there is striking convergence of adaptive cultural behaviors. Moreover, the convergence of foraging behaviors among people occupying the dynamic landscapes of the PHT is a recognized global phenomenon (Elston & Kuhn 2002; Jochim 1996).

Authors working on the subject have focused on one or more different domains of convergent foraging behavior in the PHT, including technological organization and the use of microlithic tools, high residential mobility, cultural niche construction (CNC) including creating landscape modifications in the form of hunting architecture, and fostering far reaching and continuously sustained social networks. Models posit that behaviors within each of these domains are flexible and can be changed to accommodate different ecological conditions. For the period of dynamic climate and landscape conditions of the PHT, convergence of adaptive strategies represents a common response to uncertainty in terms of resource procurement on new and unfamiliar landscapes around the globe (Elston & Brantingham 2002; Jochim 1996).

The chapter will begin by summarizing the ecological changes associated with the PHT, and how researchers have attempted to explain the global convergences in foraging behavior. Next, a new foraging model will be introduced –referred to as the Early Holocene Adaptations model (EHA)– that accounts for the suite of adaptive convergences during the PHT. The four

domains of the EHA model, including technology, mobility, CNC, and social networks will be described in terms of how they serve to function as parts of a foraging system, and how they are expected to change over time as dynamic environmental conditions stabilize along with the adaptive responses of prey species. Following this, a discussion of how the EHA model will be applied to data from the Alpena-Amberley Ridge (AAR) a 50,000 km² now submerged limestone and dolomite rock feature in the Lake Huron Basin that was exposed as dry land during the PHT. Specific expectations of the EHA model that will be applied to data from the AAR will be introduced, including seven expectations that should be identifiable at the regional scale, and three expectations that should be observed only at relatively more developed sites.

4.2 Theoretical background for the global phenomenon of convergent foraging strategies during the PHT

By the end of the Pleistocene, people had occupied every continent on earth except for Antarctica (Straus 1996: 3). As global climate and landscapes changed at the onset of the Holocene, people around the world were forced to adapt to new and uncertain circumstances. Dramatic warming of the globe caused the melting and retreat of large continental ice sheets, leading to rising sea levels, and a shift in vegetation patterns from tundra and steppe-like environments to a succession of forested environments (Courtin *et al.* 2021; McCarthy *et al.* 2015; Andreev *et al.* 2004; Payette *et al.* 2002). These ecological factors led to the extinction of many large Pleistocene megafauna species and the emergence of modern ecosystems (Stivrians *et al.* 2016; Cooper *et al.* 2015; Roberts 2013; Straus 1996).

Large-scale landscape and climate changes were accompanied by shifts in resource abundance, type, and distribution. Moreover, this was not uniform across regions, as the changes varied in magnitude, timing, and specific character (Jochim 1996: 361). Retreating glaciers in the northern latitudes, and high elevations of mountainous regions, opened vast expanse of newly habitable land characterized by cold climates, and glacial landscape features, such as moraines, eskers, and glacial till. These ecosystems also shared similarities in flora and fauna including cold adapted species such as caribou, moose, goat, Dall and Snow sheep, Arctic fox, Arctic squirrel, coniferous trees, and lichens (Stivrians *et al.* 2016; Puzachenko & Markova 2014; Hare *et al.* 2012). At the same time, sea levels around the world rose dramatically as massive amounts of glacial meltwater poured into the ocean (Zong 2015; Lambeck *et al.* 2014; Törnqvist & Hijma

2012; Lambeck 1990). This drowned or greatly eroded many coastal landscapes around the world, spurring the creation of new coastal environments including estuaries and deltas at higher elevations (Heap *et al.* 2004; Hori *et al.* 2004; Roy 1994). The flooding of coastal areas forced the displacement of foraging groups, removing them from their richest territories and into developing ecosystems. Initially, these were less productive environments, however, over time, these landscapes develop often into rich ecosystems with warmer climates, fertile soils, and diverse resources as the Holocene took shape (García-Moreiras *et al.* 2019; Brisset *et al.* 2018; Stanley & Warne 1997).

Although hunter-gatherer responses to the large-scale landscape changes of the PHT were diverse, surprisingly convergent adaptive strategies have been identified, including the use of miniaturized stone tool kits (Kuhn & Elston 2002; Elston & Brantingham 2002; Hiscock 2015a; 2015b), high mobility (Kelly & Todd 1988: 235; Jochim 1996: 359), landscape modification as CNC (Kelly & Todd 1988: 240; Lemke 2021, 2022), and fostering extensive social networks (Mills 2017; Hamilton *et al.* 2007; Whallon 2006:260-261; Kelly 1995; Wiessner 1982). These strategies have been interpreted as mechanisms to combat uncertainty in terms of procuring subsistence and other essential resources on new and unfamiliar landscapes (see Kuhn & Elston 2002; Kelly & Todd 1988; Jochim 1996; Straus 1996; Whallon 2006: 260). As Kuhn and Elston note (2002:4) “there is probably nothing riskier for humans than moving into an uninhabited and unfamiliar territory”.

The convergence of adaptive strategies seems largely due to constraints placed on resource abundance and distribution on these often newly open, and dynamic landscapes. The use of a microlithic tool kit is thought to provide a flexible and lightweight solution for transporting otherwise heavy stone tools, effectively reducing carrying costs. This has been modeled as a key component of foraging strategies during the dynamic climates of the PHT (Kuhn & Elston 2002; Elston & Brantingham 2002). The changing ecological conditions led to a level of uncertainty for foragers in terms of procuring enough vital resources on a consistent basis (Pinson 1999; Hiscock 2002; Elston & Brantingham 2002). This situation requires foraging groups to maintain the ability to be highly mobile to facilitate mapping onto potentially sparse and dynamic resource distributions (Goebel 2002; Neeley 2002; Kelly & Todd 1988).

Traditionally, the use of microlithic tools is seen as a phenomenon of the Mesolithic of Western Europe (Yi *et al.* 2016: 131; Kozłowski 2009; Kuhn & Elston 2002: 1-2; Price 1991).

However, it has been observed that the adoption of lithic miniaturization strategies at the PHT is a global phenomenon that has been documented around the world (Kuhn & Elston 2002: 1-2), including Alaska, (Anderson 1970; Holmes 2001; Potter 2008c; Potter *et al.* 2013); the Northwest Plains of North America (Lee *et al.* 2016; Magne *et al.* 2020; Magne 2023); Western Europe (Kozłowski 2009; Fisher 2006; Price 1987); North-Eastern Europe (Hertell & Tallavaara 2011; Molin & Wikell 2008; Olofsson 2002); England (Preston 2012); China (Pei 2016; Lu 1998; Chun 1984); South Asia (Wedage *et al.* 2019; Clarkson *et al.* 2017; Petraglia *et al.* 2009); Africa (Pargeter 2016; Ambrose 2002; Clark 1985); and Siberia (Terry *et al.* 2016; Graf 2009; Goebel 1999).

Many archaeologists have examined the relationship between hunter-gatherer technological organization and the nature of their mobility (e.g. Gaffney *et al.* 2015; Kelly 1988, 1983; Kuhn 2004, 1994; Bamforth 1991; Sellet 2013; Shott 1989a,b; Surovell 2009; Briz i Godino *et al.* 2018; Chao 2022; White 2021; among others). The strategies are not independent of each other; rather, by practical necessity, they go hand-in-hand. Hunter-gatherer societies need both to encounter the resource at the appropriate time and place, and to have the ability to exploit it once they get there. This means having a provisioning strategy that is informed and guided by the geographic distribution of lithic, subsistence, and water resources throughout a given year. Kuhn (2004) described a set of three tool provisioning strategies that are employed in conjunction with mobility strategies to accomplish this goal.

One strategy involves keeping individuals supplied with the tools and raw materials they are likely to need wherever they go (Kuhn 2004: 433). This works when tasks requiring tools are conducted frequently and at unpredictable times and places. In provisioning individuals, transport cost is an important consideration and should be based on maximizing potential utility of artifacts relative to weight (Kuhn 2004: 432). A second strategy is to stockpile a place on the landscape with the tools and raw material needed to exploit the particular resources in that area. Some resources are predictably associated with specific times and locations. Provisioning these places with the necessary tools and materials greatly reduces the weight of tools that need to be carried to that place (Kuhn 2004: 432). The third strategy, referred to here as *place provisioning*, involves producing tools on site as they are needed. This *ad hoc* production strategy is only viable where raw materials are known to be available close to where tools are to be used (Kuhn

2004: 433). This is the most efficient way to reduce carrying costs associated with the weight of stone tools but also requires *a priori* knowledge of the distribution of resources in that area.

Constructed hunting architecture, such as drive lines, blinds, and corrals created by highly mobile foragers has been documented in Arctic and post-glacial landscapes (Lemke 2022, 2021; Stewart 2015; Haas & Kuhn 2019; Bowyer 2011; Benedict 2005; Brink 2005; Belardi *et al.* 2017; Rimpi 2024). Additionally, weirs and other related architectures serve a similar purpose for catching fish and are increasingly recognized as a form of CNC (Smith 2015; Langouët & Daire 2009; Byram & Witter 1999; Petersen *et al.* 1994). These hunting and fishing structures were used by people that may have gathered seasonally for communal hunting events (O'Brien 2013; Lubinski 1999; Forbis 1978; Frison 1987). Along these lines, foragers actively shape their environment where landscape modifications reduce uncertainty in animal behavior and increase expected yields. Moreover, creating these kinds of settings provides a physical space to foster social networks and relationships.

In general terms, CNC is the application of ecological niche construction theory to people and posits that humans as organisms do not simply respond to their environment but alter it through their activities, and subsistence patterns (Laland & O'Brien 2011; Laland *et al.* 2007: 53; Laland *et al.* 2001; Odling-Smee *et al.* 1996: 641; Smith & Zeder 2013; Smith 2007; Lemke 2021, 2022). This concept is applicable to hunter-gatherer societies, where people can be described as having a more complex relationship with their environment than simply taking what it gives and responding to how it changes as a sort of passive participant, rather humans both intentionally and unintentionally alter their environment (Lemke 2021; Smith 2013: 9; Laland *et al.* 2001). Hunter-gatherers engage in niche construction in a variety of ways, such as the intentional or unintentional sowing and transport of wildy occurring seeds and fruits (Smith 2011), applying selective pressures to plant and animal communities through predation (Braje & Erlandson 2013), forest burning (Kirkinen 2008; Hayashida 2005), and by creating hunting architecture (Lemke 2021; Lemke & O'Shea 2017; O'Shea 2015a; Smith 2013; O'Sullivan 2004; Lubinski & Herren 2000).

With respect to CNC, it needs to be recognized that changing environmental conditions associated with the onset of the Holocene were accompanied by changes in the behavior of prey species, in terms of where on the landscape they can go and what migratory routes that can take. Changing vegetation, lacustrine, and riverine regimes provide a dynamic landscape for migrating

animals and a moving target for human hunters. For foraging societies, this means that key locations for intercepting prey and building hunting architecture will likely change over time before stabilizing along with environmental conditions. This will result in foragers using many sites in an area overtime as the most ideal places to hunt and find resources will change along with the development of the ecosystem. Foragers during the early phases of exploitation will use tool kits designed to mitigate a level of uncertainty associated with foraging in rapidly changing environments. As conditions stabilize, key sites will remain advantages for longer periods of time resulting in sites being used repeatedly on an annual basis and increased accumulation of cultural material, including constructed stone features, tools associated with place provisioning, and waste or refuse. These places may also serve as meeting sites where the presence of established hunting architecture may have facilitated communal hunting events (O'Brien 2013; Lubinski 1999; Forbis 1978; Frison 1987). It is certainly the case that highly mobile foraging groups fostered social networks to mitigate resource uncertainty (Whallon 2006; Deacon & Wurz 1996; Jochim 1998; Kelly 1995; Wiessner 1982), and communal hunting may have been a way to strengthen and maintain vital relationships.

Fostering social networks is critical for highly mobile hunter-gatherer societies for several reasons including, access to resources, territory, information, and mates to name a few (Apicella *et al.* 2012; Page *et al.* 2017; Garg *et al.* 2021; Hamilton *et al.* 2007; Cucart-Mora *et al.* 2022; Ibáñez *et al.* 2015; Newlander 2012). Moreover, maintaining far reaching and enduring social networks will have a strong influence over mobility in several ways. For one, social networks require reinforcement to keep relationships current and strong, and to make sure that information flows quickly enough for a group to act upon (Whallon 2006: 263). This will require people to move for reasons other than mapping onto resources. However, this cannot preclude the necessary movement between resources patches, thus they need to be fully integrated within the system of mobility, which is in turn linked to the other domains. Second, social networks for mobile hunter-gatherer societies can have a strong spatial component related to territoriality. Keeping strong relationships with neighboring groups may allow and facilitate your access to hunting areas claimed by other groups in a time of need. Networks and relations can also provide access to information about where –and potentially how– to access needed resources, or simply the direct transfer of needed resources. For these kinds of networks to function as safety nets, they need to be constantly maintained and sustained over long periods of time and potentially

over long distances. Another critical element with these relationships is to ensure that the social relations and reciprocal obligations are actually honored in time of need. (Apicella *et al.* 2012; Halstead & O'Shea 1989; Sahlin 1972 Binford 1984; Woodburn 1982)

4.3 A Synthesized model to account for the global phenomenon

Here, the four domains of technology, mobility, CNC, and social networks are synthesized into a single framework describing a foraging strategy designed to mitigate resource uncertainty in new and unknown, post-glacial landscapes of the northern latitudes during the PHT. Under this model, referred to as the EHA model, the four domains are interrelated with each working to facilitate subsisting in these new and unforgiving environments. The model relies heavily on theory developed in the literature about foraging in post-glacial landscapes of the PHT cited above. Importantly, unlike the previous models, the EHA model explicitly considers how the archaeological expression of the four domains should change over time, as some sites begin to be used more frequently, as the dynamic climate and ecological conditions associated with the PHT begin to stabilize along with prey species behavior. As this process unfolded while the Holocene took shape, some particularly advantageous sites within the new stable setting became used more intensively and experienced an accumulation of cultural materials over time. In the following sections each of the four domains of the EHA model is reviewed and discussed in terms of how they serve to reduce resource uncertainty in rapidly changing environments, how they should be expressed archaeologically, and how that expression should change over time as environmental conditions stabilize.

4.4 Four domains of the EHA model

4.4.1 Technology: miniaturized stone tool industry

The use of microlithic technology is understood to be an important solution to resource uncertainty (see Pargeter 2016; Elston & Brantingham 2002; Kuhn & Elston 2002; Neeley 2002: 45; Gadekar *et al.* 2022; Bousman 2005; Groman-Yaroslavski *et al.* 2020; Hiscock 1994), and to the associated lack of an embedded procurement strategy, which requires an intimate knowledge of the lithic resource landscape. It does this partly by allowing for the use of smaller, and more common, locally available materials to create a variety of composite tools where larger materials

sufficient to make bifacial tools may not be present, and, also by reducing carrying costs for transporting otherwise heavy stone tools. This strategy also increases flexibility in terms of being able to make most tool types at most times. It is expected that in post-glacial landscapes this will involve the use of a bipolar reduction method on silica rich lithologies in glacial till such as chert and quartzite (Hiscock *et al.* 2015a,b; Svoboda 2008: 228-229; Horta *et al.* 2019). This reduction strategy can take advantage of smaller cobbles and pebbles that largely comprise glacial till. This provides a level of security in terms of knowing that there is likely to be suitable raw material for making stone tools on post-glacial areas. In volcanic, post-glacial landscapes where obsidian occurs naturally, it will likely be a common component of lithic assemblages, whereas in other settings, it will likely make up only a small fraction, reflecting the far-reaching social connections of highly mobile foragers. As ecological conditions and prey species' behavior stabilize, mobility patterns will follow suit and begin to incorporate improved raw material sources into more regular mobility routes, which may allow for the manufacture and stockpiling of large tools.

4.4.2 Mobility and provisioning

Mobility strategies help to alleviate uncertainty in terms of resource availability by directly responding to the distribution of resources in a given area. It is expected that people in large, uncertain environments will need to have the ability to move frequently and over long distances to facilitate mapping onto potentially sparse and distant resource patches (Grove *et al.* 2023; Grove 2010, 2009; Goebel 2002; Neeley 2002; Halstead & O'Shea 1989: 3-4; Kelly 1983). Initial explorations of unknown landscapes likely involved the use of an individual provisioning system where people carried the majority of tools that were anticipated to be needed during a foray into an unknown landscape. This strategy would be supplemented with *ad hoc* production of tools from local material, effectively conserving formal tools overtime by advantageously providing additional cutting and scraping edges.

Changing environmental conditions throughout the PHT would have provided a moving target for highly mobile foragers, as the behavior of prey species changed in response to dynamic climates. This situation dictates that mobility and provisioning strategies for foragers will also change in response. This will result in a portion of sites in a region showing signs of early occupations as early sites will be used relatively briefly before changing conditions make other

places more suitable for forager occupations. Cultural material at these early sites will likely reflect the individual and *ad hoc* provisioning strategies associated with early forays into unknown landscapes. As environmental conditions stabilize along with the behavior of prey species, certain locations that become advantageous will be visited more regularly, resulting in the accumulation of cultural materials. At these later sites, cultural data should reflect changes in provisioning strategies to include place provisioning or stockpiling of tools including larger tools in anticipation of future visits. Additionally, some amount of individual provisioning will likely be evident throughout the use of early Holocene landscapes, as it allows for opportunistic exploitation of resources.

4.4.3 Cultural niche construction and hunting architecture

Creating hunting architecture is a means to reduce uncertainty in the procurement of animal resources by guiding them along fixed routes, to specific places, where they could be harvested by concealed hunters (Lemke 2021). Subsistence systems designed to mitigate resource uncertainty in large unknown areas are likely to involve an emphasis on hunting using landscape modifications, understanding that knowledge of animal behavior is transferable to areas where there is a similarity in fauna and environment (Kelly & Todd 1988; Minc & Smith 1989). However, it is important to note again that as climate conditions evolve throughout the PHT, the behavior of prey species changes to adapt to a changing landscape. As the pattern of movement of prey species stabilizes along with environmental conditions, prime hunting localities will become fixed on the landscape. This should be evidenced by select sites in a region exhibiting relatively more constructed stone features in total, as well as increased variety and complexity. It may be the case that certain sites are continuously expanded and elaborated as long as the location remains productive.

The buildup of cultural material at certain sites as the climate stabilizes should include new forms of construction associated with stabilizing mobility patterns such as caches, and dwellings. Additionally, increasing investment in structures in key locations is expected likely resulting in expanded size and complexity of stone features through repeated use. These constructions have a strong influence over mobility patterns as they serve fixed stopping points along mobility routes with provisioned resources. Establishing these kinds of places will serve to stabilize mobility patterns along certain routes. This represents predictable diachronic change

and cultural development in response to the dynamic climate conditions of the Late Pleistocene and Early Holocene landscape.

4.4.4 Social networks

The use of social networks as “safety nets” can be critical to survival in times of local resource scarcity or failure and has been recognized as an important part of hunter-gatherer adaptations to uncertain environments (Whallon 2006: 260-261; Kelly 1995; Wiessner 1982; Pearce 2014). Through the use of social networks, in times of stress, people can access information about where resources may be available. Both resources and information can be passed along through these networks and may be visible archaeologically as the presence of exotic materials or artifacts occasionally showing up in site assemblages. People utilizing the AAR will be local to the GLR and have far reaching social relationships that extend deep into neighboring ecological regions including the woodlands to the east, and the plains to the west. It is imperative that social networks be continuously maintained through regular meetings and communal events. It is likely that key places on the landscape for intercepting migrating prey, such as natural bottlenecks, would be built up with stone hunting features over time providing an attractive place to meet for multi-group, communal hunting events. This kind of event serves the dual purpose of providing subsistence to a large number of people, by taking advantage of seasonally abundant resources, and reinforcing important relationships at the same time.

Additionally, considering the absence of large-scale permanent storage facilities in low-density hunter-gatherer societies, the ability to use social networks to buffer against scarcity is inherently limited. However, smaller-scale storage facilities can be utilized and may prove vital, especially over winter in northern latitudes where stores are unlikely to be taken by others traversing the area, as they cannot be continuously guarded. Additionally, intentional preservation, or under exploitation, of certain areas within a territory can act as a kind of natural, passive storage. This strategy works best with smaller foraging groups, where low density networks will actually be able to provide sufficient relief to each other in the absence of physical storage facilities. Knowing that an area is being preserved for times of stress reinforces social ties between the group preserving the area, and other groups who could potentially exploit it times of need.

4.5 Applying the EHA model to the submerged landscape of the Alpena-Amberley Ridge

Leading up to the Younger Dryas period from about 12,900 - 11,500 Cal. B.P, the retreating Laurentide Ice Sheet released meltwater into the Great Lakes basin, which increased lake levels drastically and formed the Lake Algonquin highstand between about 14,000 - 12,000 Cal. B.P. This spurred a climate reversal that prolonged tundra and spruce-dominated environments in the Great Lakes basin, including a glacial re-advance. As the Younger Dryas came to an end, newly exposed drainage outlets and increased aridity in the early Holocene caused lake levels to drop significantly. By around 10,000 Cal. B.P. this led to the formation of hydrologically closed lakes such as Lake Stanley and Lake Chippewa in the Huron and Michigan basins respectively.

This lowstand exposed the AAR, a limestone and dolomite rock feature covering more than 50,000 km^2 , effectively forming a land bridge running northwest to southeast across the Lake Huron Basin creating two smaller lakes on either side (Lewis 2016; Lewis *et al.* 2005) (figure 4.1). However, in the earliest days of Lake Stanley, much more of the Lake Huron bottomland was exposed than the AAR itself, before the slow lake level rise inundated these areas. Post-glacial features that were preserved under Lake Algonquin, such as eskers, moraines, hills and plains of glacial till, and large erratic boulders predominate the physiographic landscape features of the AAR. Moreover, several lines of evidence including the identification of testate amoeba, pollen, and botanical remains indicate that conditions on the AAR were characterized by a sub-Arctic environment consisting of a patchwork of boggy ponds, marshes, rocky and grassy areas, along with scattered spruce trees (Sonnenburg & O'Shea 2017: 238-239). The AAR likely retained a colder climate later into the Holocene than other portions of the GLR, because of the lake effect from its close proximity to two large bodies of glacial meltwater on either side of the landform (Sonnenburg & O'Shea 2017). See Chapter 2 for an overview of environmental conditions associated with the PHT in the GLR. Considering the similarities between the AAR and other post-glacial landscapes of the PHT, it is likely that people in the respective environments would have used a similar foraging strategy as described for the EHA model and the body of theory cited above.

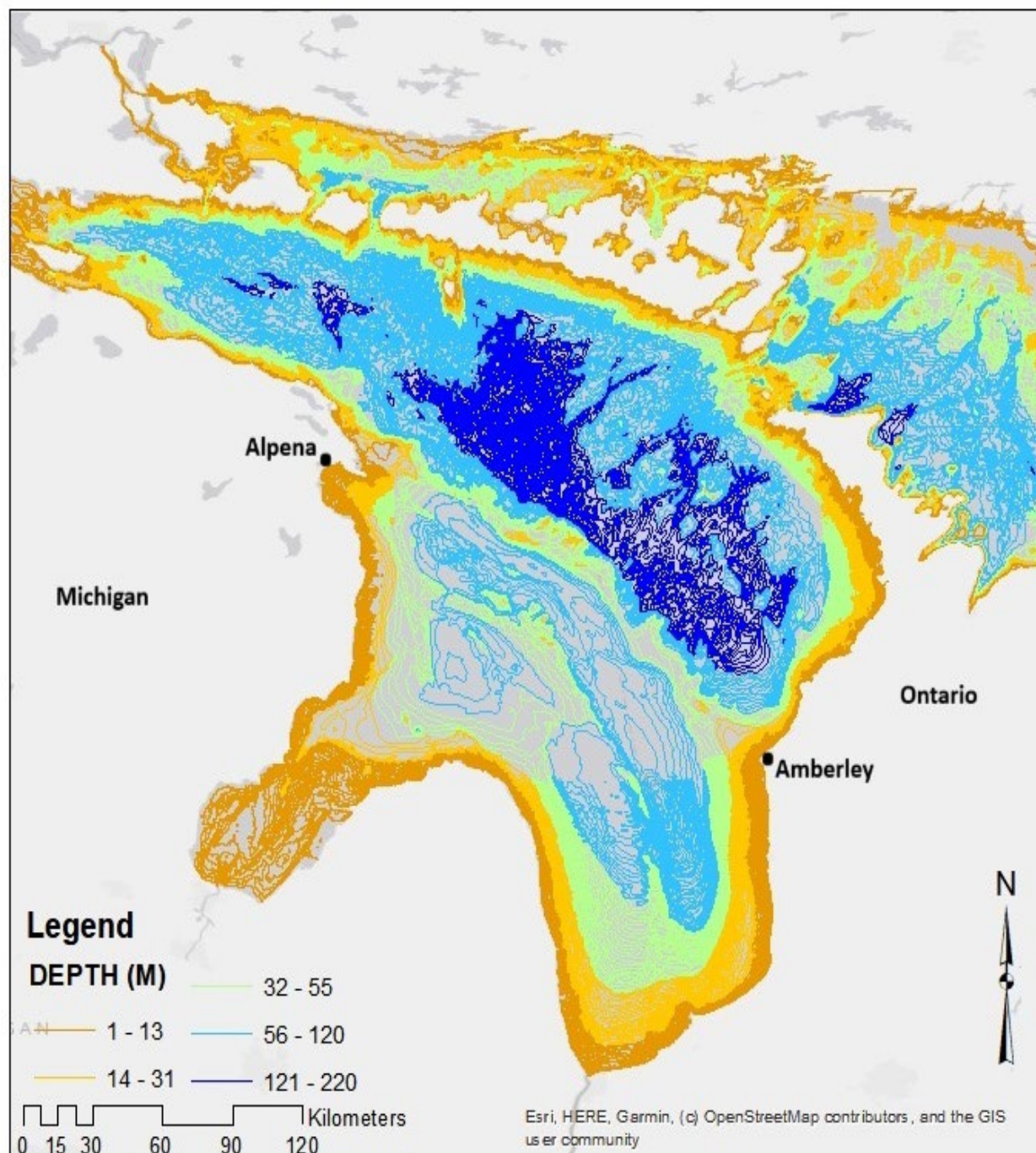


Figure 4.1 Bathymetric map of the Lake Huron Basin.

However, each landscape is unique, and there are fundamental differences between the exploitation of the AAR and the colonization of other recently deglaciated landscapes. Primary, that the landscape was exposed from under the water, rather than the ice, and people had already colonized the surrounding areas about a thousand years before. The AAR had an established

population on both sides, ready to exploit it once it was exposed. This could greatly affect the perceived level of risk for the initial exploitation of the AAR, considering that other groups who could provide a social safety net are not too far away to access in times of need. However, the environment surrounding the AAR was more temperate than the AAR itself and would have better suited to foraging strategies observed archaeologically at the far north edge of the GLR and further into the Canadian shield and the Interior Plains.

4.6 Specific expectations for the EHA model on the AAR

At the regional level, this analysis applies seven expectations (*a-g*) derived from the four domains of the EHA model (Table 4.1). These expectations are critically applied across four nested spatial scales: (1) the AAR as a whole, (2) the three research areas, (3) six site clusters, and (4) the 31 individual sites (see Chapter 5). Each site may fulfill one or more expectations, and when considered within the nested framework, all expectations are anticipated to be met. Chapter 5 presents the critical application of these expectations to the AAR dataset, along with detailed descriptions of the methods used to test them.

Table 4.1 Summary of Early Holocene Adaptations model expectations and how they will be tested.

Domains	Specific Expectations for the AAR Case Study
Technology	a) The dimensions and lithologies of local resources promoted the creation and use of microlithic tools.
	b) Microlithic tools were created ' <i>ad hoc</i> ' with bipolar reduction.
Mobility	c) Microlithic tools will be used for multiple tasks.
	d) Diachronic change in landscape use will be identifiable at the regional scale, as some sites will show signs of elaboration.
	e) Mobility patterns will lack an embedded procurement strategy, unless local outcrops are available
Niche Construction	f) Constructed hunting architecture will be used to hunt large-bodied animals, such as caribou.
Social Networks	g) Exotic raw materials and/or artifact types will occasionally occur within site assemblages, reflecting external connections.

For technology, there are two related expectations; a) that the nature of the sediments and the small packages of locally available glacial cobbles of chert promoted the manufacture of small tools, such as microblades, wedges, and scrapers, that should predominate artifact assemblages from sites on the AAR, and b) that these tools were made with a bipolar reduction method, *ad hoc* from the local cobbles that comprise the glacial till of the AAR. This strategy takes advantage of the small but often high-quality glacial gravels.

The three expectations for mobility build on the two for technology by positing that, c) small tools will often show evidence of having been used for multiple tasks, reducing the total number of tools needed to be carried and facilitating a highly mobile lifestyle. And, that d) as highly mobile people will occupy many sites in a region over time, it is likely that some sites will have been utilized more often and show signs of development. Moreover, considering that lake levels in the Huron basin rose slowly over time, after the exposure of the AAR during the initial Lake Stanley lowstand, it is expected that sites at higher elevations will show signs of greater

use, relative to lower sites on average, as they were exposed and accessible for a longer period of time relative to shallower sites that would have been inundated earlier. *e*) mobility patterns will not include an embedded procurement strategy for acquiring raw material for making stone tools, unless outcrops are locally available. In this case, they would be exploited and potentially promote an early adoption of an embedded strategy. These patterns should be reflected by the raw materials qualities, and sources at sites on the AAR, where the occurrence of high-quality chert from particular sources occurring at many sites indicates an embedded procurement strategy.

This leads to the next domain, cultural niche construction, where the EHA model predicts that, *f*) landscape modifications –often in the form of hunting architecture located at strategic places on the landscape– will be used to hunt large-bodied animals, such as caribou. This should be evidenced by the presence of hunting technology in association with constructed stone features. And, for the final domain, social networks, it is expected that, *g*) far reaching social connections will be evidenced by exotic raw materials or artifacts that derive further from the site, and from a different direction than a group typically moves during the course of a year will occasionally occur within site assemblages (Whallon 2006: 260-262)

There is also a set of three additional expectations (*1-3*) relating to how three or the four domains should be expressed at sites that underwent relatively more development and experienced more frequent visitation. As dynamic climate conditions in the Lake Stanley Basin begin to stabilize along with prey species behavior on the AAR, some sites would have begun to be used more intensively (table 4.2). The sites that experience more visitation after climate stabilization should be the ones that show signs of increased development reflected in the three diachronic expectations. Thus, they are not expected to be satisfied for most sites on the AAR, rather, a select few.

Table 4.2 Shows the diachronic expectations of the Early Holocene Adaptations model for individual sites on the AAR along the four Domains.

Domains	Diachronic Expectations
Technology	1) Incorporation of higher quality raw materials.
Mobility	2) Repeated use and <i>Place provisioning</i> (stockpiling) of the sites.
Niche Construction	3) Increase in count, complexity and variety of features

The expectation for developed sites relating to technology is that some sites will begin to show evidence of higher quality material as people begin to incorporate the best sources into their mobility patterns. It may be the case that some eskers, patches of moraine, or even exposed limestone outcrops have higher quality raw material than others on the AAR. However, they may not be regularly incorporated into mobility patterns until they stabilize along with prey species behavior and environmental conditions.

In terms of mobility, it is important to note that the EHA model posits that people used the AAR seasonally and not year around, thus high residential mobility was a central component to the foraging strategy. It is therefore expected that the long-term, high residential mobility by foraging groups on the AAR would incorporate repeated use of certain sites. It is also expected that this strategy should be evidenced by a change in provisioning strategies from purely *ad hoc* production of expedient tools associated with initial short-term visits, to also include place provisioning or stockpiling with larger, less portable artifacts in anticipation of future visits.

For CNC, it is expected that as the cultural exploitation of the AAR develops, along with the environment, after its exposure around 11,500 Cal. B.P, select sites will be used more frequently, and niche construction behaviors will begin to intensify, resulting in increased count, variety, and/or complexity of constructed features.

4.7 Conclusions

The EHA model proposes that high residential mobility facilitates a foraging system where people would be where the food and other critical resources were when they need them, effectively reducing uncertainty associated with initial foraging in recently deglaciated, sub-

Arctic landscapes. For the AAR specifically, this includes intercepting migratory caribou at key bottlenecks on the landscape at certain times and having a plan to sufficiently provision with tools necessary to hunt and process prey when they arrive. As the dynamic climate conditions of the PHT stabilize, and the migratory routes of prey species become relatively fixed across the landscape, select sites will be used more often and for a longer period of time relative to earlier sites. The later sites at key intercept locations will begin to be stockpiled with resources and significantly modified with hunting and catching architecture making them even more productive for seasonal hunting, and habitation.

The use of small tools and multi-function tools facilitates subsistence systems involving high mobility by reducing carrying costs, offering a lightweight solution for transporting otherwise heavy tools over long distances. Further, when combined with stockpiling of tools and storing of food, mobility patterns should become more fixed, by providing a level of certainty about available resources at certain places on the landscape, resulting in the modification and reuse of key locations overtime.

Physical storage facilitated by constructing stone caches introduced an additional layer of stability, influencing mobility routes as will be a reason to adhere to certain paths that take them by cached resources. Physical storage may reduce overall mobility by allowing people to spend more time at a site before food and other resources are depleted. In either scenario, physical storage reduces risk and uncertainty in terms of procuring vital resources. Social networks are the safety net to this system, in case of times when hunting is unsuccessful for whatever reason, there may be neighbors you can rely on for food. In this case, the ability to be highly mobile remains key.

By testing the series of expectations derived from three domains with specific data from the AAR, I hope to gain insight into how each of the four parts of the EHA model work together to constitute a foraging system. Each of the domains will have a different relationship with the other three which will be influenced by both the natural and social landscape. These relationships constitute the foraging system and describe how people utilize the natural resources that are available at different places and times. The seven regional scale expectations will be tested in Chapter 5, while the three diachronic expectations for more developed sites will be tested in Chapter 6.

Chapter 5 Testing of the Early Holocene Adaptation Foraging Model at Multiple Scales: An Analysis of the Cultural Landscape of the Alpena Amberley Ridge

5.1 Introduction

Since 2009 a team of researchers led by Drs. John O'Shea and Ashley Lemke have been investigating the prehistoric occupation of the Alpena-Amberley Ridge (AAR). Through the course of their research, they have documented a largely preserved cultural landscape where foragers constructed hunting architecture, such as hunting blinds and drive lines at certain places on the landscape to enhance advantageous hunting locations. This now submerged landscape was only exposed during the Lake Stanley lowstand that occurred during the Pleistocene Holocene Transition (PHT), between about 11,000 - 7,500 Cal. B.P, where lake levels dropped drastically before slowly rising back to current levels (Lewis 2016; Lewis *et al.* 2005). See chapter 2 for an overview of the paleoenvironment and archaeology of the Great Lakes Region (GLR) during the PHT.

The team documented dozens of potential stone structures and collected over 200 sediment samples from the AAR, ranging in volume from 0.2 liter vials to 20 liter buckets. Within these samples, dozens of expedient stone tools have been recovered along with several curated artifacts (Lemke 2015a; O'Shea *et al.* 2021). The goal of the present analysis is to better understand how foragers on the AAR utilized the landscape and positioned themselves to be able to take advantage of periodically available resources, such as caribou. This will be accomplished by applying a four-part behavioral foraging model, referred to as the Early Holocene Adaptation (EHA) model (presented in chapter 4) that focuses on four domains of foraging behavior including technological organization, mobility, cultural niche construction (CNC), and social networks.

Seven specific expectations have been derived from the four domains (*a-g*) relating to data that should be expressed at the regional, multi-sites scale (see Chapter 4). Testing the regional expectations will provide insight into aspects of foraging behavior related to the four domains, and whether portions of the model need to be refined or nuanced. In order to perform

the tests, relevant data were collected from the recovered materials, including from lithic artifacts, sediment samples, field notes, and videos of submerged stone structures taken from a remotely operated vehicle (ROV). This analysis will utilize all the existing and relevant data collected between 2009 - 2022, including every likely stone artifact and likely structure. This range was chosen because it includes the first recovered sample through the final collection of data for this project. Several additional structures and artifacts have been recovered since 2022. These data are still being evaluated and will not appear in this analysis.

5.2 Testing the EHA Model

What follows is an assessment of the EHA model using data from the AAR, focusing on each of the seven regional expectations (*a-j*), laid out in Chapter 4 (table 5.1). The analysis will be conducted at four nested scales, the AAR as a whole, three large research areas (previously described by O'Shea 2023; O'Shea 2015b), six site clusters, and 31 sites as the smallest scale of analysis. The analysis will begin with a brief review of the expectations, the specific variables used to test them, and why they were chosen. Then, a description of the materials and methods that will be used for model testing will be provided. This will include a materials section that describes the different classes of data and how they were collected from the field and the laboratory. Next, in the methods section, I will describe how the raw data were organized and analyzed for testing the seven expectations, and how the model testing will be conducted. This includes a description of how the four nested scales of analysis were delineated, and how the expectation tests will proceed. Each of the seven regional model tests will be conducted separately and consist of a statement of the expectation, how it will be tested, and the results. After testing, a discussion of the results will be provided focusing on what was learned about foraging behavior on the AAR and how well the model seems to fit. If any portion of an expectation is not satisfied, then the reason for the incongruity will be described, and explored with respect to why it failed and what can be learned from that outcome.

5.3 Regional expectations and variables for the EHA model

Table 5.1 Summary of EHA model expectations.

Domains	Specific Expectations for the AAR Case Study
Technology	a) The dimensions and lithologies of local resources promoted the creation and use of microlithic tools
	b) Microlithic tools were created ' <i>ad hoc</i> ' with bipolar reduction
Mobility	c) Microlithic tools were used for multiple tasks to reduce carrying costs
	d) Diachronic change in landscape use will be identifiable at the regional scale, as some sites will show signs of elaboration in the form of increased structure count.
	e) Mobility patterns lacked an embedded procurement strategy, unless local outcrops were available
Niche Construction	f) Constructed architecture was used to hunt large-bodied animals, such as caribou
Social Networks	g) External connections are denoted by the presence of exotic raw materials and/or artifact types that will occasionally occur within sites assemblages

There are two expectations relating to **technology** (table 5.1). The first relates to the nature of lithic resources on the AAR, in terms of size and lithologies of locally available material, that promoted the creation and use of small tools. To test this, the proportion of chert for the 1/4 in. and larger fraction of each sample was measured, along with the maximum dimension of the largest chert cobble from each sample to assess whether traditional bifacial tools could be reliably made from the locally occurring material. Pebbles in the 1/8 in. fraction are too small to reliably make stone tools, so the 1/4 in. fraction will be the focus for understanding how much raw material for making stone tools was available for each area.

The second expectation relating to technology is that small tools were created *ad hoc* with a bipolar reduction method (see Shot 1999; Pargeter & Eren 2017; Hiscock 2015a,b). To

test this, an assessment of the reduction strategy for each artifact was determined, using the criteria presented below in the *methods* section. Reduction strategy is preferable to using a size cut-off for tools when testing for microlithic technology, partly because it allows for the identification of the strategy on debitage and debris, not just the tools themselves. Also, this tests for a technological system known to be commonly employed by people in Arctic environments (Davis & Knecht 2005; Elston & Brantingham 2002), rather than simple size categories that may not always be reflective of technological strategy they were intended to show. I.e., some bifacial tools, and their refurbishment flakes, can be very small and a simple size cut-off could mistake specimens like these for the more expedient technology it was intended to identify.

For **mobility**, there are three expectations, the first is that tools will often show evidence for being used for multiple tasks to reduce carrying costs associated with transporting stone tools (see Sánchez-Morales 2025; White 2021; Eren *et al.* 2013). This will involve both a morphological analysis aimed at identifying one or more working edges, and macroscopic use-wear analysis to identify potential working and hafted edges on each artifact. Using morphology and use-wear is preferable to morphology alone because the function of some artifact features can be ambiguous, and use-wear can confirm a likely function (Ibáñez & Mazzucco 2021; Macdonald *et al.* 2020; Rots 2005; Hardy & Garufi 1998). A robust microscopic examination of use-wear traces on each stone tool would be an informative addition, and this process is underway at the university of Tulsa, however it is not complete, and the results will be absent for this analysis.

The second expectation related to mobility is that patterned diachronic change in landscape use will be identifiable at the regional, multi-site level, as some sites will show signs of development. To test this at a basic level, elevation of sites will be used as measure of potential age, where sites at higher elevation were exposed for longer, and therefore may potentially have a longer history, relative to lower sites that may have been inundated earlier without as much time to develop. However, it is possible given that the landscape is evolving over time, that a location that was not particularly suitable for hunting might become so later on. Elevation is used as a measure of potential relative age because most sites on the AAR do not have associated C14 dates to facilitate a comparison. Moreover, increased development will be measured by the number of total structures at a site and will be plotted against elevation to

determine if there are differences in structure count by depth, perhaps related to the length of exposure for that site.

Next, the depth of each site on the AAR will be plotted against its topography to determine if any patterns identified by elevation are actually a result of a particular setting occurring at that elevation. Topographic setting is an important variable to consider, as each zone affords distinct resources and could have attracted foragers for different purposes. Disproportionate use of a particular topography could help explain the pattern of site distribution on the AAR. A more detailed diachronic analysis of the four domains –including mobility and the anticipated diversity and complexity of stone structures– is presented in chapter 6. The methods section below outlines the procedure for determining the setting of each site.

The third expectation related to mobility is that foraging strategies will lack regular movements between high quality lithic resources patches reflecting an absence of an embedded procurement strategy. To test this, each artifact was assessed for lithology, and whether it is local or imported. These data are ideal for testing for regular mobility patterns because if similar non-local lithologies dominate assemblages from the AAR it is clear evidence for such a strategy, whereas if they are found only as small and inconsistent concentrations, then trade is a better explanation for the presence of non-local lithologies.

For **niche construction**, it is expected that landscape modifications in the form of hunting architecture were used to hunt large-bodied animals, such as caribou. It has already been demonstrated that many of these structures are cultural features likely used for hunting based on morphology and placement on the landscape (Lemke 2016, 2021, 2022). This test is designed to further evaluate the role of constructed features by testing their association with hunting technology. To test this expectation, the density of artifacts per liter of sediment will be calculated for each site on the AAR, and the average value will be compared to artifact densities at three excavations from two Arctic sites on Adak Island in Alaska (Wilmerding & Kay 2011). Artifact density is preferable to total count when assessing the association of structures with artifacts because it accounts for volume of sediment recovered which can differ greatly between excavations. Further, the type of site, in terms of activities represented, can have a significant effect on the count and density of artifacts, thus data from the AAR should be compared to other Arctic hunting sites, rather than other site types in other geographic settings.

For **social networks**, it is expected that external connections should be evidenced by non-local raw materials and/or artifact types occasionally occurring within site assemblages. There are a series of identifiable, non-local, high-quality cherts that occur around Lake Huron and the Great Lakes (Fox *et al.* 2015). If any of these materials can be identified on the AAR, then that would indicate social connections to that area for AAR foragers. To test for the presence of these materials, each artifact will be assessed for lithology and whether it conforms to a known source. Additionally, prominent chert sources in and around the Lake Huron Basin and the Great Lakes that are absent from AAR assemblages will be used as evidence for a lack of social connections to those areas. In cases where material cannot be not so reliable sourced, the presence of non-local artifact types/forms would also be viable evidence to test this expectation. However, to date, no artifacts with the necessary features have yet been found on the AAR.

5.4 Materials

Materials for this analysis consist of three groups, 1) likely lithic artifacts, 2) likely stone constructions, and 3) sediment samples that produce data comparable to shovel tests on land (table 5.2). A total of 70 lithic specimens are included in this analysis (appendix 1) that were collected from the 254 sediment samples gathered from the AAR between 2010 - 2022 (appendix 2). The third class of data is the 188 potential stone structures identified on the AAR during the same period and as part of the same investigation (appendix 3).

Table 5.2 List of the three data categories and very brief description of the materials.

Data	Description
Stone tools	70 Lithic specimens collected from the AAR
Stone constructions	188 stone features documented on the AAR
Sediment samples	254 sediments samples of varying sizes

5.4.1 Data for stone tools

Lithic artifacts are recovered from bulk sediment samples after they are dried and sorted in the laboratory. The sediment samples were collected in a number of ways: by scuba divers

scooping sediment from the lake bottom into 5-gallon buckets (20 liter) and floating them to the surface; in mesh bags of various sizes and 0.2-liter vial samples carried to the surface by drivers; or by airlift vacuum for specimens collected between 2014 - 2017. Each recovered lithic artifact has been assessed along the lines necessary to test the seven regional expectations (*a-g*) of the EHA model on the AAR. This includes assessing the manufacturing or reduction strategy for each specimen to determine what system of reduction the specimen derives from. Each artifact will also be assessed for its raw material, quality, lithology and whether it is local (occurring on the AAR). Finally, each artifact will be assessed for its likely functionality and whether it served as a multi-functional tool (table 5.3).

Table 5.3 Lists the data collected from each of the stone tools that are needed to test the expectations of the Early Holocene Adaptations foraging model.

Data collected from each stone tool	Descriptive Categories
Reduction strategy	• Bifacial reduction, • Bipolar reduction, • Unidirectional microblade, • Ground stone • Modified stone
Quality	• High • Medium • Low
Lithology	• Chert • Quartzite • Obsidian • Other igneous stones
Local or imported stone	• Locally available on AAR • Not locally available
Multi-use versus single use	• Single use • Multi-function

It is important to note that many of the artifacts recovered from the AAR are expedient in nature and are usually made from local cobbles. This often makes it difficult to distinguish cultural items from the background glacial till. Lithic specimens with freshly broken edges, macroscopic use-wear, and apparent working edges, were set aside for closer inspection to

determine if it was most likely modified and/or used by people on the AAR. For this reason, artifacts in this analysis are considered to be *likely* artifacts. Microscopic use-wear to confirm these determinations is underway at the University of Tulsa, but the results will not appear in this analysis.

When determining the reduction strategy that produced each artifact, a series of observable features were identified and examined. Artifacts with opposing flake scars on the ventral face, crushing on opposing ends, and/or a prismatic shape, were classified as resulting from bipolar reduction (Pargeter & Eren 2017; Hiscock 2015a,b). No artifacts classified as bifaces have been recovered from the AAR, however a number of flakes derived from bifacial reduction have been recovered and identified by their thin shape that expands from an acute platform. Modified stones will typically have only simple modifications such as in the case of the net weights, where a simple notch may be chipped into the stone, or a chopper that has a modified edge on an otherwise unmodified stone (table 5.4). In at least one case a stone has been heavily modified on one part with other parts left natural (324-2). Unidirectional microblade technology, as opposed to bipolar, is identified based on the presence of multiple flake scars from the same directions, either on a core or the blade itself. There is also one ground stone artifact from the Dragon site that is identified based on the convergence of ground surfaces to create a working edge.

Table 5.4 List reduction strategies identified on the AAR.

Reduction Strategy	Description
Bipolar Reduction	Opposing flake scars on the ventral face, crushing on opposing ends, and/or a prismatic shape.
Bifacial Reduction	Thin shape that expands from an acute platform.
Modified Stones	Simple modifications such as a notch may be chipped into the stone, or a modified edge on an otherwise unmodified stone.
Unidirectional Microblade	Multiple flake scars from the same directions, either on a core or the blade itself.
Ground Stone	Polished surfaces that converge to create a working edge.

Stone quality is a subjective determination that is assessed by looking for qualities that seem conducive to flint knapping such as being fine grained and highly silicious. Based on these data, the raw material for each artifact will be assessed as either low, medium, or high quality. Relative silica content will be judged based on how well defined visible conchoidal fractures appear on each specimen. For this reason, only chert, obsidian, and quartzite artifacts will be considered for this analysis, excluding the three artifacts on other volcanic rocks from this test. The variety of these lithologies will be subjectively determined largely on similarities with color and texture.

The naturally occurring lithologies on the AAR were not difficult to discriminate and fit neatly into common rock types that are common across the entire GLR. These include igneous rocks such as granite, diorite, rhyolite and basalt. Metamorphic quartzite, and sedimentary rocks such as sandstone, limestone and chert comprise the primary lithologies on the AAR. All artifacts on local stone have been identified as either chert, quartzite, sandstone (n=1), or igneous. Any other lithology such as obsidian or chert that is distinct and belongs to a known source are determined to be non-local, imported stones. In total, there were three artifacts determined to be made from imported material, including two obsidian flakes (105-1,2) from the South Gap site (O'Shea *et al.* 2021), and a multi-function scraper/graver from the Drop 45 site made on Bayport chert (131-1).

Multi-use versus single-use tools were determined based on several factors, including multiple visible working edges, evidenced by visible use-wear, or morphology suggesting multiple working edges. Bipolar cores that result from repeated bipolar crushing are considered to be multi-functional because of their use as cores and subsequently as wedges, and scrapers. Microblades are not considered multi-function unless there is evidence otherwise.

5.4.2 Data for stone constructions

The location, type, and elevation of stone structure constitute a major source of data for this analysis (appendix 3). Data including video of the 188 potential constructions were collected from 2009 - 2022. I was involved in this process from 2018 - 2022 and was present for the discovery of several of the structures and the recovery of many sediment samples during this time. Collecting data on the stone structures involved using a submersible ROV (Outland 1000) equipped with a video camera and an onboard acoustic transponder (Tritech Micronav 100

USBL system) linked to the GPS on the boat allowing for real world locations, and elevations of submerged features to be established and to gather video evidence. I tabulated these data by going through all of the existing field notes and videos for each recorded structure, to confirm the descriptions and determine a structure type for the purposes of this analysis. The structure types are similar but not exactly the same, as previous reports on this material from the AAR (O'Shea 2015a; Lemke 2016).

Seven classes of structure were identified, which correspond to certain morphologies that suggest particular functions, including 2 rock clusters, 3-5 rock clusters, V-shaped blinds, stone lines, stone lanes, enclosures, and circles. 2-rock clusters are defined as two isolated rocks of .75m in diameter or larger touching or very close to touching, often associated with other nearby structures; 3-5 rock cluster defined as three to five or more isolated rocks touching or very close to touching forming a cluster; V-shaped blind defined as three to five or more isolated rocks touching each other to form a V shape large enough to serve as a hunting blind; stone line defined as five or more isolated rocks evenly spaced or touching to form a line; stone lane defined as two stone lines (as described above) or one stone line next to a natural barrier or scarp such to form a drive lane; stone circles are defined as five or more isolated stones touching or almost touching to form a circle, such as a hearth or tent ring; enclosure defined as five or more isolated rocks to form a rectangular structure; standing and stacked stones defined as Individual stone stood up on their long axis, or two or more stones stacked on top of one another (table 5.5).

Table 5.5 List of categories for potential stone construction identified on the AAR.

Construction type	Description
2-Rock Cluster	Two isolated rocks of .75m in diameter or more touching or very close to touching, often associated with other nearby structures.
3-5 Rock cluster	Three to five or more isolated rocks touching or very close to touching forming a cluster.
V-shaped blind	Three or more isolated rocks touching each other to form a V shape large enough to serve as a hunting blind.
Stone line	Five or more isolated rocks evenly spaced or touching to form a line.
Stone Lane	Two stone lines (as described above) or one stone line next to a natural barrier or scarp such to form a drive lane.
Circle	Five or more isolated stones touching or almost touching to form a circle, such as a hearth or tent ring.
Enclosure	Five or more isolated rocks forming a rectangular structure.
Standing stone	Individual stone stood up on their long axis.
Stacked stone	Two or more stones stacked on top of one another.

Although the AAR is a submerged post-glacial landscape dominated by glacial features such as eskers, ground moraine, and glacial till, there were several thousand years of landscape development after the glacial retreat but before final inundation. This resulted in the development of riverine and lacustrine systems imprinted onto the post glacial landscape of the AAR. For these reasons, locations on the AAR can be productively grouped into four major topographic categories: 1) locations alongside eskers, 2) lake edges and riverbanks (identified by large, bowl shaped sandy areas representing lakes, and sandy incised channels for rivers), 3) marshy areas (identified by a mix of sandy and rocks patches covering a shallow basin), and 4) rocky terrain areas not near eskers, lakes, or rivers. These were identified by nearly complete ground cover of rocks, this surface would be relatively flat in the case of a glacial till plain, or hummocky in the case of ground moraine. If this setting occurs alongside an esker, which is common, the site is

labeled as an esker site (table 5.6). While watching the video for each structure, I spent several minutes before and after the structure appeared assessing the topographical setting around each structure. Additionally, acoustic back scatter data from side-scan and multibeam sonar of the Lake Huron Basin gathered by the project was key for these determinations as sites covered with sand or clay show less reflectivity than sites covered in rocky till or exposed bedrock. Moreover, the presence wetlands and marshy areas on the AAR have been confirmed by Sonnenburg and O'Shea (2017) with an analysis of paleoenvironmental indicators including organic remains, and testate amoeba.

Table 5.6 List of topographic classes for sites on the AAR.

Site type	Conditions
Esker site	Sites adjacent to eskers.
Lake/Rive site	Sites on the bank or high area overlooking a lake or a river.
Marshy site	Sites that have a mix of sand and rock in shallow basin areas that would have been marshy.
Rocky terrain sites	Sites covered with ground moraine or gravely glacial till not adjacent to eskers, lakes, rivers, or marshes.

5.4.3 Data for sediment samples

Select sediment samples have been chosen to characterize the naturally occurring lithologies from each of the three areas, primarily for testing *expectation a*. The test samples were chosen because they have the most sediment in the 1/4 in. and the larger size fraction that was saved and available for this analysis. This includes one large sample each from the three most prolific sites Drop 45 (20AL104), Dragon (20AA230), and South Gap (20AA232). These will serve to characterize the sediments for Areas 1, and 3, while Area 2 will be represented by two slightly smaller samples that combine to be comparable to the other three samples (table 5.7).

Table 5.7 List of sediment samples used for testing expectation a.

Sample	Site	Area	1/4 in. fr. kg (oz.)
F-2	Dragon	1	2.35 kg (83 oz)
S-17	Drop 45	3	2.01 kg (70.9 oz)
F-5	South Gap	3	2.95 kg (104.2 oz)
KA-1	A2RLIN	2	0.68 kg (23.9 oz)
JH-1-3	A2RLIN	2	1.03 kg (36.5 oz)

5.5 Methods

5.5.1 How the EHA model will be critically applied

The analysis presented in this chapter will involve testing the seven regional expectations of the EHA model with the three sources of data described above. Importantly, each of the three sources of data has a spatial component relating to its position on the AAR. In order to understand how activities may have differed throughout the landscape of the AAR, four nested spatial scales have been defined. The largest scale is the AAR as a whole, then the three research areas within the AAR constitute the second largest scale. Six site clusters/localities within the three areas comprise the next largest scale, while 31 individual sites within the localities make up the smallest scale (table 5.8). Where possible, each of the seven expectations will be tested at each of these scales.

Table 5.8 Scales of analysis.

Scale	Number of units
Whole AAR (American portion)	1
Areas	3
Site clusters	6
Sites	31

No strictly defined site boundaries had been designated for clusters of cultural material identified and/or gathered from the AAR, however certain areas and structures were given names (O'Shea *et al.* 2014; O'Shea 2015a; Lemke 2016; O'Shea 2023). These place and structure names were incorporated in the system of nested scales used here wherever possible. First, it was necessary to define the smallest scale of analysis, the “site”. Here, sites are defined as locations that produced at least one artifact, or at least two constructed structures. Additionally, no structure can be more than 75 meters away from the next closest structure at the site. Clusters of structures in different topographies may also be considered a separate site even if it is less than 75 meters away. These simple rules facilitated the creation of 31 site boundaries within the three areas. The next level of analysis is the site cluster. These were determined by the presence of clusters of sites where each site in a cluster is closer to other sites within the cluster than to sites outside, and no site can be more than 600 meters from the next closest site in the site cluster.

The next level of analysis is the three areas. The three areas were initially selected to represent differing kinds of hunting settings (O'Shea 2023). Area 1 was the region with large outcrops and high ground, where the team thought that they might encounter chert outcrops. Area 2 was predicted to be a water crossing, and Area 3 was an area overlooking a lower elevation plain that might be attractive to migrating animals. Finally, the AAR as a whole is the largest scale unit of analysis (figure 5.1). Following the determination of topographic setting for each potential structure, these settings have also been applied to the individual sites that contain them. The spatial component of the dataset has been modeled in Arch GIS Pro, to determine the distance between different data points.

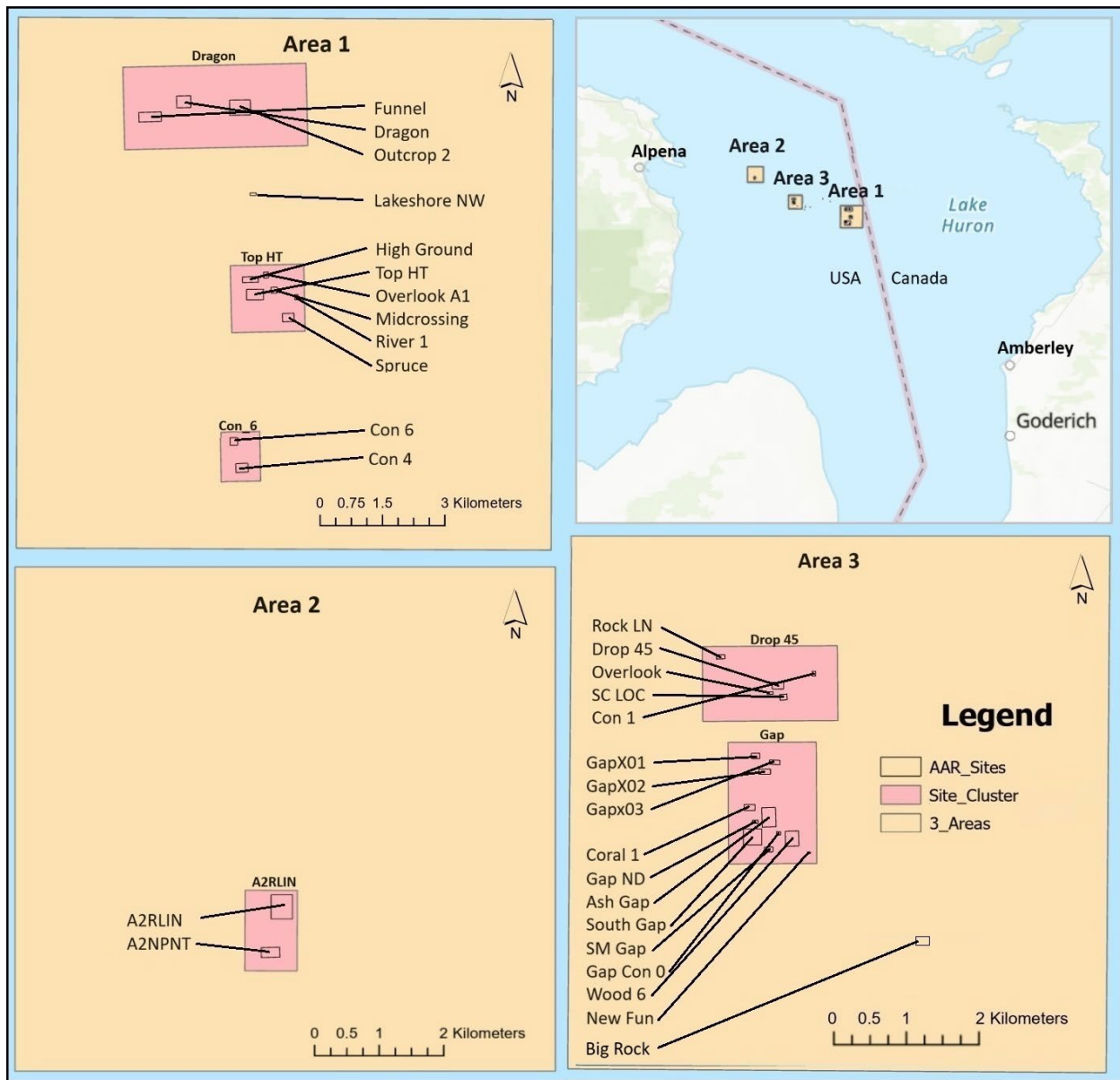


Figure 5.1 Shows Areas 1, 2 and 3 with the smaller scales of analysis including the locations of the six site clusters/ localities and the 31 sites within them.

In the model testing that follows, each of the seven regional expectations are evaluated independently with the relevant data. Where possible, the expectations will be tested at the four different scales (table 5.8). This will include the use of bar graphs (created in JMP 17 Pro) to represent a degree of correspondence between the selected variables and each scale of analysis. These data will be interpreted to determine whether the expectation was satisfied or, if not, the

reason for the failure and what insights can be gained from that outcome will be discussed. Each test will begin with a description of the expectation, followed by a passage describing specifically how it will be tested including the data that was used and the methods that are applied. Finally, the results of the test will be described and discussed with respect to the stated expectations and any additional relevant insights that can be drawn from the exercise. The analysis will focus largely on the stone tools and their association with the other classes of data.

5.6 Test results for technology

5.6.1 Expectation a

The relatively rare occurrence and small size of high-quality chert on the AAR limited the ability to create larger bifacial tools similar to those found on contemporary terrestrial sites in the surrounding regions and promoted the creation of small tools made with a bipolar reduction strategy.

5.6.2 Testing expectation a

To test whether the naturally occurring materials on site could have supported biface production, a survey of unmodified stones from each of the three study areas was conducted. The proportion of the chert fraction relative to the rest of the sample, and the maximum size of the chert cobbles, will be used to assess whether locally occurring materials would be suitable for making bifacial tools, or if the sediments are too small and are better suited for making small tools, following Pargeter and Shea (2019: 74).

5.6.3 Results for expectation a

The largest sediment samples from Area 1 (F-2) comes from the Dragon site with the 1/4 in. and larger fraction (the fraction with rocks large enough to make traditional stone tools) weighing a total of 2.35 kg (83 oz.). However, this fraction only contained 3.6% chert, with the largest chert cobble measuring 21.7 mm on its longest axes (table 5.9). The quantity and size of the chert cobbles in this sample suggests that locally occurring materials at the Dragon site in Area 1 would not have been conducive to making traditional bifacial tools.

Table 5.9 Shows weights of select sediment samples in four fractions, with the addition of the maximum dimension and weight of the largest chert specimen in the sample, and the percent of 1/4 in. material that is chert.

Sample	Diss Site	Area	1/16in. kg.	1/8in. kg.	1/4in. kg.	Total Wt. kg.	Chert 1/4 kg. (%)	Max Chert Dimension	Max Chert Wt. g
F-2	Dragon	1	6.53	12.05	2.35	20.94	0.09 (3.6%)	21.7mm	6.53
KA-1	A2RLIN	2	nc	0.46	0.68	1.14	0 (0%)	7.6mm	0.85
JH-1-3	A2RLIN	2	nc	0.06	1.03	1.09	0.01 (1.4%)	31.5mm	1.42
F-5	South Gap	3	12.43	4.93	2.95	20.32	0.27 (9.3%)	43.7mm	119.07
S-17	Drop 45	3	nc	0.66	2.01	2.67	0.01 (1.3%)	11.4mm	0.71

For Area 2, two sediment samples (KA-1, JH-1-3) combine to have a 1/4 in. and larger fraction that weighs a total of 2.23 kg (78.7 oz.). These samples produced, 0% and 1.4% chert in the 1/4 in. and larger fraction respectively, with the largest piece of chert from the KA-1 sample coming from the 1/8 in. fraction and measures less than 1 cm on its longest axes (table 5.9). The only piece of chert from the 1/4 in. and larger fraction from sample JH-1-3 is a scraper (265-1) (described for *expectation b*) made from a local chert cobble and is only 31.5 mm on its longest axes (table 5.9). Considering the near absence of chert from the 1/4 in. and larger fractions from Area 2, it's reasonable to conclude that the naturally occurring materials in this area would not have been conducive to making traditional bifacial tools.

For Area 3, sediment samples from its two most prolific sites, South Gap and Drop 45 will serve to characterize local material. Sample F-5 from the South Gap site had a 1/4 in. and larger fraction weighing a total of 2.95 kg (104.2 oz), with chert only comprising 9.3%. The largest chert cobble from this sample was 43.7 mm on its longest axes. Sample S-17 from the Drop 45 site in Area 3 had a 1/4 in. and larger fraction weighing 2.67 kg (94.3 oz.), with chert

comprising only 1.3%, and the largest chert cobble measuring only 11.4 mm on its longest axes (table 5.9).

That the South Gap site had a larger percentage of chert cobbles than the other sites and the largest single chert cobble recovered, suggests that different areas on the AAR may have had slightly different lithologies in the glacial till. However, taken together, these data strongly suggest that the nature of the sediments on the AAR as a whole, and in each of the three areas separately, would not have been favorable for making traditional bifacial tools, particularly those of that typically characterize the archaeology of the GLR during the PHT.

Moreover, considering that the locally occurring material on the AAR are from glacially produced features such as glacial till, ground moraine, and eskers, it makes sense that the more brittle lithologies such as chert would break down faster, and into smaller pieces than the tougher, more fracture resistant materials such as quartzite, limestone and many igneous rocks. These lithologies comprise the majority of recovered rocks on the AAR and common in all sizes from the 1/8 in. fraction of the sediment samples to the 1/4 in., to the boulders that make up the eskers that stretch for miles along the AAR. There would have been no limit or pressure on the size of artifacts made from local quartzite and volcanic rocks.

5.6.4 Expectation b

People occupying the AAR employed a technological system revolving around the use of locally available chert cobbles (following *expectation a*) to create microlithic tools *ad hoc* with a bipolar reduction method. This system was designed to take advantage of the locally occurring resources and facilitate a highly mobility lifestyle by reducing carrying costs for transporting otherwise heavy stone tools that typically characterize the GLR during the PHT.

5.6.5 Testing expectation b

A technological analysis of each lithic specimen aimed at assessing the method of manufacture, to determine if it was produced from bipolar reduction, bifacial reduction, microblade production, or if they are best described as modified stones, or ground stone. A degree of correlation or association between reduction strategy and the spatial component of the data set will be measured at four nested scales starting with the whole AAR, then by the three

areas, site clusters, and finally by individual sites to examine any difference with technology within the spatial component of the data. Additionally, descriptions of select, particularly informative, specimens from the AAR that exemplify the predicted strategy will be presented, along with a specimen that may not fit the predicted technological pattern.

5.6.6 Results for expectation b

For the AAR as a whole, bipolar reduction represents the most common reduction strategy for recovered artifacts (36.7%), while debitage derived from bifacial reduction, and simple modified stones represent 31% and 28.2% respectively. Additionally, two artifacts from the Drop 45 site (2.8%) can best be described as deriving from unidirectional microblade technology, and 1 artifact from the Dragon site (1.4%) is a ground stone tool (figure 5.2).

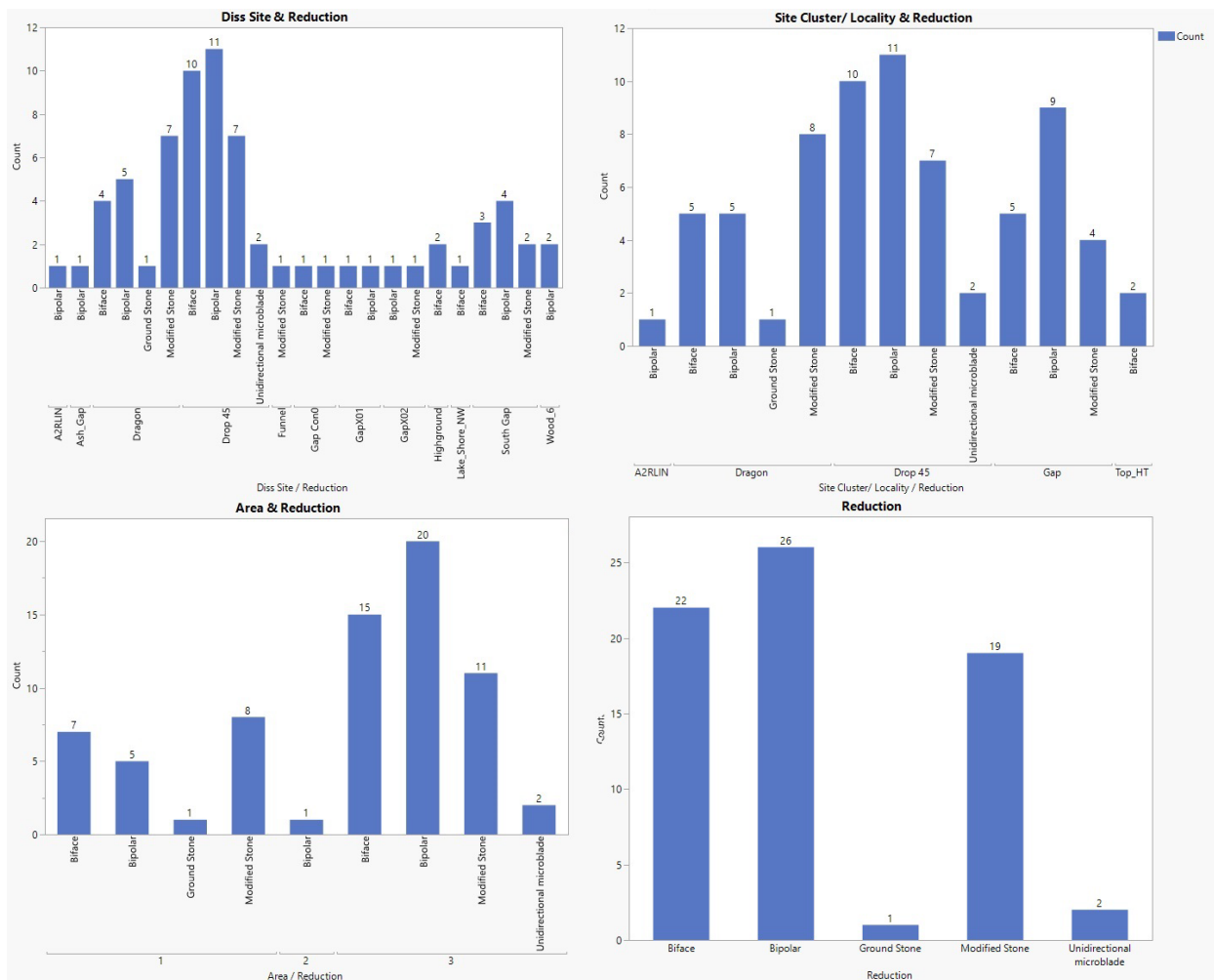


Figure 5.2 Shows the four primary reduction strategies –and one ground stone– for tools on the AAR at the four nested scales.

At the scale of the three areas, Area 1 has 33.3% of artifacts derived from a bipolar reduction system, while Areas 2, and 3 have 100% and 40.8% respectively. The difference in the proportion of reduction strategies observed in the three areas is likely due, at least in part, to the difference in the total number of artifacts recovered from each area. Area 3 has two of the three most prolific sites, including Drop 45 (n=30 artifacts) and South Gap (n=9 artifacts), while Area 1 contains the third, the Dragon site (n=17 artifacts), while the more lightly sampled Area 2 has only one artifact (figure 5.2).

At the level of the site cluster, a more even distribution is observed with the Drop 45 and the Gap localities having bipolar reduction as their primary reduction system with 36.6% and 47.4% respectively, while the Dragon site cluster has only 26.3% (figure 5.2). Interestingly, at

the Top HT site cluster in Area 1, three out of three recovered artifacts are derived from bifacial reduction. This may suggest a different pattern of technological organization for the occupations at this site cluster.

Finally, at the level of a single site, bipolar reduction is the most prevalent strategy. At Drop 45, it represents 36.7 percent of the site's assemblage (the Drop 45 site is the only site in the Drop 45 site cluster that contains artifacts). This is just below the proportion of bipolar reduced artifacts at South Gap (44.4%), and just over the proportion at Dragon (29.4%). At the other less prolific sites, a total of 6 out of 15 artifacts (40%) are derived from a bipolar reduction method (figure 5.2). In the following passages, three artifacts will be presented, including one that serves to exemplify the predicted pattern of small tool use, and two others that provide nuance for the predicted pattern by adhering to some of the predicted aspects but not others.

A wedge (293-1) likely produced *ad hoc* with bipolar production of a local chert cobble was recovered from the Drop 45 site in 2018 and exemplifies the kind of small tools that predominate in the lithic assemblages from the AAR (figure 5.3). This tool was made on the characteristic honey colored chert that is common on the AAR. The color is not the natural one but appears to be due to iron staining during sub-areal exposure associated with rising and falling lake levels after abandonment. This is discussed further with *expectation 2* in chapter 6. Visible use-wear on both the distal and proximal end shows good evidence for use as a wedge, with smoothing visible on one end and heavy battering visible on the other (figure 5.3). This kind of tool indicates that people on the AAR were splitting wood, and/or bone to make additional tools, including hafting elements for microlithic stone tools. Considering that the AAR is a chert poor region (following *expectation a*), the majority of tools used on the AAR were likely made from organic materials. A preliminary microscopic use-wear analysis by Dr. Marvin Kay at the University of Arkansas produced evidence for linear striations running down the edge of the tool, strongly suggesting its use as a wedge. A thorough microscopic use-wear analysis is currently underway at the University of Tulsa by Dr. Danielle Macdonald.

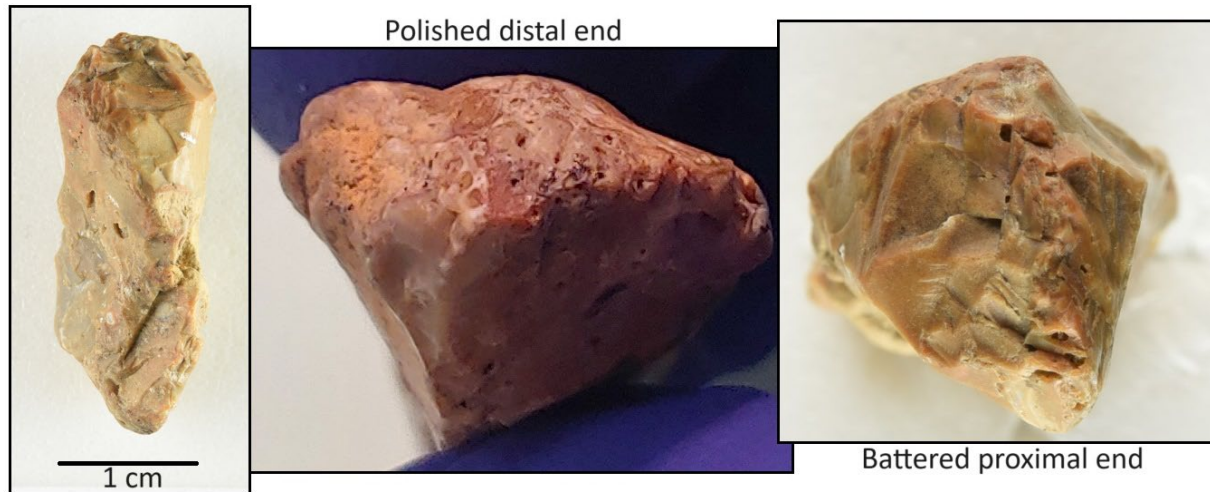


Figure 5.3 A wedge likely produced from a bipolar reduction method from the Drop 45 site, showing macroscopic use-wear with a heavily battered end and an end that was polished from use as a wedge.

The one artifact from Area 2, a scraper (265-1), also provides a good example of the predicted pattern for tools on the AAR, as it is produced from a local cobble with a bipolar reduction method (figure 5.4). The specimen has minimal modifications that include a retouched edge and visible wear on the working edge (figure 5.4). This specimen is not necessarily smaller than a typical terrestrial scraper and represents one of the larger tools made from a local chert cobble. However, the slightly larger size did not prevent people from transporting this tool around the AAR, as it was the only piece of chert larger than a 1/4 in. from the sediment sample (JH-1-3) (see *expectation a*). This provides a bit of nuance for the strategy involving the use of small tools to reduce carrying costs by suggesting that using local cobbles to produce slightly larger tools *ad hoc* still reduces carrying costs for transporting tools to the AAR. Moreover, that this tool was left on the AAR, and never resharpened suggests that the tool was likely discarded after just a few uses, rather than being curated and transported away, suggests that it was intended for expedient use.

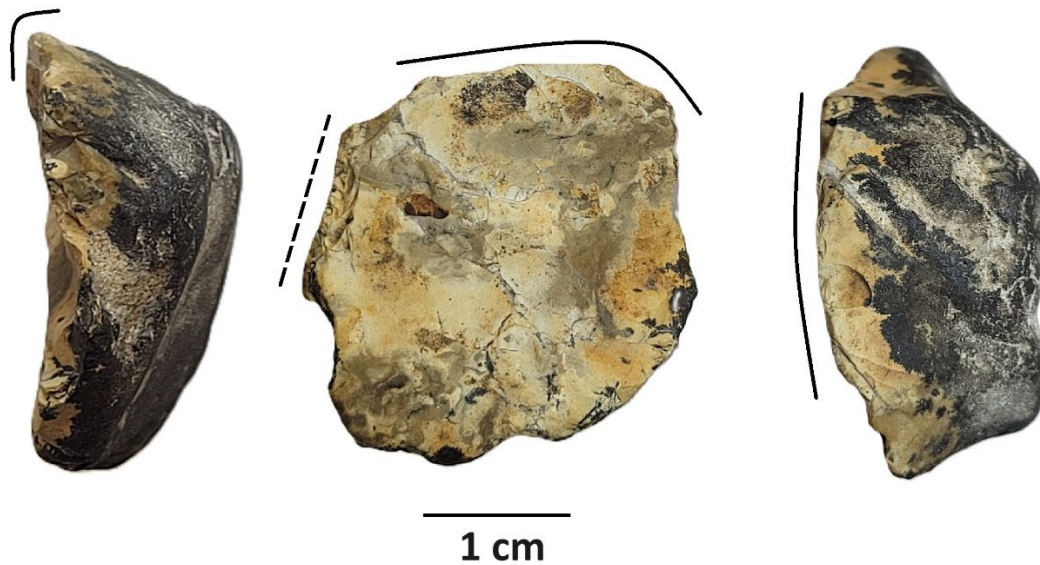


Figure 5.4 Shows the only artifact recovered from Area 2 from three different angles. It is a scraper (265-1) made with a bipolar reduction method from local cobbles. The solid line indicated the edge that functioned as a scraper, and the dashed line indicates a modified edge.

Although bipolar reduction is the primary reduction strategy on the AAR at each scale, it always represents less than half of the artifacts, with bifacial reduction, unidirectional microblades, ground stone, and modified stones combining to describe the remaining artifacts. This shows that although bipolar reduction was used as a method to utilize local cobbles to make small tools *ad hoc*, it was not the only strategy in use on the AAR. Debitage from bifacial reduction shows that strategies typical of the GLR were used on the AAR alongside small, and expedient tools. In some cases, these were likely from traditional bifacial knives and points characteristic of the GLR at this time. These tools would have been carried onto the AAR and refurbished after use, leaving behind mostly small bifacial refurbishment flakes. Specimen (138-4) is a small, white, edge retouch flake matching this description and likely represents careful resharpening of a bifacial tool with pressure or light percussion flaking (figure 5.5).

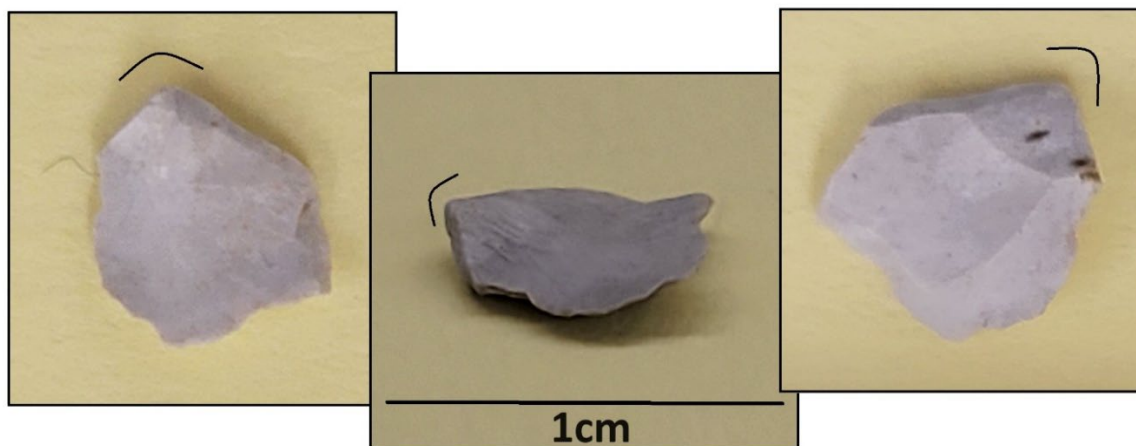


Figure 5.5 Small, white, edge retouch flake (138-4) from three angles. The curved black line indicates the platform of the flake.

Notably, the longest axis of a chert cobble in the measured background samples is 43.7 mm (following *expectation a*), while the longest axis of a chert tool recovered from the AAR is the scraper from South gap (324-2) that measures 52.7 mm. This is likely to represent foragers on the AAR selecting the largest locally available piece of chert to make tools. The next largest tool measures 38.1 mm on its longest axis and is shorter than the longest background samples. This provides further evidence that the tools recovered from the AAR are indeed made from local stones.

Taken together, these data support the expectation that small tools were created *ad hoc* with a bipolar reduction method from local gravels to reduce carrying costs associated with transportation. However, the use of small tools on the AAR may be overstated relative to the use of more expedient and bifacial tools in the current EHA model. Moreover, although the local chert gravels and tools made from them are typically small on the AAR (following *expectation a*), when larger chert cobbles were encountered, they were also used to produce expedient tools. It may be the case that the expedient nature of the tools on the AAR may have been as important for reducing carrying costs as their actual size.

5.7 Test results for mobility

5.7.1 *Expectation c*

In order to facilitate a highly mobile lifestyle necessary to extract materials from a landscape with dispersed resource distribution, microlithic tools were produced and used for multiple tasks to reduce carrying costs of otherwise heavy stone tools. This expectation is closely related to *expectation b* and expands on it by adding the additional element multi-functional use. This addition to the small tool strategy is expected to further reduce carrying costs by replacing two or more tools with one multi-functioning tool.

5.7.2 *Testing expectation c*

Each tool recovered from the AAR was analyzed to assess whether it likely had multiple functions. This was done by considering each specimen's morphology, and determining where there are multiple working edges apparent, and by examining each specimen for macroscopic use-wear. A degree of association between multifunction tools and the spatial component of the dataset will be assessed at four different scales starting with the whole AAR, then by area, site cluster, and finally by individual sites (table 5.8).

5.7.3 *Results for expectation c*

For the AAR as a whole, 28 out of 70 (40%) recovered artifacts can be described as potentially having multiple functions based on their morphology and visible, macroscopic use-wear. If the 12 specimens described as debitage with no evidence of utilization are removed from the list, as they are not themselves thought to be tools –rather debris from tool manufacture– then the percentage of multifunction tools recovered from the AAR rises to 48.3%. This general ratio of multi-function to single-function tools holds true at the area level where Area 1 has 52.9% multi-function tools, and Area 3 has 47.5% multi-function tools, however, Area 2 has only one tool (265-1), and it is single-function (figure 5.6).

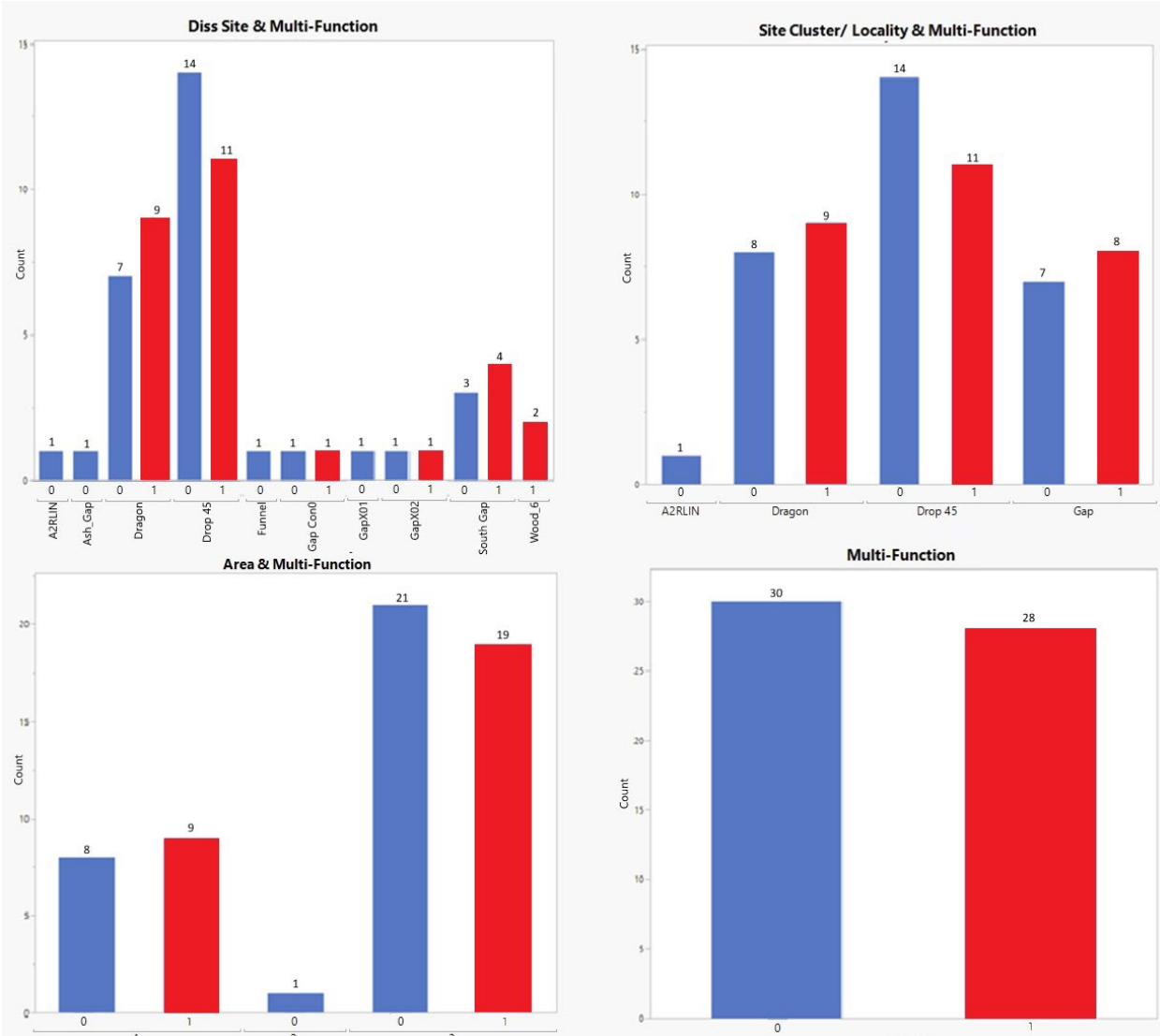


Figure 5.6 Shows tools (with debitage removed) recovered from the AAR that were likely to be used for multiple tasks at four different scales. Red bars indicate the tools that were likely used for multiple functions, while blue bars indicate single-use tools.

The pattern for Areas 1 and 3 holds largely true at the level of a site cluster with 52.9% of tools being multifunction at the Dragon cluster (all tools in Area 1 are from the Dragon cluster which includes the Dragon and Funnel sites), 44% being multi-function at the Drop 45 cluster, and 53.3% being multi-function at the Gap cluster (figure 5.6).

At the single site level, this pattern holds true, including the Dragon site with 56.3% multi-function tools, while the Drop 45 site contains 44% multi-function tools (all of the tools from the Drop 45 site cluster are from the Drop 45 site). The South Gap site contains 57.1%

multi-function tools. For the remaining, less prolific sites, 4 or 10 (40%) tools are likely multi-functioning (figure 5.6).

Multi-functioning tools make up just under half of the total lithic assemblage recovered from the AAR, their occurrence at every scale indicates that this strategy for reducing carrying costs of stone tools was commonly in use by foraging groups on the AAR. When combined with the other strategies for reducing carrying costs, described for *expectation b*, including the use of small, and larger tools produced *ad hoc* from local cobbles, including expedient modified stones, the percentage of recovered tools that represent a strategy for reducing carrying costs rises to 83%. These data provide strong support for the expectation that a technological system utilizing stone tools was designed to facilitate a highly mobile lifestyle on the AAR. In the following passages, two multi-functioning small tools from the AAR that exemplify the model prediction will be described.

A multi-function chert scraper made on Bayport chert (131-1) (discussed further for *expectation g*) recovered from the Drop 45 site has a steep retouched edge around its circumference and a contracting asymmetrical stem that likely functioned as a graver (figure 5.7). Tools like this are often referred to as “thumbnail” scrapers due to their small size. Fractures from opposite directions visible on one face are evidence that the tool was made with a bipolar reduction method. This small, multi-functioning tool made from non-local chert exemplifies the kind of technological organization predicted by the EHA model and is good evidence for a technological strategy designed to facilitate a highly mobile foraging lifeway on the AAR.

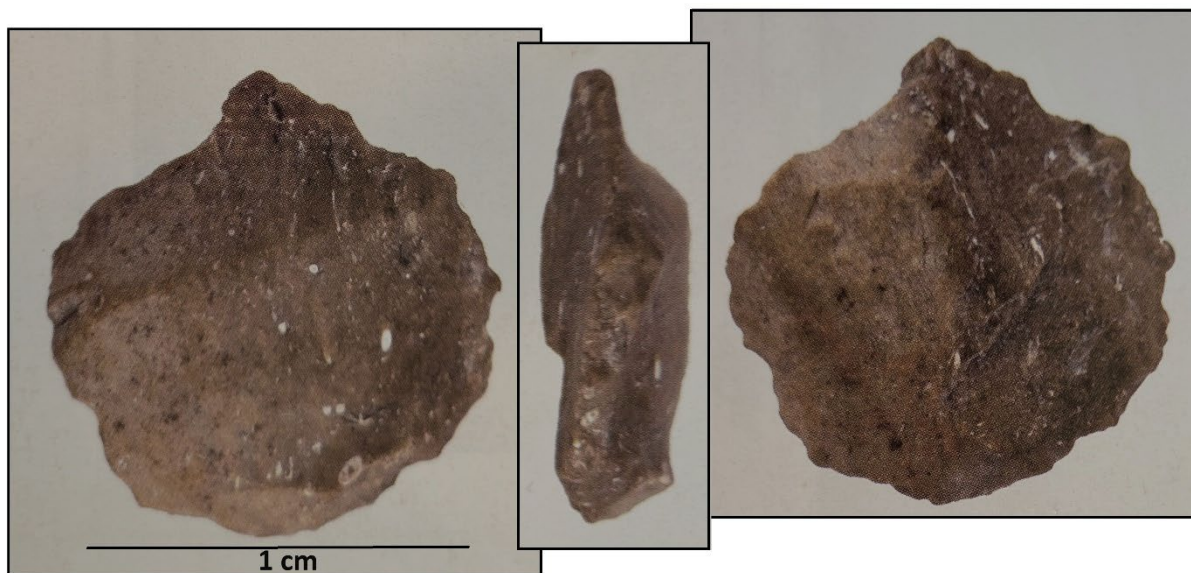


Figure 5.7 Shows a multi-functioning small tool: specimen 131-1, a “thumbnail” scraper with a potential graver on Bayport Chert recovered from the Drop 45 site.

A small chert scraper (299-1) recovered from the Dragon site has multiple working edges, including a burinated edge and a retouched scraper edge (figure 5.8). The tool is made from a local cobble with one edge retaining the original surface of the pebble. The large central facet that covers most of one face originates from the edge that appears to be retouched as a scraper, likely indicating that this tool was a scraper before being turned into a burin. In this way the tool is multi-functioning, although it is not exactly how the model predicts as with specimen (131-1). This suggests that this portion of the model should be nuanced to explain that multi-function tools should also include recycled tools.



Figure 5.8 Shows a multi-functioning small tool (299-1) with its remnant scraper edge indicated with a curved line and its burinated edge indicated with a straight line.

5.7.4 Expectation d

As highly mobile people will occupy many sites in a region over time, it is likely that some sites will have been utilized more often and show signs of development or elaboration. Further, considering that lake levels in the Huron Basin rose slowly over time, after initial drop in water levels associated with the Lake Stanley lowstand, it is expected that sites at higher elevations (shallower in the water) will show signs of increased development relative sites at lower elevations (deeper in the water). Sites at higher elevations were exposed and accessible for a longer period of time relative to sites at lower elevations that would have been inundated earlier. Lower sites at major geographic bottlenecks are also likely to be relatively more developed due to their particularly advantageous locations and may break the trend of increasing complexity with elevation.

5.7.5 Testing expectation d

To test for the predicted pattern of site development resulting from a system of high residential mobility by foragers on the AAR (i.e., higher sites showing signs of increased

development relative to lower sites), the total number of recorded structures will be correlated with the elevation of each site (measured as the average elevation of documented structures). Further, to test whether there is any influence on site development based on topographical setting, rather than elevation (i.e., near lake or river edges, near eskers, in marshes, or on rock terrain), these settings will be associated with structure elevations and structure type to determine if the influence on site development is better predicted by topography than elevation.

5.7.6 Results for expectation d

When the number of structures for each site is plotted against elevation a clear clustering of sites between 30 - 35 meters in depth with a strong spike at about 32 meters is apparent (figure 5.9). The smoothing parameter –or Lambda– for this function is 0.05 suggesting a good fit for the data. The spike at 32 meters likely represents the major period of occupation and is good evidence that highly mobility foragers utilized a multitude of sites on the AAR for hunting and other activities over a period of time. However, it does not show that sites at higher elevations have more structures because they have been exposed longer and were potentially utilized for a longer period. Rather, it shows a period of relatively more intensive foraging at a certain range of elevations that likely correspond to certain lake levels and a particular span of time. It may be the case that higher elevation sites were less accessible when lower elevations on the AAR become inundated. Moreover, rising lake levels may have also affected the ecology of the AAR and made it less conducive for highly mobile foraging, either by restricting access or altering the plant and animal communities that lived on the AAR.

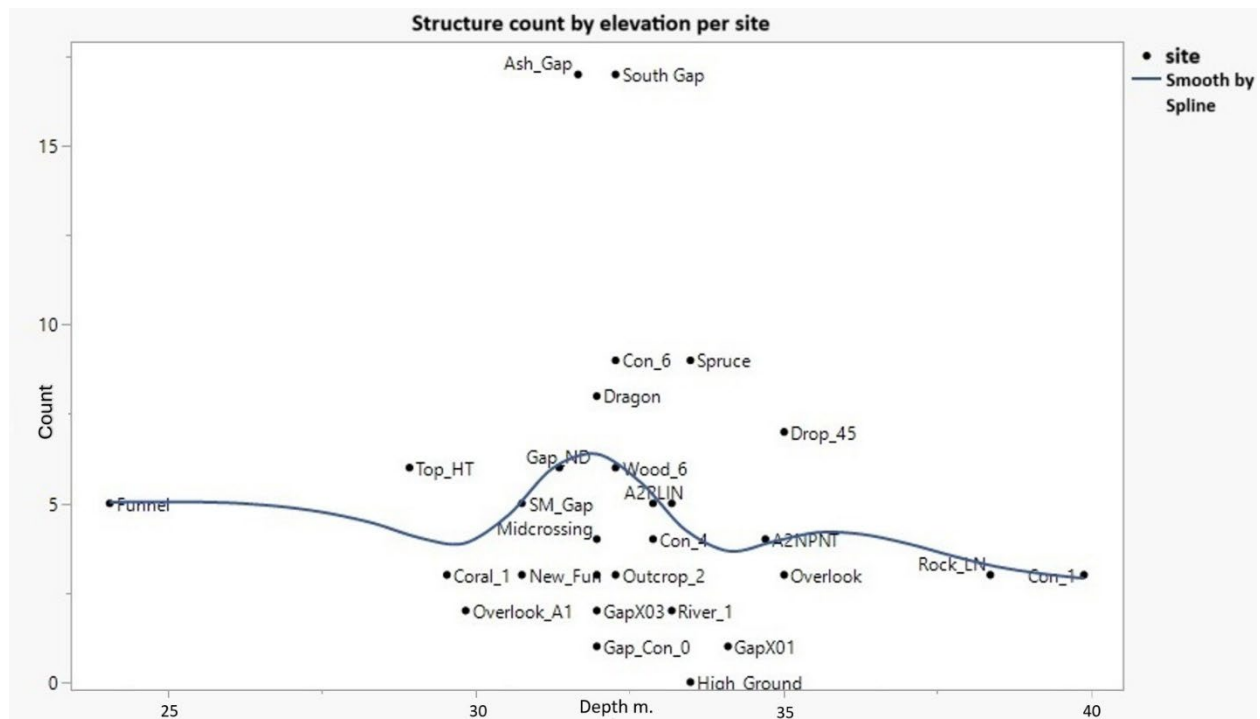


Figure 5.9 Shows the number of structures at each site plotted against the average elevation of the structures for each site. The graph shows a strong clustering of sites between about 30 and 35 meters below the modern lake surface, suggesting a single major phase.

When looking at the elevation of sites by the four topographic classes, the pattern of clustering between 30 and 35 meters holds true for each and does not suggest that site development is greatly influenced by ecological setting. However, when the type of structures is correlated with the four ecological settings, a pattern suggesting that site setting has an influence on structure type is also present (figure 5.10). Sites adjacent to eskers have the highest average number of hunting blinds (i.e., rock clusters and V-blinds), suggesting that these sites were more often used as hunting sites than other topographies. This fits the model well as eskers provide natural drive lines to guide prey species such as caribou to predictable locations for hunters. These would in turn be good places to build hunting blinds. Sites on the banks of lakes and rivers have more stone circles than sites in the other topographies (figure 5.10), suggesting that these sites were multi-function, and used for more than hunting alone (as hunting blinds are also present), such as for habitation and ritual activities. Sites in marshes exhibit relatively more rock clusters and drive lines (figure 5.10), suggesting that these were also primarily hunting sites. This is also supported by the lack of stone enclosures and low average number of stone circles. Sites

on rocky terrain such as ground moraine and glacial till plains, not near eskers or water bodies, have a higher proportion of hunting structures to other structures (figure 5.10), and are also sparse in structures not related to hunting, suggesting these sites are also primarily used for hunting.

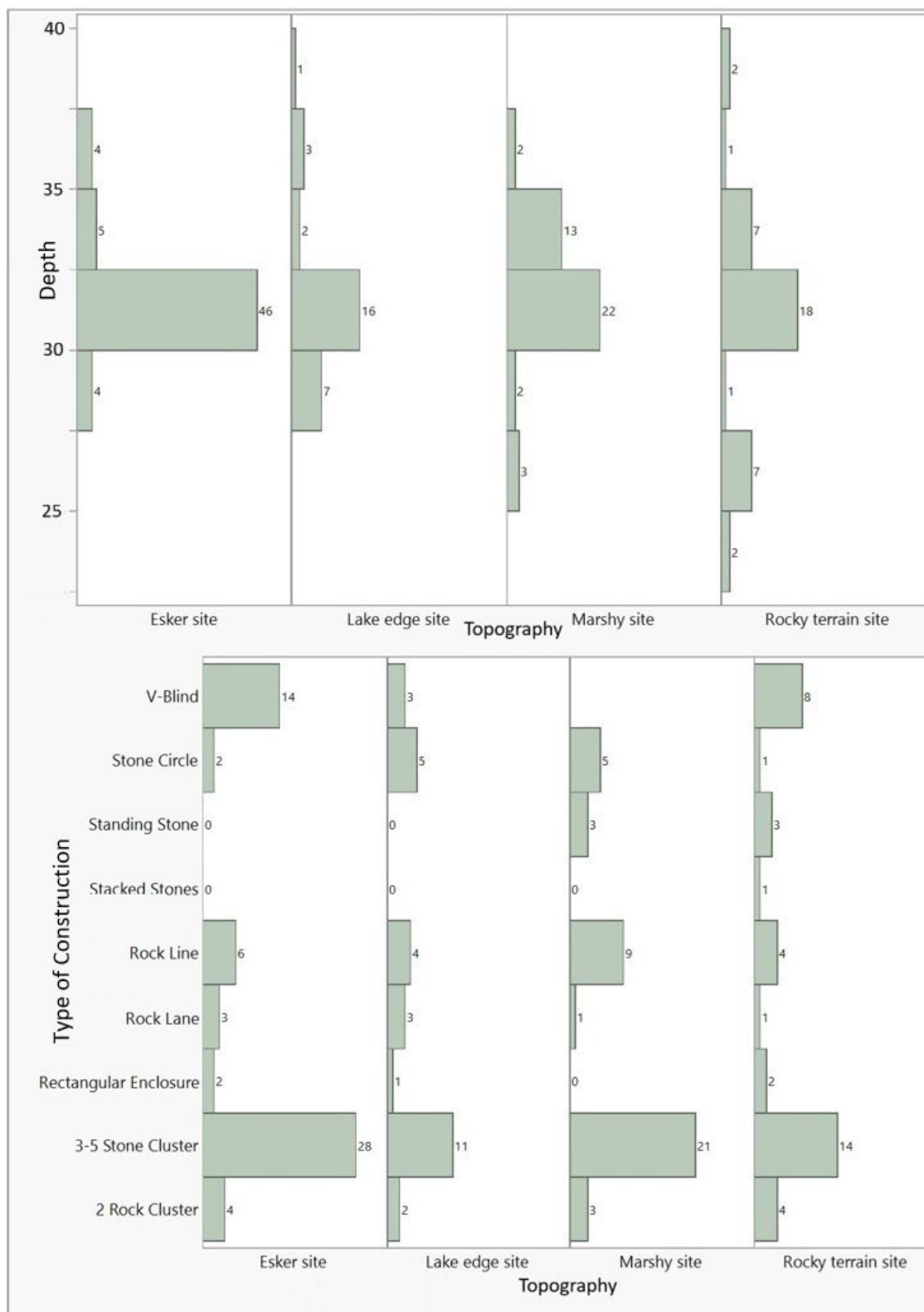


Figure 5.10 Top) Shows the depth (elevation in meters) of structures at site from certain topographical settings, and Bottom) shows the number of different types of structures for each topographical setting.

Taken together, these data indicate that sites at higher elevations are not typically more developed than sites at the lower modal elevations on the AAR (in terms of number of structures), and that the expectation cannot be supported. However, insights into the nature of the occupation of the AAR can be derived from this analysis. The pattern of sites clustering at a certain elevation suggests that the occupation of the AAR was likely single modal with a ramp up in the intensity of exploitation leading to a time of peak use followed by a time of decreasing use. However, it should be noted that there has been very little investigation below about 40 meters, and shallow areas on the AAR are heavily vegetated and difficult to survey and sample.

5.7.7 *Expectation e*

Because the AAR is a chert poor region, as high-quality chert outcrops seem to be absent from the landform, and the glacial till that covers a significant portion of the traversable ground contains only sparse, small packages of chert (following *expectation a*), it is expected that the absence of high quality outside material precludes there having been an embedded strategy.

5.7.8 *Testing expectation e*

To test whether mobility patterns included embedded procurement of lithic resources, an analysis was conducted focused on the association between the raw materials used for stone artifacts at the four different scales. This will consist of determining whether each artifact was made on local versus imported stones, and their lithology. This will involve visual (macro and microscopic observation) for the identification of most specimens, and whether they seem to match geological samples recovered from the AAR, or if they match a known source outside of the AAR. These data will be supplemented by published sourcing results (O'Shea *et al.* 2020) of obsidian using neutron activation analysis (Glascok 2006; Glascok & Neff 2003), and x-ray fluoresces analysis (Shackley 2010; Ferguson 2012)

5.7.9 *Results for expectation e*

When the different lithologies of tool stone are evaluated at the four scales, it becomes apparent that tools made from local chert cobbles dominate the AAR assemblages at every scale (figure 5.11). 81.7% of tools from the AAR are made from local chert cobbles, 14.1% are made

from local quartzite and volcanic rocks, and only 4.2% of artifacts are made on imported stone. At the scale of the three areas, 71.4%, 100%, and 87.8% of tools are made from local chert cobbles from Areas 1, 2 and 3 respectively (figure 5.11).

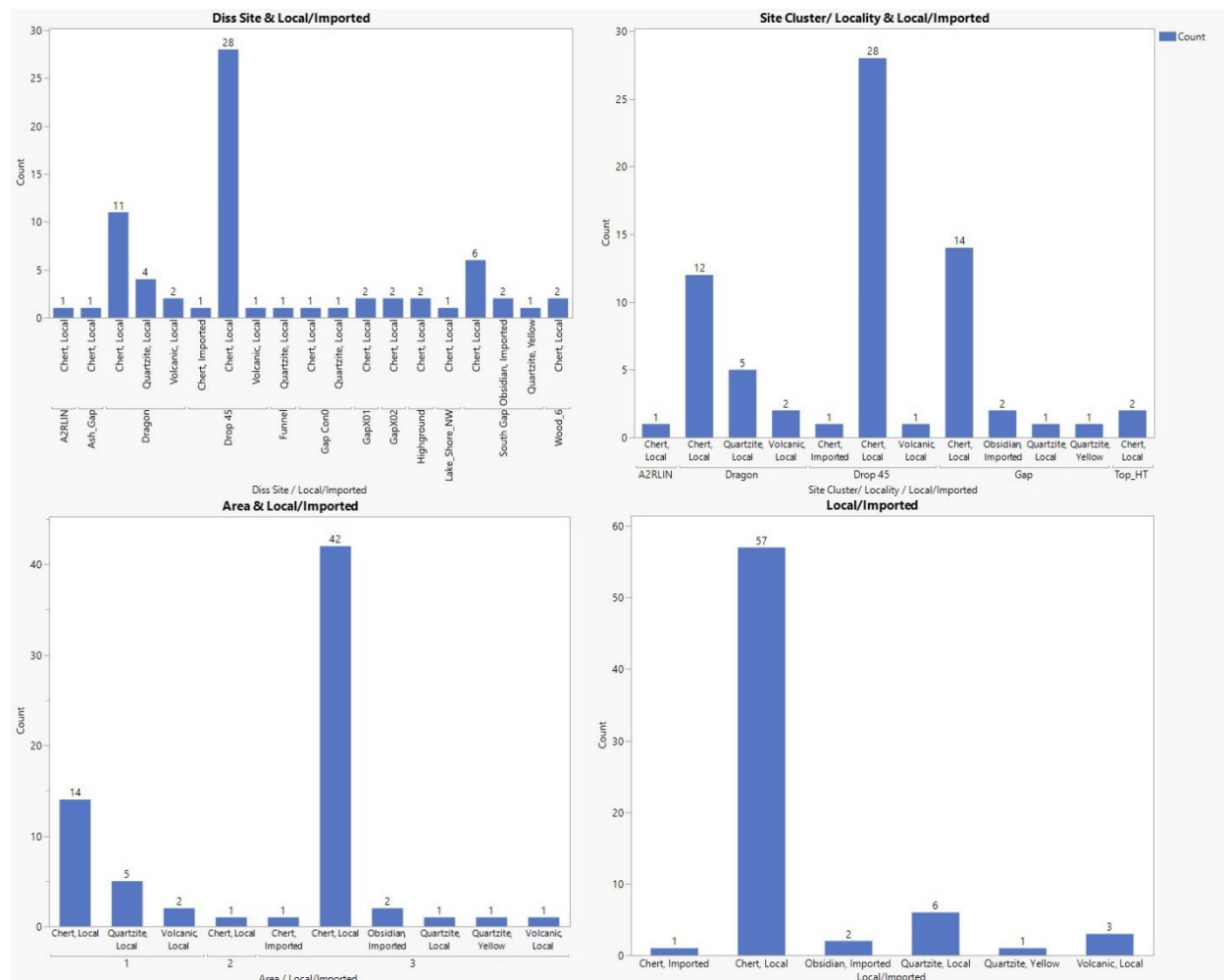


Figure 5.11 Shows the occurrence of local and imported lithologies for artifacts recovered from the AAR at the four scales.

At the scale of a site cluster, Drop 45 and Gap are dominated by local cherts with 93.3% and 78.9% respectively. The Top HT cluster produced only three tools each made from local chert. For the Dragon cluster, local chert was the dominate raw material (63.24%), however, here there is a much stronger representation of tools made on local quartzite and volcanic rocks (36.8%) 1 than the other site clusters. In sum, the high occurrence of tools made from local chert gravels largely support the expectation that foragers on the AAR lacked an embedded

procurement strategy for acquiring raw materials from the AAR, however there are a couple other ideas to consider.

First, there are more tools made from local quartzite and igneous stones such as granite and basalt, than exotic/non-local lithologies. In particular, the Dragon site cluster, and Dragon site itself, has a relatively high occurrence of tools made on local quartzite and igneous rocks (figure 5.11). These are typically larger tools such as, the quartzite chopper (299-8), a diorite net sinker (299-21), and the diorite ground stone tool (299-2) (figure 5.12). This potentially represents stockpiling of the Dragon site with tools likely to be needed later and may suggest that this site was utilized habitually (following *expectation d*). Further, foragers intended to return to the site where there would be large tools available, that would not otherwise be conducive to highly mobile foraging. This argument for stockpiling or place provisioning is supported by the fact that all of these specimens, as well as several other tools, are from the same sediment sample directly adjacent to a hunting blind that likely also served as a cache (Lemke 2015b).

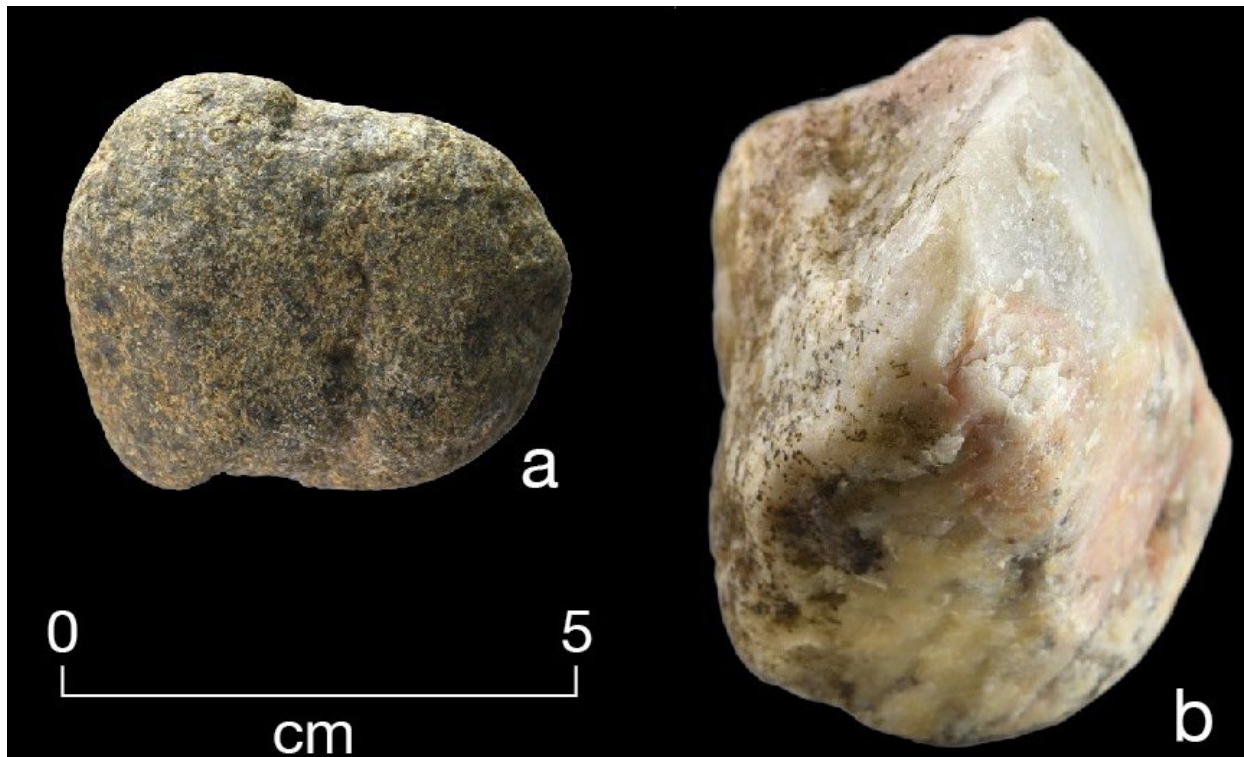


Figure 5.12 Two of the larger tools from the Dragon site a) diorite ground stone tool (299-2) b) quartzite chopper (299-8).

Second, the three specimens on imported materials seem to represent highly curated tools that are recognizable as traditional tools typically found in the GLR during the time of the PHT. This includes one specimen from the Drop 45 site, namely the “thumbnail” scraper (131-1) (discussed for *expectation c*) made from Bayport chert that outcrops south of the AAR near Saginaw Bay in the Huron Basin. This lithology is recognized by the particular suite of microfossils. Additionally, the two obsidian flakes (105-1, 105-2) are the product of refurbishing a highly curated biface on a non-local material (figure 5.13). A robust geochemical assessment of the two flakes shows that they are from the Wagontire source in central Oregon (O’Shea *et al.* 2021; Riebe *et al.* 2022). The considerable distance that this material traveled supports the notion that they derive from a highly curated biface that has likely been used and refurbished multiple times on its long journey. Although they are only two flakes, they are good evidence that the traditional bifacial tools on exotic stone typical of the GLR during the PHT were in fact in use on the AAR alongside microlithic and expedient tools made from local cobbles.

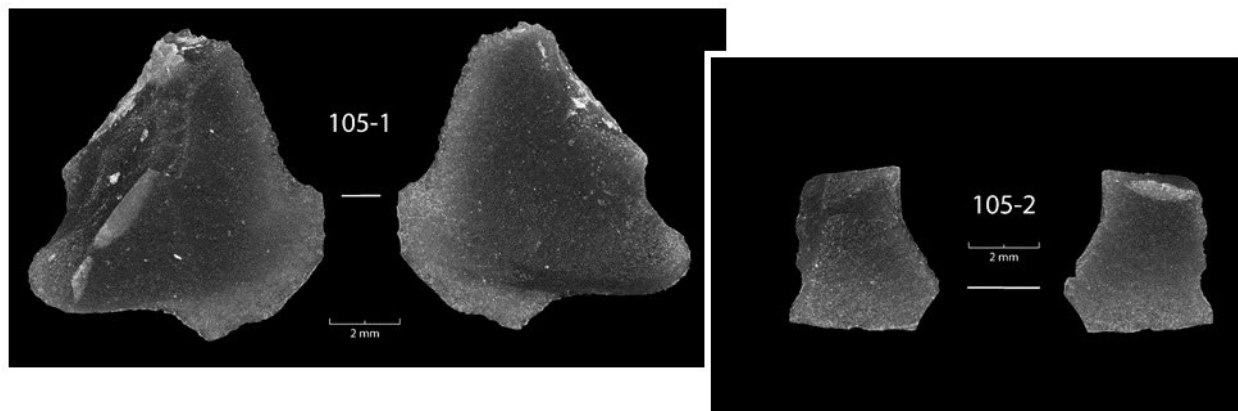


Figure 5.13 Obsidian flakes from a biface, recovered from the South Gap site.

A third observation is that quartzite is a main lithology in the $\frac{1}{4}$ in and larger fraction and occurs in large enough packages to make traditional bifacial tools. Interestingly, bifacial tools dating to the time of the AAR made on quartzite have been recorded in the Lake Huron Basin on Manitoulin Island (Julig & Beaton 2015: Julig 2002a,b), however, to date, there has been no evidence for the production of bifacial tools from quartzite on the AAR. Considering the amount of debitage that this activity would have produced, and that a multitude of other kinds of tools

that were recovered from the AAR, it seems that evidence for this activity would likely have been recovered if it had been present.

An additional consideration is that the foragers on the AAR are commonly using the high-quality cherts in the glacial till to make small and expedient tools. Considering that this appears to be a primary strategy for acquiring tool stone, it may be the case that this represents a form of embedded procurement, where foragers were confident in the ability for glacial till on the AAR to provide small siliceous cobbles. This reliance on locally available materials suggests a deep understanding of the landscape, providing evidence against notions of foraging uncertainty in terms of the distribution of resources. This form of embedded procurement focuses not on small, localized outcrops that constrain mobility, but ground cover over a large area that facilitates dynamic mobility patterns.

Taken together, this pattern of raw material utilized by foragers on the AAR supports the expectation that the lack of high-quality chert outcrops dictated the utilization of local chert cobbles that occur in the glacial till covering much of the AAR (following *expectation a*). However, the use of the local material to reduce carrying costs (following *expectation b and c*) was only part of the technological strategy in use on the AAR. The use of traditional bifacial tools that typically characterize the GLR during the PHT were also in use alongside small stone tools on local materials, as is evidenced by the three of the four specimens on non-local lithologies. It is also likely that the nature of the chert on the AAR prompted people to curate their bifacial tools from non-local sources more intensively than they otherwise would, thus leaving behind very little evidence of their existence. This suggests that the archaeological evidence for traditional technologies would be overwhelmed by the remains from production and use of small expedient tools that would more likely be left on site. Thus, the proportion of recovered small expedient tools made from local cobbles versus traditional tools made from non-local lithologies is likely not reflective of the technological organization employed on the AAR: it is likely that traditional tools were in use on the AAR far more often than the recovered assemblage might suggest.

5.8 Test results for cultural niche construction

5.8.1 *Expectation f*

It has already been demonstrated that many of these structures are cultural features often used for hunting based on morphology and placement on the landscape (Lemke 2016; Lemke 2021). To further test the function of constructed features as hunting architecture, it is expected that artifact assemblages that incorporate microlithic tools for hunting and subsequent animal processing (following *expectation d*), will occur in association with hunting features in concentrations comparable to other Arctic sites.

5.8.2 *Testing expectation f*

To test the expectation that constructed stone features on the AAR are associated with hunting technology, an examination of artifact densities at sites with hunting structures is carried out. If the structures were used for hunting, then artifacts associated with hunting and subsequent animal processing are expected to be found in association. The density of artifacts are calculated as the number of artifacts per liter of sediment and will be compared data from three other excavations at two Arctic sites on the Adak Island in Alaska (Wilmerding & Kay 2011). Net sinkers are removed from list as they are not related to hunting or animal processing. If concentrations of artifacts are similar to those reported here for the AAR, then the expectation is considered satisfied.

5.8.3 *Results for expectation f*

Of the 31 sites on the AAR considered here, 29 have documented hunting structures, 25 have been sampled, and 12 have produced stone tools. The 12 (48%) sites that have produced both hunting structures and artifacts will be used to further test the association of tools with structure (table 5.10). Although these data alone are good evidence for the association of hunting structures with stone hunting and processing tools on the AAR, the association can be examined further by comparing artifact density among sites.

Table 5.10 Shows data related sites on the AAR in terms of number of sites with hunting structures, artifacts related to hunting and animal processing, and samples.

Number of sites in total	Number of sites with hunting structures	Number of sites with samples	Number of sites with hunting and processing tools	Number of sites with tools and hunting structures that were sampled (%)
31	29	25	12	12 (48%)

The site with the lowest density of artifact per liter of recovered sediment is the Ash Gap site with 0.01, while the highest density of 0.22 is reported from three sites, Gap_Con_0, GapX02, and Dragon (table 5.11). Sampling at the Ash Gap site was spread out fairly evenly over the majority of the site, providing evidence that the density of artifacts is not a product of constrained sampling. Sampling at the Gap_Con_0 and GapX02 sites was more limited and constrained to a few small samples from single portions of each site suggesting that the artifact density data may be influenced by limited sampling. At the Dragon site, sampling was similar to Ash Gap in terms of number of samples and volume of sediment recovered, but with slightly less coverage of the site area. However, the number of tools is far greater with 17, and further 15 come from just two samples. Based on these data, the artifact density at the Dragon site is not likely to be a product of limited sampling, however additional sampling in the less sampled areas could confirm these results.

Table 5.11 List of sites with the total number of hunting structures and artifacts with the total volume of recovered sediment, and the density of artifacts per liter of sediment for each site.

Site	Hunting structures	Samples	Volume (l)	Number of hunting and processing artifacts	Density of artifacts per liter
Ash_Gap	15	12	76.7	1	0.01
Gap_Con_0	2	2	9	2	0.22
Wood_6	3	6	22.5	2	0.09
Funnel	5	17	36	1	0.03
Dragon	8	11	77.6	17	0.22
South Gap	17	52	215.7	8	0.04
GapX02	3	4	9.2	2	0.22
GapX01	1	3	13.5	2	0.15
Drop_45	7	54	512.8	29	0.06
A2RLIN	5	12	29.6	1	0.03
Average	6.6	17.3	100.3	6.7	0.07

The two most intensively sampled sites on the AAR, Drop 45 and South Gap, show a relative consistency in artifact density of .06 and .04 respectively and are very close to the average density for the AAR as a whole of .07 (table 5.11). Sampling at these two sites has been spread out over most of the site area, however some sample locations that produced artifacts were sampled multiple times. This is similar to how an excavation would often proceed on land where dense parts of artifact scatters are selected for additional sampling in the form of excavation. That the two best sampled sites are very in line with the average AAR site provides a level of confidence that artifact density on the AAR, are likely mostly reflective of past behaviors without taphonomy processing greatly obscuring cultural deposits.

Although less than half of the sites with structures are associated with tools, the intensity and nature of sampling is substantially different for each site, with an average of 100.3 liters of

sediment being recovered from sites with tools, while only 2.9 liters of sediment was recovered from site lacking reported tools (table 5.12). Many of the samples from sites without tools are from 0.2-liter vial samples and contribute to the lower average volume for these sites. Based on these data, the lack of tools at some sites with structures is likely a product of limited sampling.

Table 5.12 Compares the volume of sediment recovered for sites with and without tools.

	Average number of samples per site	Average Volume (l) of sediment recovered per site
Site with tools	17.3	100.3
Sites without tools	5.2	2.9

Moreover, when the average artifact densities from sites on the AAR with tools are compared to data from three excavations at Arctic sites in Adak Island in Alaska, i.e., ADK - 171-test pit 55-1, ADK - 171, and ADK - 012 that date to 6,040 Cal. B.P, 5,735 - 6,000 Cal. B.P, and 1,515 - 2,470 Cal. B.P respectively (Wilmerding & Kay 2011), a remarkable consistency is apparent (table 5.13). While the total number of tools recovered is different, the density of artifacts from earliest dating excavation (ADK - 171-test pit) is nearly identical to the artifact density at the average site with artifacts and structures from the AAR with 0.07 artifacts per liter. Considering that the test pit is described as located at the intersection of the bluff overlooking Clam Lagoon and the edge of a steep-sided swale, and not associated with midden deposits, this was likely a short-term extraction area (see Wilmerding & Kay 2011: 53, 55) similar to many sites on the AAR.

Table 5.13 Data from three sites on Adak Island in Alaska including artifact density, and calibrated c14 dates from (Wilmerding & Kay 2011).

Site	Date in Calibrated years B.P	Artifact count	Volume of sediment (l)	Artifacts per liter of sediment
AAR sites	11,200 - 7,500 Cal. B.P.	6.7	100.3	0.07
ADK – 171 –test pit 55-1	ca. 6,040 Cal. B.P.	133	1820	0.07
ADK – 171	5,735 - 6,000 Cal. B.P.	267	900	0.3
ADK – 012	1,515 - 2,470 Cal. B.P.	1480	1600	0.93

For the ASK - 171 excavation, 0.3 artifacts were recovered for each liter of sediment which is similar to the density of artifacts from Cap_Con_0, Dragon, and Gapx02 of 0.21- 0.22. Considering that ASK – 171 is described as a midden site, these data may suggest that the AAR sites with similarity artifact density experienced artifact accumulation from multiple visits, although no proper middens have been reported from the AAR.

The artifact density from the excavation at ADK-012 of 0.93 is higher than anything reported from the AAR (table 5.13). There are a couple possible reasons for this, including 1) being a much later dating site, there may have been a larger occupation that left behind more material. 2) The longer period of time represented may have resulted in the accumulation of more material due to a potentially greater number of occupations.

Considering the close match between the average density of artifacts at sites on the AAR, the two most sampled sites on the AAR, and the density of artifacts at ADK - 171 -test pit 55-1 (the closest dating excavation), the expectation that small tools for hunting and animal processing should be associated with hunting architecture at several sites on the AAR can be supported.

5.9 Test results for social networks

5.9.1 *Expectation g*

Social networks were likely important for foragers on the AAR for a multitude of reasons, including to provide access to resources from adjacent regions when they have become scares on the AAR and surrounding areas. As stone tools are the best surviving evidence for mobility and trade networks on the AAR, it is expected that locally available materials will predominate the lithic assemblage, but occur alongside occasional items on non-local material that derives further from the site, and from a different direction than a group typically moves during the course of a year, if they were acquired through far reaching trade networks (Whallon 2006: 260- 262).

5.9.2 *Testing expectation g*

To test whether foragers utilizing the AAR maintained far reaching social networks that could be called on for a multitude of reasons including for aid in times of resource uncertainty, material sourcing of stone tools and debitage (following *expectation e*) was carried out. Additionally, a discussion of specimens that are made from imported materials considering the source, direction, distance from the AAR, and the technology to assess whether they are likely to represent long distance trade and the presence of far-reaching social networks. Prominante chert types from in and around the Lake Huron Basin that do not appear in AAR assemblages will be used to suggest regions that were not socially connected to AAR foragers.

5.9.3 *Results for expectation g*

The vast majority of stone tools recovered from the AAR are derived from the local materials (95.8%) (following *expectation e*). However, there is a representation of imported materials from Area 3 at the two most heavily sampled sites on the AAR (Drop 45 and South Gap) (table 5.14). These sites are relatively complex, in terms of the number and complexity of stone constructions, compared to other sites on the AAR (following *expectation 3 in Chapter 6*). South Gap has a series of hunting blinds on the east side of the esker, and several more potential blinds on the west and northwest of the esker. Drop 45 has a 10-meter-long drive lane abutting an esker punctuated by blinds on either end and two other potential blinds within the site area

(O'Shea 2015a; O'Shea *et al.* 2014). It is likely that these two sites were constructed or built up over time during recurring visits over many years. These sites may have become places where people from different communities came together for communal hunting events, which would explain the presence of non-local lithologies, or they could represent a highly mobile people who traveled off of the AAR to trade for the material before bringing it to the AAR for use alongside locally produce expedient tools. That these sites occur near a major geographic bottleneck further supports the idea that this location would have been suitable for communal hunting events.

Table 5.14 Lists the three artifacts made from non-local materials, and their direction and distance from the source.

Specimen	Site	Source	Distance	Direction
131-1	Drop 45	Saginaw Bay	135 km	South
105-1	South Gap	Central Oregon	2,900 km	West
105-2	South Gap	Central Oregon	2,900 km	West

Considering the difference in source and direction among the three specimens, two distinct routes are apparent, i.e., that the obsidian flakes come from extremely far to the west, while the non-local specimen from the Drop 45 site comes from much shorter distance to the south (figure 5.14). The distance and directions of the obsidian flakes strongly suggest the presence of far-reaching social networks (O'Shea *et al.* 2021). However, the sourcing for the one specimen from the Drop 45 site is in line with previous reports about stone sourcing distances and directions in the GLR (Ellis 2011). The latter specimen could have arrived at the AAR by trade or by direct procurement as part of yearly migratory routes. Either way this would have involved encountering other groups of people and either establishing a relationship of some sort or continuing a previously established relationship. In both cases, these relationships could have been vital in times of resource stress, and for other things such as routine trade of resources, finding mates, and friendships. In the following passages, the three recovered specimens made from non-local materials will be described.

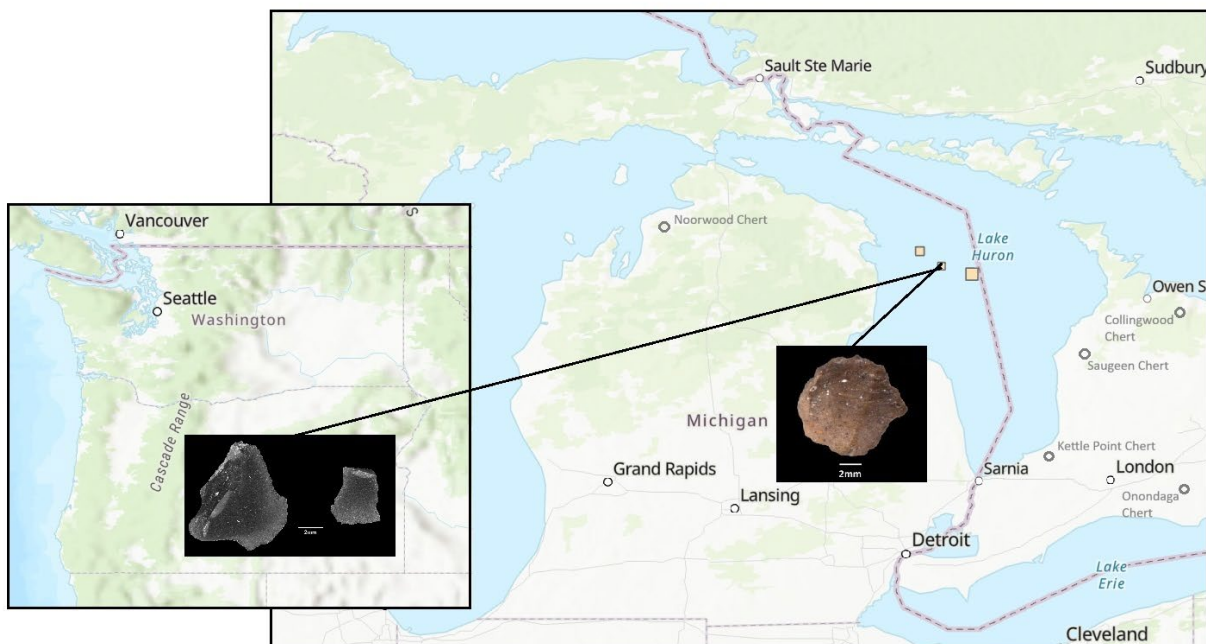


Figure 5.14 Show tools on imported material from the AAR, and their source location.

Specimens (105-1, 105-2) are obsidian flakes, described for *expectation e* (figure 5.13) from the Wagontire source in central Oregon (O'Shea *et al.* 2021; Riebe *et al.* 2022) about 2,900 km away, (table 5.14). As discussed for *expectation e*, these flakes are derived from a biface and likely represent resharpening of a bifacial point, or knife in between uses. These specimens are derived from a highly curated stone tool that traveled thousands of kilometers and went through at least one (although it was likely more) round of use and resharpening.

Specimen 131-1 is the “thumbnail scraper” from the Drop 45 site (figure 5.7) described for *expectation c*. It is made from non-local Bayport chert (following *expectation e*) from the Saginaw Bay area about 135 km away to the south (table 5.14) and could have been acquired through trade or direct procurement depending on the pattern of seasonal mobility. If people using the AAR move north to south on seasonal relocations, then they might encounter the Bayport source.

It is also informative to consider several prominent chert types from in and around the Lake Huron Basin that apparently were not utilized by AAR foragers. This includes Kettle Point chert from the southern portion of the Huron Basin, Saugeen chert from the eastern portion of the Huron Basin, Collingwood chert from Georgian Bay in northeastern lake Huron Basin,

Onondaga chert from Southwest Ontario, and Norwood chert from Northwestern lower Michigan (figure 5.14) (Fox *et al.* 2015: 67-72). Most of these sources occur to the southeast of the AAR and their complete absence from lithic assemblages suggests that foragers utilizing the landform did not frequently traverse or have strong social ties to these areas.

In sum, the data for non-local materials is limited but strongly suggests that people utilizing the AAR had far-reaching social networks, likely to the west. The one artifact on non-local chert from the Drop 45 site does derive from the south and could have been obtained directly or through trade. The obsidian flakes from Oregon, however, almost certainly arrived at the AAR after being traded some number of times to people who took it east into the GLR.

5.10 Discussion of results for the regional model tests

Results from testing the seven regional expectations related to the four domains show that the EHA model provides a good fit for foraging behavior on the AAR, however several additional insights and cautions can be drawn from the results. First, the use of small tools made from small local cobbles to facilitate a system of high mobility, may be slightly overestimated with the current form of the EHA model. Although a technological strategy fitting this description was certainly employed by foragers on the AAR, the model may underrepresent the use of traditional bifacial tools that typically characterize the technologies in the GLR during the PHT. The presence of the two obsidian flakes from the South Gap are proof positive for the uses of traditional bifacial tools on the AAR. Moreover, the obsidian flakes are made from stone not local to the GLR so debitage from the original manufacture would not be present on the AAR. Only the small refurbishment flakes and discarded biface fragments would be present. Additionally, considering that the AAR is a chert poor area, it is reasonable to posit that curated bifacial tools may have been conserved more than they otherwise would, leaving behind very little evidence of their existence.

However, there is a complicating factor when identifying bifacial technology from small flakes on the AAR. In one case, an expedient scraper recovered from the South Gap site in Area 3 made from a local chert cobble (324-2) has a bifacial edge potentially for hafting (figure 5.15). This is not a traditional bifacial tool, and it is important to note that flakes removed from the edge of this tool would look very similar to flakes derived from traditional bifacial reduction of

large bifacial points and knives. It may be the case that bifacial debitage on local stones from the AAR may be from more expedient tools than one might expect.



Figure 5.15 Shows a scraping tool (324-2) made from a relatively large local chert cobble, and it has a bifacial edge that would have produced flakes classified here as derived from bifacial reduction.

It may also be the case that the use of relatively large, single use, expedient tools are underrepresented by the model. This kind of strategy also accomplishes the goal of promoting a system of high residential mobility by reducing carrying costs associated with transporting stone tools. This type of reduction system is common on the AAR and may be more archaeologically visible than the small tools, and traditional bifacial tools, as expedient tools are made and discarded on site often from the largest cobbles, leaving behind more evidence of their existence than the other technological strategies.

The presence of traditional bifacial tools on non-local stone at sites that show more development (*i.e.*, Drop 45 and South Gap) could also be interpreted as representing places of aggregation where people from different areas meet on the AAR for communal hunting events, similar to how it has been described in the Great Basin (Hockett *et al.* 2013; Arkush 2014). In this case, the AAR may be a place where social networks are created and strengthened, to be used for a multitude of functions including for finding mates, friends, trading partners, and social safety nets in times of stress. In order for social networks to work, they must function –and be strengthened– in times that are not stressed, so that they can be activated during times of stress.

Along with resource extraction, this may have been a primary function of communal hunting events on the AAR.

It is striking that the lithic assemblages from the AAR show a distinct lack of cherts known to exist relatively nearby in the GLR (other than the one specimen on Bayport chert) (following *expectation g*). This includes cherts from the eastern portion of the Lake Huron Basin and southeast Ontario, such as Onondaga chert from Ontario, Manitoulin quartzite and Collingwood chert from Georgian Bay (Fox *et al.* 2015: 67-69), suggesting that visiting these sources was not incorporated into the mobility strategy, or social networks for foragers utilizing the AAR. Norwood chert from northwestern lower Michigan is also absent from AAR assemblages, suggesting that people utilizing the AAR did not have this area incorporated into their mobility systems. Other than the Norwood chert, these sources are largely to the east of the AAR and do not correspond to the direction of the recovered non-local material that source to the southwest in Saginaw Bay and the far west in central Oregon. As reviewed in chapter 3, during the PHT people in western Canada and as far south as Oregon employed a technological strategy that involved the use of microlithic tools alongside bifacial tools (Magne *et al.* 2020, Magne 2023). That our exotic stone sources to this area indicate that at least some foragers utilizing the AAR had social connections to the far west.

Additionally, the prevalence of stone hunting architecture and the varied topographies where they occur (following *expectation d*), suggests that hunting was a main activity on the AAR and took place in multiple settings. However, the presence of structures not related to hunting, such as stone circles for hearths and habitation structures at river and lake edge sites—such as at Con 6 and Wood 6— suggest that activities beyond hunting took place on the AAR (figure 5.16). Considering the size of the AAR, it would have taken at least a couple of days to walk to the hunting sites near the center of the ridge, and potentially more to walk back through or around the basin depending on the amount of newly acquired animal resources that were being transported. It is only reasonable to expect to find camp and habitation sites in the vicinity of hunting sites and positioning them next to fresh water only makes sense.

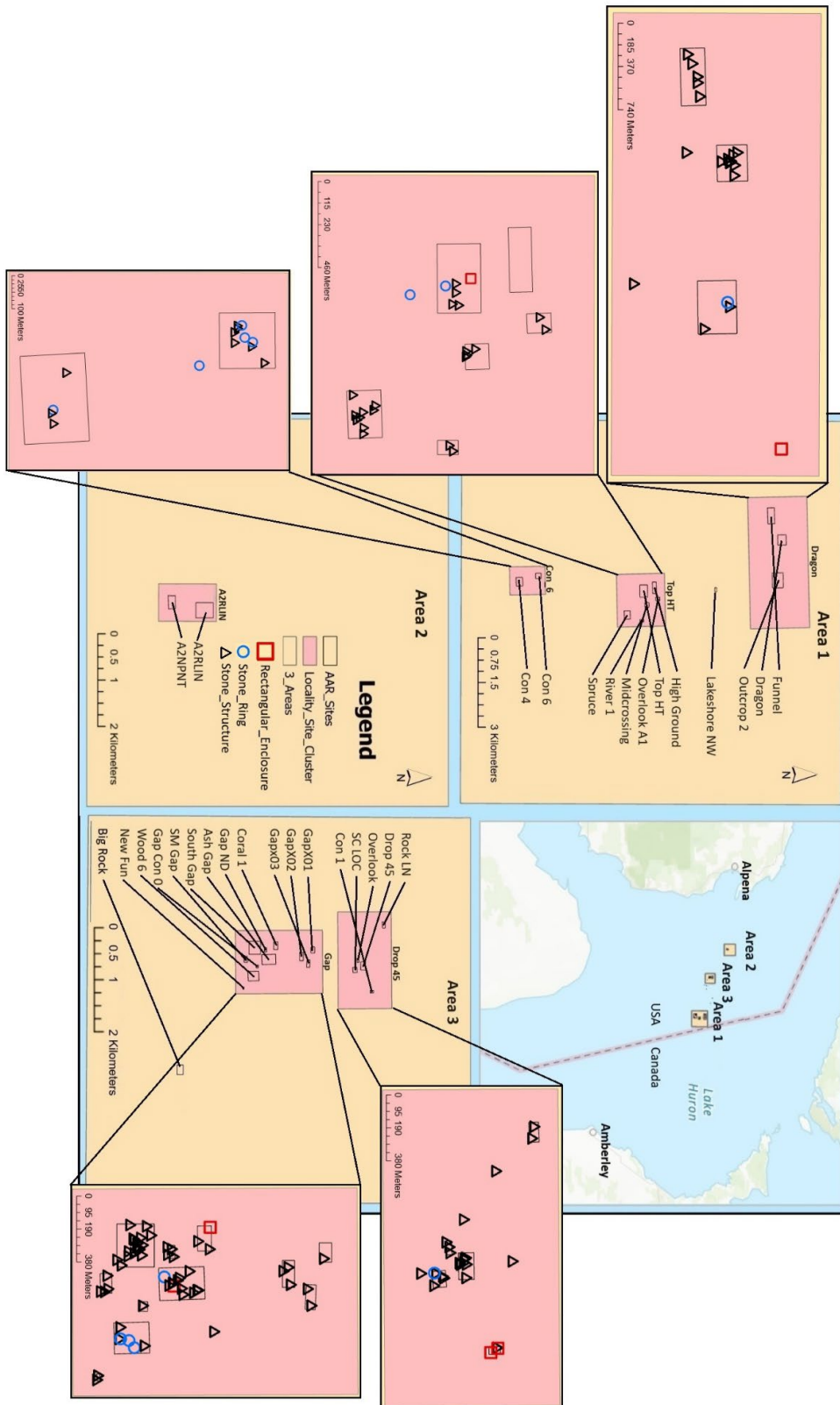


Figure 5.16 Map showing AAR sites with non-hunting features including rectangular enclosures and stone rings.

The results of the analysis of site elevation presented for *expectation d*, show that most documented sites with structures occur between about 25 - 40 meters deep from the modern lake surface (figure 5.9). The occupation associated with these lake levels likely dates to the middle portion of the Lake Stanly period between about 10,000 - 8,500 Cal. BP (Lemke 2016: 103; Lewis *et al.* 2005). The team has largely focused on investigating sites at these elevations as they near the top, traversable portion of the ridge that connects both sides of the Huron Basin and represents the land surface that migrating animals and the human predators would travel on seasonal migration routes. Locations in this setting were chosen for intensive investigation because of their likelihood of containing caribou hunting sites (O'Shea 2023; O'Shea 2015b). In this way, data from the AAR likely over represents hunting behaviors relative to other activities that certainly took place. Sites at elevations below about 50 meters are too deep for sample collection using the scuba methods currently employed and would likely date to the early portion of the Lake Stanely period dating to between 11,200 - 10,000 Cal. B.P (Lemke 2016: 103; Lewis 2016; Lewis *et al.* 2005). Although the ROV and special dive equipment have been used to investigate deeper sites on the AAR, they have not been the main focus of investigation to date

Finally, I found little evidence to support the notion that uncertainty of resource distribution was a driver of foraging behavior on the AAR. Rather, I found a system of foraging behavior that reflects an intimate relationship with the landscape including, knowledge of the geomorphologic structures on the landscape, how caribou would likely interact with the natural setting, and knowledge of the nature and distribution of lithic resources such to determine what tools could be made on site and what would need to be carried onto the AAR to make up the difference.

5.11 Conclusions

Key insights into the systematics of foraging life ways on the AAR and interpretations about the nature of the archaeological record were derived from formulating and applying the EHA model. This includes cautions about the interpretations of the recovered assemblage. Most significantly, that the proportion of recovered materials does not necessarily directly reflect how intensively different behaviors occurred on the AAR. It was also important to consider what traces individual activities may have left behind and recognize that some behaviors will leave

behind more material to be incorporated into the archaeological record than others, but that does not necessarily indicate that one activity occurred more often or more intensively.

Another significant insight derived from applying the EHA model to AAR is that sites reported from this now submerged region, likely date to the middle period of Lake Stannely between about ca. 10,000 - 8,500 Cal. B.P (following *expectation d*). Foragers on the AAR during this period would have navigated a patchwork of cold, boggy marshes with patches of conifer trees and exposed moraine and/or glacial till material (see chapter 2 for a description of the ecological setting of the AAR). Dating of the occupation of the AAR was largely deduced from site elevation data, considering that certain elevations would have been exposed at different times (Lemke 2016: 103)

A final consideration for the analysis, and what it describes about foraging behaviors on the AAR, is that areas targeted for investigation were places that appeared to be advantageous for caribou hunting (O'Shea 2023; O'Shea 2015b), such as bottlenecks on the landscape. This process of site discovery has likely led to an overrepresentation of hunting sites relative to sites with other functions, such as habitation, fishing, and other activities. The sites under investigation here are too far from the mainland for people to travel to and from these sites in a single day, thus there are certainly sites with functions beyond caribou hunting on the ridge that have not been discovered. Importantly, this research has only considered the portion of the AAR in American waters, all of which is now within the Thunder Bay National Marine Sanctuary.

In the following chapter the three diachronic expectations of the EHA model will be critically applied at each site on the AAR to identify sites that are relatively more developed than others. This serves as a complement to the regional expectations applied here by considering behaviors associated with habitual use sites rather than foraging behavior and landscape use at the regional level.

Chapter 6 Critically Applying the Diachronic Expectations of the Early Holocene Adaptation Foraging Model to Sites on the AAR

6.1 Introduction

The EHA model developed in Chapter 4 describes a specific set of diachronic expectations for three of the four domains: technology, mobility, and niche construction. These are supplementary to the broader expectations tested against data at the regional scale in Chapter 5. Those patterns –such as the concurrent use of multifunction and microlithic tools alongside hunting architecture– were anticipated to occur at the majority of sites on the AAR. The three diachronic expectations tested here, however, relate to a select few sites that likely experienced more frequent use. It is expected that as environmental conditions stabilize along with prey species behavior, certain locations become and remain advantageous for caribou hunting (see Chapter 4). Additionally, major geographic bottlenecks in the landscape also provide an advantage for caribou hunting and may be places that experienced more frequent visitation and potentially increased development.

The results of the regional tests in Chapter 5 indicate that four sites (Dragon, Drop 45, South Gap, and Funnel) have elaborated stone constructions that indicate increased investment relative to other sites. This was recognized in the field, and for this reason, these sites were subject to more intensive investigation including increased sampling and sonar mapping. This resulted in the majority of lithic artifacts coming from these sites (80%), and a more precise understanding of site layout.

The goal of the diachronic tests is not to arrive at a seriation of sites, or to determine which sites were visited most frequently. Rather, it is to evaluate the expectations of the EHA foraging model relevant only to sites that were used relatively frequently. Many identified sites on the AAR were likely used during times of rapid environmental change associated with the onset of the Holocene and were not advantageous hunting locations for long enough to experience increased cultural development. Utilization of these sites is evident only from a couple simple structures and few stone tools when sampled (see Chapter 4)

The chapter begins with a background section that describes the research history of the four sites. Then, there is a brief presentation of the diachronic expectations of the EHA model, followed by a description and justification of the variables used to test each one. Each expectation will be tested individually, starting with a statement of the expectation, followed by a description of the testing process, and section describing the results. This is the same organization employed to test the regional scale expectations in Chapter 5. After this, a discussion of what the findings reveal about the different domains and how their expressions over time on the AAR will be provided.

6.2 Background for select sites

6.2.1 The Dragon Site (20AA230).

The Dragon site in Area 1 was the subject of the first publication about the archaeology of the AAR (O'Shea & Meadows 2009). The paper focused on the Dragon blind and the linear feature that guided migrating animals along a path that leads them past the blind where concealed hunters would wait. This was the first evidence for a method of hunting that would eventually be documented at several sites on the AAR. Additionally, data from the Dragon site has appeared in several publications, including a 2013 article that describes the function and construction of the Dragon blind (O'Shea *et al.* 2013), and a 2017 article that, among other things, considered the seasonality of the Dragon site from the orientation and function of constructed features (Lemke & O'Shea 2017).

In a chapter of *Caribou Hunting in the Upper Great Lakes* (Sonnenburg *et al.* 2015), O'Shea compares different forms of stone construction documented on the AAR. He describes the Dragon blind as consisting of three large stones that are stacked or resting on smaller ones to form a small enclosure (O'Shea 2015a: 121). The scatter of stones around the blinds may have been stacked up on top of the structures creating a cache space inside. This interpretation is evidenced by a fragment of a cervid tooth recovered from inside the structure (Lemke 2016: Lemke 2015b). Subsequent AUV and ROV surveys have demonstrated the existence of a series of stone constructions at the location. Lithic artifacts recovered in association with this feature have not been previously published, but largely consist of scrapers, bipolar cores, flakes, choppers and net sinkers (appendix 1).

6.2.2 The Drop 45 Site (20AL104)

Data from the Drop 45 site was first published in 2014 by O'Shea *et al.*. This report describes the relatively complex stone hunting structure documented at the site. Constructed on level limestone bedrock, the feature is comprised of one line of stones about 30 meters long running parallel to a natural scarp, creating an 8 meters wide drive lane with four hunting blinds abutting or built into the stone line (O'Shea *et al.* 2014: 6912; O'Shea 2015a: 126; Lemke & O'Shea 2017: 4-5). Data from the Drop 45 site was also published by O'Shea (2015) in the edited volume by Sonnenburg *et al.* (2015:126-130), where the stone features from different sites on the AAR are compared to arrive at a typology. This typological system was the starting point for the classification system employed throughout this research and described in Chapter 5.

The lithic assemblage from the Drop 45 site was the first collection of tools to be published from the AAR (O'Shea *et al.* 2014: 6913). To date, the site has produced lithic material in the form of flakes, micro-blades, bipolar cores, a net sinker, and a thumbnail scraper with a graver tip made from Bayport chert that outcrops about 150 kilometers southwest of the site in what is now the Saginaw Bay (Lemke 2015a: 142-144; Fox *et al.* 2015: 68). Notably, the initial investigations at Drop 45 used 1/4 in. screen to search for artifacts in sediment samples, which may have failed to capture smaller tools, fragments and debitage.

6.2.3 The South Gap Site (20AA232)

The South Gap site at the southern end of the Gap locality was discovered in the summer of 2010 by researchers searching the lake floor for archaeological sites using a remotely operated vehicle (ROV). Two prominent, and isolated 'V' shaped stone structures are what first caught their attention and alerted them to the archaeological potential of the site. Data from the South Gap site was first published in 2013 by O'Shea *et al.* and provided the initial report about the V-shaped blind that first alerted researchers to the archaeological potential of the site. This blind is referred to as "V-Cluster" and was subsequently reported in 2015 by O'Shea in an edited volume by Sonnenburg, Lemke, and O'Shea. Moreover, a report illustrating the two obsidian flakes from South Gap was first provided by Lemke (2015:142) in a chapter in the same volume. However, they were not identified as obsidian until 2021 when they were sourced with a variety of methods

and multiple labs (O'Shea *et al.* 2021; Riebe *et al.* 2022). See Chapter 7 for an in-depth examination of the South Gap site.

The majority of the South Gap site occurs on the east side of an esker running north - south with a central drive area consisting of a drive lane leading southeast to a series of hunting blinds, including the prominent V-shaped blind that first caught the attention of researchers in 2011. The west side of the esker has several potential blinds placed at key locations along the esker and likely functioned independently of the central drive area (see Chapter 7 for an extended discussion of site features).

6.2.4 The Funnel Site (20AA231)

The Funnel site was first investigated in 2011 and reported in 2013 (O'Shea *et al.* 2013; O'Shea 2015a: 126). The Funnel site is placed to utilize two linear natural features including a boulder field to the southwest and a limestone scarp drop-off of about 1m to the northeast (O'Shea *et al.* 2013: 39-40; O'Shea 2015a: 126-129; Sonnenburg & O'Shea 2017). This natural bottleneck was enhanced by the creation of two lines of relatively large stones that converge to create a funnel shape leading to a 6-meter-wide opening with a large rock in the middle, that effectively created two 2.5-meter openings (O'Shea 2015a: 126-129). It was this funnel shaped structure that first caught the attention of researchers and led to initial mapping with scanning sonar in 2011. Due to the bare limestone surface of the site and its relatively shallow depth, there was little sediment available to sample for artifacts. The area beyond and behind the structure, however, seems to contain sediment and has yet to be archaeologically sampled. The lithic assemblage from the site consists of a single tool, a relatively large chopping tool made from quartzite.

6.3 Diachronic expectations of the EHA model

There are three diachronic expectations (I-3) that are relevant to three of the four domains of the EHA model that are laid out in Chapter 4; technology, mobility, and niche construction (table 6.1). These expectations relate to sites that underwent increased development, in terms of elaborated cultural features. Either due to being advantageous places for hunting caribou after climate conditions stabilize as the Holocene sets in, or sites at geographic

bottlenecks that would likely have been good hunting sites throughout the exposure of the AAR. For this reason, the four sites on the AAR reviewed above will be the focus of the expectations. Below is a description of the variables used to test each of the diachronic expectations.

Table 6.1 Shows the diachronic expectations for individual sites on the AAR along three domains of the EHA model.

Domains	Diachronic Expectations
Technology	1) Incorporation of higher quality raw materials.
Mobility	2) <i>Place provisioning</i> indicating repeated use of the site.
Niche Construction	3) Increase in number, complexity, and variety of constructed features.

The diachronic expectation related to **technology** is that as mobility routes stabilize along with dynamic climate conditions of the PHT, people will begin to incorporate the best stone sources into more fixed mobility systems, whether from an exposed outcrop, or from localized high-quality chert from particular patches of moraine or esker (if they exist). Data used to test this expectation will be derived from observable features on each lithic artifact, including grain structures i.e., coarse - fine, and whether it appears to be highly siliceous, relative to other rocks on the AAR. Relative silica content will be judged based on two criteria: whether any breaks show a conchoidal fracture and how sharp or well-defined fracture patterns appear, and how vitreous the stone looks relative to other rocks recovered from the AAR. These observations will be used to create three categories of quality for each lithic artifact: low, medium, and high. These data will be used to assess differences in raw material quality for stone tools between the three sites.

The diachronic expectation for **mobility** is that as a subset of sites are visited more frequently, some may show evidence for place provisioning or stockpiling of tools including larger tools. Weight will be used as an approximation for size of the stone tools. This is preferable to dimensions as the tools are not regular shapes, and it is difficult to get a precise measure of size from them. Although the different lithologies may have slightly different densities, the difference in size between microlithic tools, and larger tools such as net sinkers and

choppers should be so great that differences in density will not be a significant factor. The density of artifacts (measures as the number of artifacts per liter of sediment), per sample location (which may include multiple samples) will be used to assess whether large, outlier artifacts occur alongside others, and whether they appear to have been concentrated or clustered at certain portions of the site. The function of any larger, clustered tools will be examined to determine what behaviors they represent, and if they appear to have been stockpiled for use during subsequent visits.

For **niche construction**, it is expected that niche construction behaviors should intensify at some sites over time. Three different lines of evidence will be used to test for site elaboration, including increased structure count, variety, and complexity. It is expected that the three sites should show increases in one or more of these variables. To test this three-part expectation, data collected from the potential hunting structures, including location, type, and an assessment of complexity will be used. The location of structures was used to assign them to specific sites, facilitating a count of structures per site. Each structure was assessed for function and morphology to create categories or types that could be used to judge the variety of structures per site. The process for creating site boundaries and assigning types to structures is presented in Chapter 4.

Determinations for the complexity of structures will be based on an assessment of how the structures were made and whether they incorporate multiple components, or contain stacked stones, rather than simpler arrangements of rocks on the ground. This is similar to how simple and complex structures are defined by Lemke and O'Shea (2017). However, it differs slightly in that here, individual structures are classified as simple or complex, where Lemke and O'Shea (2017) use the term complex to refer to a site where multiple features are used in tandem to facilitate hunting. The system used here breaks this definition of complex into three different parts where each is used as evidence for intensification of site use and niche construction behaviors.

6.4 Test results for the diachronic expectation of the EHA model related to technology

6.4.1 Expectation 1

Some sites should have higher proportions of artifacts made on high-quality materials than others. As mobility routes stabilize along with dynamic climate conditions of the PHT, people would begin to incorporate the best sources into more fixed mobility systems, whether from an exposed outcrop, or from localized high-quality chert from particular patches of moraine or esker.

6.4.2 Testing expectation 1

To test this expectation, each lithic specimen from the AAR was examined to determine the variety and the quality of stone. This will provide the data necessary to assess whether select sites on the AAR (Dragon, Drop 45, and South Gap) have a higher proportion of higher quality raw materials relative to other sites on the AAR. The variety is determined based on color, texture, and lithology, while quality is assessed based on how silicious the stone appears, and thus how sharp it can be and well it can knap. Data from the three developed sites will be compared to the aggregated data from the remaining, less developed sites as a control.

6.4.3 Results for expectation 1

After examination of each lithic specimen, eight varieties of chert, four varieties of quartzite, and one of obsidian were identified (table 6.2). All of these varieties derived from either glacial transport or occur locally in the limestone and dolomite bedrock, save for the two non-local varieties i.e., the obsidian and Bayport chert (following *expectation e*). It is currently not possible to distinguish between local and glacially transported chert as no *in situ* outcrops have yet been identified on the AAR, and all specimens here appear to have been gathered from glacial till.

Table 6.2 List of raw materials for artifacts recovered from the AAR, including the site(s) where they occur, and their quality. For certain tool types, quartzite is considered a high-quality material.

Material	Count	Site(s)	Quality (tool type for quartzite)
Chert, limestone	1	Dragon	Low
Chert, gray	7	Dragon, South Gap, Drop 45	High
Chert, light gray	2	Drop 45	High
Chert, honey	38	Dragon, South Gap, Drop 45	High
Chert, mottled	5	Dragon, South Gap, Drop 45	High
Chert, black	1	Drop 45	High
Chert, white	3	Drop 45	High
Chert, Bayport	1	Drop 45	High
Obsidian	2	South Gap	High
Quartzite, yellow	1	South Gap	High (net sinker)
Quartzite, white	2	Dragon, South Gap	High (chopper, chopper)
Quartzite, brown	1	Dragon	High (wedge)
Quartzite, orange	2	Dragon	High (wedge, hammerstone)

The majority of flaked stone artifacts recovered from the AAR come from three sites: Dragon, Drop 45, and South Gap and together represent 80%, while other sites combine to form the remaining 20%. At each of the three sites, a high-quality, honey colored chert is the most prevalent (table 2), with Dragon, Drop 45 and South Gap having 47%, 60%, and 33% of all stone artifacts made from it respectively, while other sites on the AAR –that contained artifacts– combined for 64%. There is only one type of chert determined to be of low quality, and it is represented by a single specimen from the Dragon site and no chert of medium quality (table 6.2).

When compared to the background occurrence of honey colored chert in the 1/4 in. fraction (following *expectation a*), at these locations (3.6% at Dragon, 1.3% at Drop 45, and 9.3% at South Gap), it is apparent that foragers on the AAR are preferentially selecting the honey-colored cobbles from the glacial till to make small and expedient tools. This explains why the honey-colored chert makes up a much larger portion of the lithic assemblages than the background till.

Notably, a cobble of honey colored chert was sawed in half by Professor O'Shea, per suggestion by colleague Bill Fox, as an experiment to examine the properties of the stone and revealed that the honey color was a product of iron staining associated with sub aerial erosion associated with rising lake levels (figure 6.1). It is likely the case that the chert cobbles were grey when they were being selected by foragers. Further, the gray, and light gray chert variants described here may be from the same source as the honey variety that makes up the majority of the assemblage from each site.



Figure 6.1 Honey colored chert cobble that was cut in half to reveal that it is actually a high-quality grey chert.

The four varieties of quartzite are represented by only seven artifacts, three large chopping and smashing tools, one net sinker, two wedges, and a scraper. It is important to note that several of these artifacts are different in kind than the chert artifacts and determinations of quality were likely different for these tool types: quartzite may be an idea stone for making net sinkers, choppers, and hammer stones, as they are durable but less sharp (see Ebright 1987; Driscoll 2011; Spry *et al.* 2022). All of the quartzite artifacts belong to these tool types except

for one scraper from the Gap Con 0 site. Thus, the quartzite tools will be considered on high quality material except for the one specimen from the Gap Con 0 site.

Considering that quartzite may be an ideal material for making certain kinds of tools, the vast majority of the artifacts from each of the three prolific sites, and other sites in aggregate, are on high quality material: Dragon (94%), Drop 45 (100%), South Gap (100%), other sites in aggregate (93%) (figure 6.2). This consistency in quality is largely due to the occurrence and quality of materials being relatively consistent throughout the AAR (following *expectation a*).

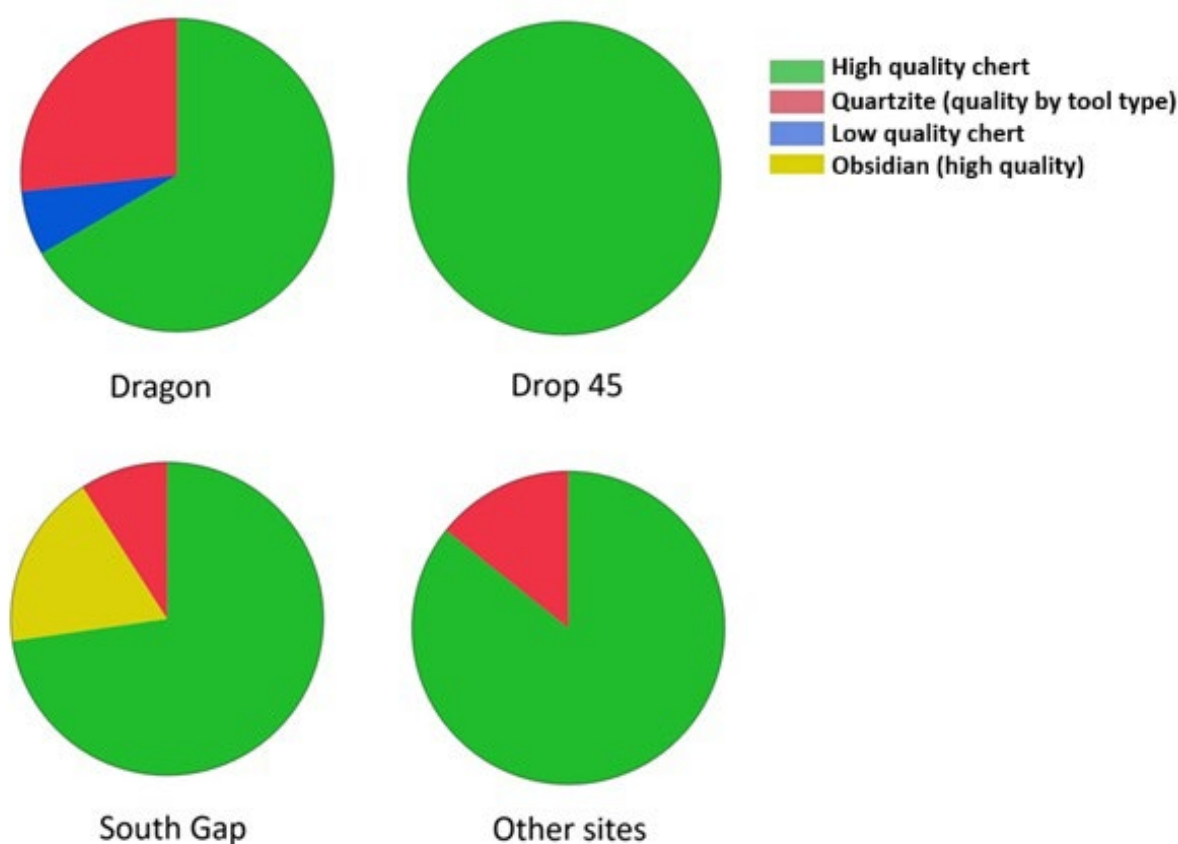


Figure 6.2 Pie charts showing the proportions of flaked artifacts that are on high, medium, and low-quality chert quartzite, and obsidian from Dragon, Drop 45, and South Gap.

A notable pattern is the increased proportion of quartzite tools at the Dragon site and the complete lack of quartzite tools at the Drop 45 site (figure 6.2). Following *expectation 2*, It may be the case that quartzite tools are associated with place provisioning or stockpiling behavior at the Dragon site that did not take place at the potentially earlier dating Drop 45 site. As the

exploitation of the AAR progressed, however, more stable environments associated with the onset of the Holocene allowed certain sites to remain productive for long periods of time, relative to earlier Late Pleistocene sites. At this point in the developmental history of the AAR stockpiling may have become more common.

In sum, there were only two specimens recovered from the AAR that we're determined not to be on a high-quality material for the specific tool type. One is the scraper on quartzite from the Gap Con 0 site that may be considered medium-quality raw material for that tool type, and there is only one artifact made from a low-quality material, found at the Dragon site. Although this may be interpreted to suggest that the more developed sites have a slightly higher proportion of high-quality raw materials than the other sites in aggregate—with an average of 98% (55 of 56) high-quality raw materials for developed sites and 93% (13 of 14) for other sites in aggregate—a single specimen that is not made on high-quality materials from each group is not deemed sufficient to completely satisfy this expectation.

6.5 Test results for the diachronic expectation of the EHA model related to mobility

6.5.1 Expectation 2

Foragers utilizing the AAR employed a pattern of high residential mobility that incorporated repeated use of certain sites. It is expected that this strategy should be evidenced by a change in provisioning strategies from purely *ad hoc* production of expedient tools associated with initial short-term visits, to also include *place provisioning* or stockpiling with larger, less portable artifacts in anticipation of future visits.

6.5.2 Testing expectation 2

An outlier formula is applied with JMP Pro 17 (using the Interquartile Range (IQR) method, that identifies points beyond the upper limit ($Q3 + 1.5 \times IQR$)) to artifact weights to identify larger, outlier tools in the assemblages from each site. If any site contains more than one large outlier, the density of artifacts—per liter of sampled sediment—from the different sample locations will be calculated and compared to other sites on the AAR to test whether they occur in denser patches and may represent stockpiling behavior.

6.5.3 Results for expectation 2

Of the three sites with larger tool outliers, only the Dragon site has more than one (figure 6.3). The Drop 45 and South Gap sites have only a single large outlier (a net sinker in both instances), and although this is enough to suggest a wider range of activities than just hunting, and subsequent animal processing, it is not enough to establish a pattern of *place provisioning* or stockpiling behavior.

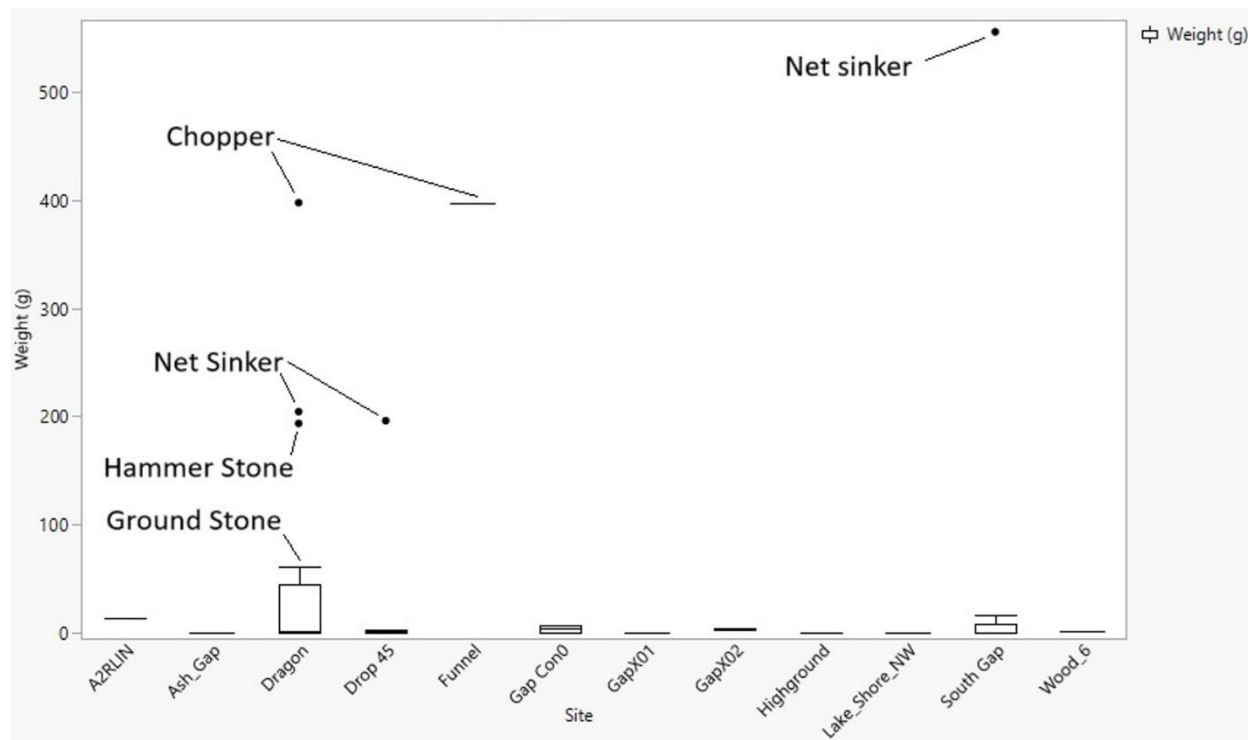


Figure 6.3 Show the weight of tools for each site with the function of large outliers labeled. Horizontal lines not attached to boxplots represent artifacts in cases where there are not enough at a site to create quartiles and calculate outliers.

The Dragon site, however, has three large outlier artifacts –and a ground stone tool that is the next heaviest artifact although not technically an outlier– that represents a range of activities. The presence of a chopper and a ground stone tool (both were likely used as wedges and/or as choppers) indicates that activities related to creating larger organic objects such as canoes, drying racks, dwellings, and/or organic portions of hunting blinds likely took place at this site. The presence of a net sinker at Dragon and the other two sites suggests the presence of activities other than hunting caribou, such as fishing or trapping of smaller animals, which may reflect use

in summer to bridge between hunting seasons in the fall and spring. Additionally, two bipolar cores have been recovered from the Dragon site and raise the average weight of the non-outlier tools above the other sites (figure 6.3, appendix 1). This further suggests a broader range of activities than hunting and caching alone.

To further test for stockpiling behavior at the Dragon site, the pattern of occurrence of artifacts within the site, and the volume of sediment recovered from each sample location, was assessed to determine if they were likely clustered together. Of the 17 artifacts from the Dragon site, 15 come from a single location that was sampled three times for a total of 30.2 liters of sediment, this includes each of the four larger outliers. For this location, 0.5 artifacts were collected per liter of sediment. A second sample location about 40 meters north of the previous location produced 2 additional tools from a total of 18 liters of sediment. This works out to 0.11 artifacts per liter of sediment for this sample location. When compared to the density of artifacts at other sites on the AAR (following *expectation f*), the former location produced more than double the highest value of 0.22, while the latter location is below this number. The 9 remaining samples from Dragon are from 4 different locations scattered around the site, account for the remaining 29.4 liters of sediment and did not produce any artifacts.

These data strongly suggest that the artifacts at Dragon occur in clusters that include larger outlier tools. Further, considering that the sample location that produced the highest density of artifacts is only about 10 meters from the Dragon blind/cache, where a fragment of a cervid tooth was recovered (Lemke 2016: 296; Lemke 2015b), the presence of stockpiling or *place provisioning* behavior associated with the Dragon blind can be supported.

6.6 Test results for the diachronic expectation of the EHA model related to cultural niche construction

6.6.1 *Expectation 3*

It is expected that as environmental conditions stabilize and the cultural exploitation of the AAR develops, select sites that provide an advantage for hunting will be used more frequently. This is expected to result in an increased count, variety, and/or complexity of constructed features, relative to other less visited sites on the AAR.

6.6.2 Testing expectation 3

To test this expectation, data from the stone structures for each site on the AAR will be examined for increased count, variety, and complexity separately. The results of the three simple analyses will be assessed to determine if together, they are sufficient to satisfy the stated expectation that select sites on the AAR will show signs of development in terms of the increased intensity of niche construction behaviors relative to other sites. Determinations of the variety of stone structures documented at each site will be based on the number of different types of structures. The typology used throughout this analysis to categorize the different stone structures documented on the AAR has been presented in Chapter 5. Determinations for the complexity of structures will be based on an assessment of how the structures were made and whether they incorporate multiple components, or contain stacked stones, rather than simpler arrangements of rocks on the ground. This will be assessed through photo, video, and remote sensing data on showing the morphology of constructed stone features and their position within a site.

6.6.3 Results for expectation 3

6.6.4 Count

Following *expectation d* in Chapter 5, the South Gap and Ash Gap sites present the highest total number of structures of any site on the AAR with 17 documented plausible structures each. This is far above the average and median number of structures per site at 4.6, and 3 (figure 6.4). Thus, the expectation that select sites should show increased number of structures relative to others on the AAR can be satisfied for the South Gap and Ash Gap sites. It should be noted that as exploration continues it is possible that additional structures are identified at these sites or new ones.

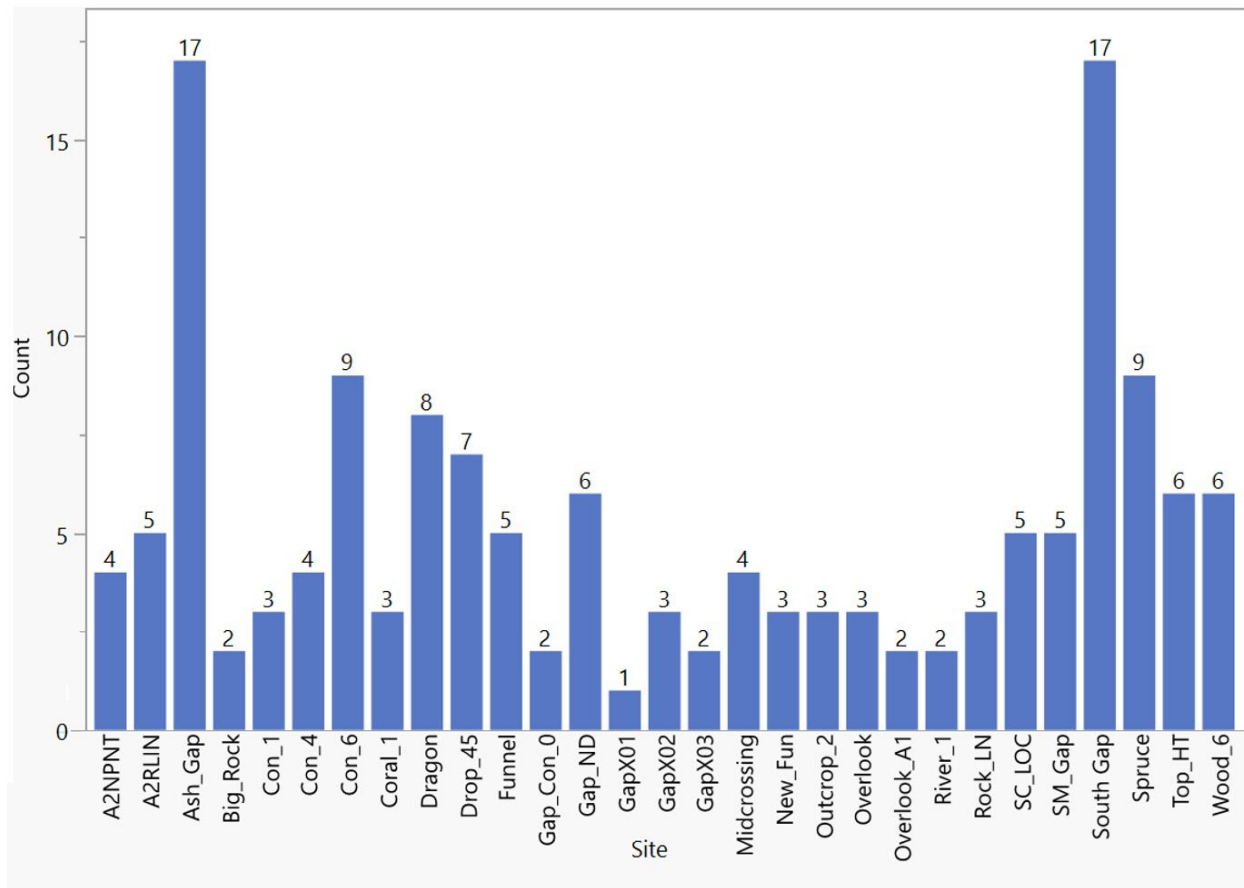


Figure 6.4 Bar graph showing the total count of documented plausible structures for each site on the AAR.

6.6.5 Variety

The typology of stone structures presented in Chapter 5 describes nine classes or types of constructions documented on the AAR. With respect to this typology, the Dragon site has the widest variety of structure types of any sites on the AAR with 6, followed closely by Ash-Gap and Top HT with 5 (figure 6.5). This is above the median, number of structure types per site on the AAR is 3. Taken together, these data largely support the expectation that select sites should contain a wider variety of structures than others, as they were visited more frequently. Specifically, the Dragon site more than doubles the median figure and satisfies this exception.

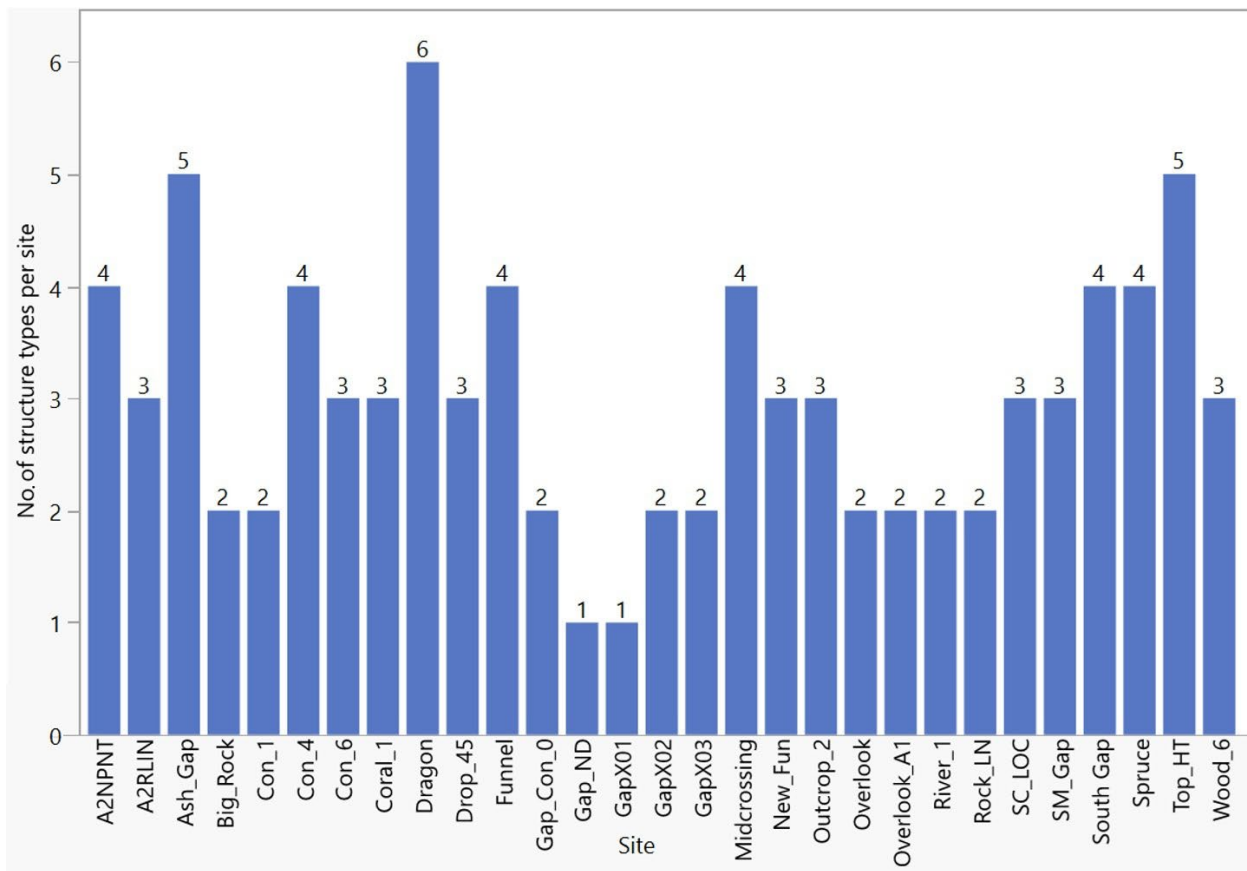


Figure 6.5 Bar graph shows the total count of structure types out of six different classes for each site on the AAR.

6.6.6 Complexity

The Dragon, Drop 45, and Funnel sites show signs of complexity in the stone constructions in terms of incorporating stacked stones or multiple components, while other sites on the AAR are devoid of this evidence. The Dragon site has three documented structures that are comprised of stacked stones, two are classified as 3-5 stone clusters that likely served as hunting blinds and/or meat caches. The other is a stacked stone cairn that abuts a standing stone that likely served as a site, or drive marker (figure 6.6). These are the only examples of stacked stone features reported on the AAR.

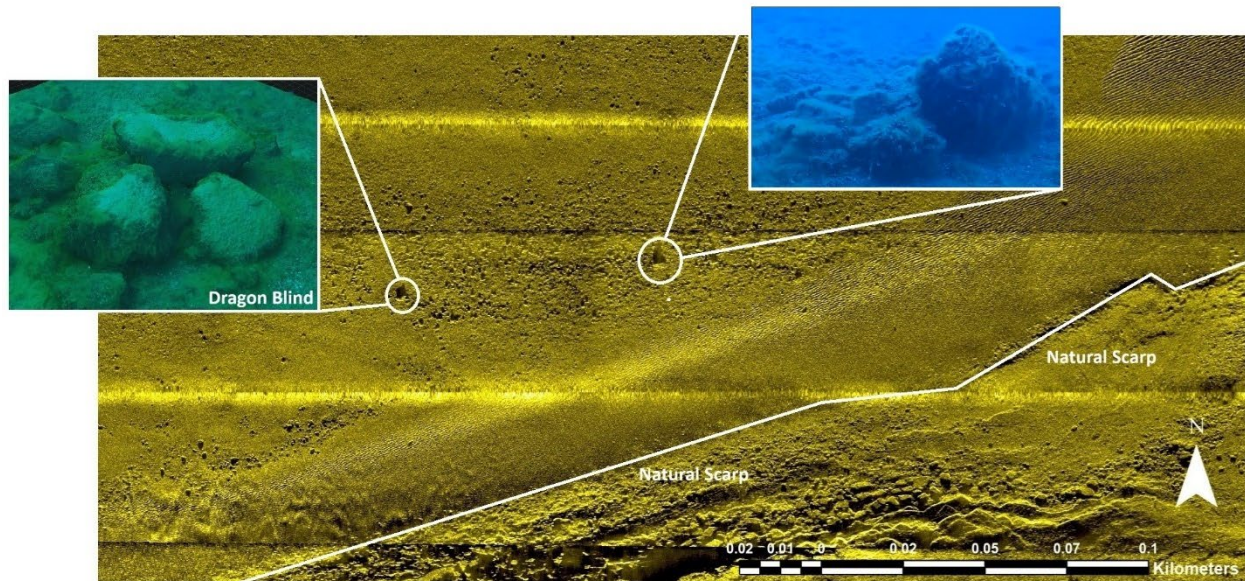


Figure 6.6 Dragon site acoustic map showing the natural escarpment that directs animals along a predictable path.

The Drop 45 site does not contain stacked stone structures; however, it has a unique structure that incorporates multiple components, including an 8-meter wide and 30-meter-long drive lane with three blinds abutting or “built into” the ends; one where the animals enter the lane and two where they end up at the kill area (figure 6.7). The lane is constructed by making a line of rocks parallel to a natural scarp by pushing the rocks out of the lane area into a linear pile or line (O’Shea *et al.* 2014).

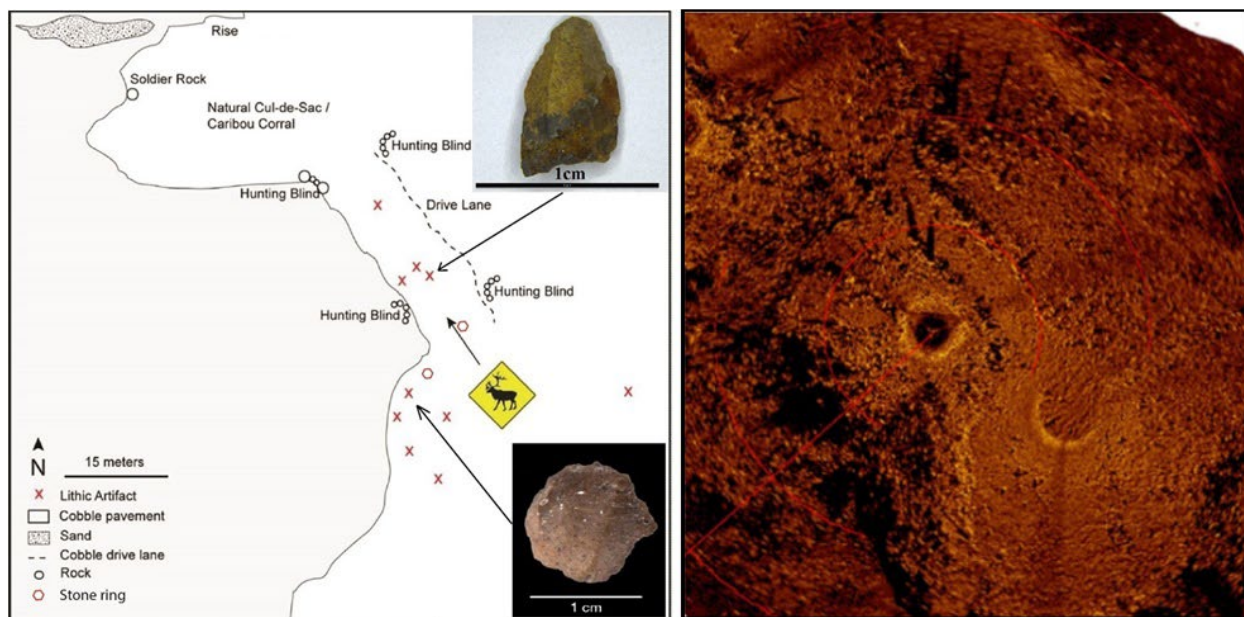


Figure 6.7 (After O'Shea et al. 2014) Functional diagram of the Drop 45 site drive lane complex including hunting blinds and a couple examples of associated tools in their find locations (left), and the original sector scan sonar data showing the drive lane, and blinds (right).

The Funnel site does not contain stacked stones; however it does have a standing stone, and hunting complex that contains multiple features that were likely used in tandem, including a drive line (wall in figure 6.8) next to a linear arrangement of rocks to form a funnel feature with a single bolder in the exit (figure 6.8). The funnel feature is flanked with natural barriers on both sides that prevent moving caribou from moving away from the drive complex once they enter it (O'Shea 2015a: 128-129).

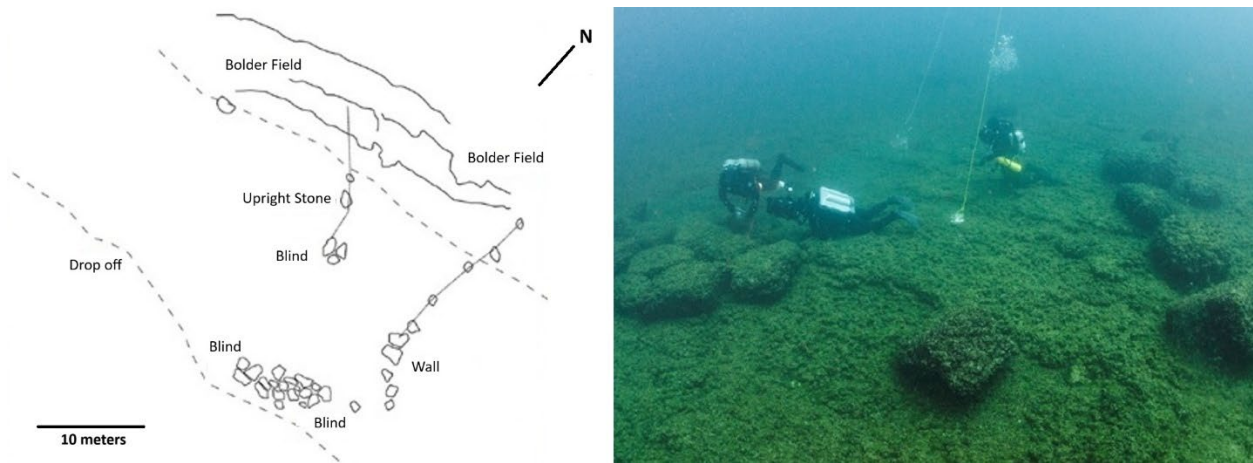


Figure 6.8 The Funnel site complex. Diagram of cultural stone features above, and a photograph of the complex below After: O'Shea (2015).

In sum, when applied to data from each site on the AAR, six show possible signs of increased complexity relative to other sites and includes the four intensively investigated sites (table 6.3). The South Gap and Ash Gap sites are tied for the highest number of documented features. The Dragon site contains the widest variety of structures for any site on the AAR, followed the Ash Gap and Top HT sites. Dragon also showed increased complexity of stone features by incorporating stacked stones. The Drop 45 site contains the most complex hunting feature documented on the AAR that incorporates several conjoining components including a drive lane and several hunting blinds. The Funnel site also shows increased complexity in the form of a hunting complex comprised of several stone features that were likely used in tandem as part of a system for caribou hunting.

Table 6.3 Results for the diachronic expectation tests relating to cultural niche construction.

Expectation	Dragon	Drop 45	South Gap	Funnel	Ash Gap	Top HT
Count	no	no	yes	no	yes	no
Variety	yes	no	no	no	yes	Yes
Complexity	yes	yes	no	yes	no	no

6.7 Discussion of the diachronic expectation tests

The diachronic expectation related to technology states that select sites will contain increasing amounts of higher quality raw material as mobility routes stabilize along with dynamic climate conditions of the PHT. This is when people are expected to incorporate the best sources into more fixed mobility systems, whether from an exposed outcrop, or from localized high-quality chert from particular patches of moraine or esker. This did not turn out to be the case for the sites identified on the AAR, as there was no meaningful difference in the proportion of high-quality raw materials in the cultural assemblages among the four intensively studied sites, or between the intensively studied sites and the other sites on the AAR. This is likely due to the fact that high-quality cherts occur naturally throughout the study area of the AAR. If foragers had a familiarity with the AAR itself or other post glacial setting where glacial till covers large areas, then depending on these resources for necessary tool stone may represent a form of embedded procurement.

Considering these results, there would have been no selective pressure placed on material quality created by the local environment. However, there was a constraint on the size of the raw material packages. If people utilizing the AAR typically relied on the large bifacial tools that commonly predominate lithic assemblages from the GLR during the PHT, then we would expect the relatively small size of raw material to place pressure to bring larger pieces of exotic raw material or finished tools to the AAR. Although the two obsidian flakes –from a single sample and likely from a single biface– are evidence of this behavior, it is only one example and does not seem to be the typical provisioning strategy utilized by foragers exploiting the AAR. Instead, people seem to be relying heavily on tools produced *ad hoc*, while selecting for the high-quality local cherts from the glacial till. If foragers commonly used microlithic and expedient tools when foraging off the AAR, then they would not feel pressure to provision with exotic material before moving onto the AAR, as the local stone sources are conducive to the technological strategy already employed by this group of foragers.

Testing the diachronic expectation relating to niche construction behavior revealed a consistent strategy for caribou hunting on the AAR, in terms of the relative position of constructed and natural features. Specifically, hunting blinds are positioned to take advantage of natural linear features such as scarps and eskers that effectively guide caribou along predictable routes where concealed hunters would wait. Previous analyses of the orientation of constructed

features at the Drop 45 site suggest that it best facilitated hunting during the spring migration, while site features at Dragon can be interpreted to suggest use in the fall or spring (O'Shea *et al.* 2013: 38; O'Shea *et al.* 2014: 6914; Lemke & O'Shea 2017: 5). Features at South Gap are oriented to focus on animals moving into the kill zone, presumably coming from the north in the spring fall. However, considering the orientation of other structures at South Gap, it is likely that some might also have been suitable for the spring migrations as well. See Chapter 8 for an extended discussion of the four intensively studied sites.

6.8 Conclusions

Testing the three expectations for developed sites revealed meaningful differences among the 31 sites on the AAR, pointing to varying degrees of site development. Specifically, some locations exhibit more elaborate and numerous stone features that indicate greater investment in key locations by modifying and enhancing the landscape to improve hunting success. These differences in site elaboration indicate that some locations were not only visited more frequently but also played more central roles in regional subsistence and mobility strategies. In this context, the most developed sites appear to have functioned as key nodes in a broader mobility network, repeatedly visited by foraging groups following seasonal and strategically planned routes.

The Dragon site, for example, where at least one food cache was documented, likely served as a logistical hub, visited at least twice annually; once in the fall to deposit food and again in winter or early spring to retrieve it, with possible winter use during times of extreme need. The presence of net sinkers at three of the four most developed sites suggests that summer fishing and trapping were part of a diversified seasonal subsistence strategy. Taken together, the data point to sustained use of the AAR landscape from spring through fall, with winter occupation unlikely –in most cases– due to severe lake-effect conditions.

Despite the lack of direct diachronic controls, such as radiocarbon dates for each site and occupation, or stratigraphic sequences that could seriate the sites, the patterns observed strongly support the core proposition of the EHA model: that under increasing stable environmental conditions, human foragers repeatedly invested in select locations over time. This strategy left behind an archaeological record that reflects a subsistence strategy that involved diverse toolkits, high residential mobility that incorporated the repeated use of key sites, and increasingly complex niche construction behaviors to facilitate caribou hunting.

Chapter 7 South Gap Site Investigation

7.1 Introduction

The South Gap site (20AA232) is a caribou hunting location about 55 kilometers offshore from mainland Michigan on the Alpena Amberly Ridge (AAR) (figure 7.1). The site features a sinus esker that runs north to south and serves as a natural barrier that forces migrating caribou along a predictable route through the site. Hunters utilizing the area build a series of stone hunting blinds and a drive lane from the local stones along this feature to create a hunting complex that could be used seasonally. Recovered in association with the constructed features is a small assemblage of stone tools that were used for hunting and subsequent animal processing, confirming the function of the site as a hunting location. It is important to note that this site, as well as others on the AAR, are submerged under 30 meters or more of water and had never been walked on since archaeological times, let alone imaged, mapped, or sampled before the AAR project was initiated in 2008. The South Gap site was discovered and first investigated in 2010. Since then, it has been the subject of periodic investigation and sampling over the course of a decade.

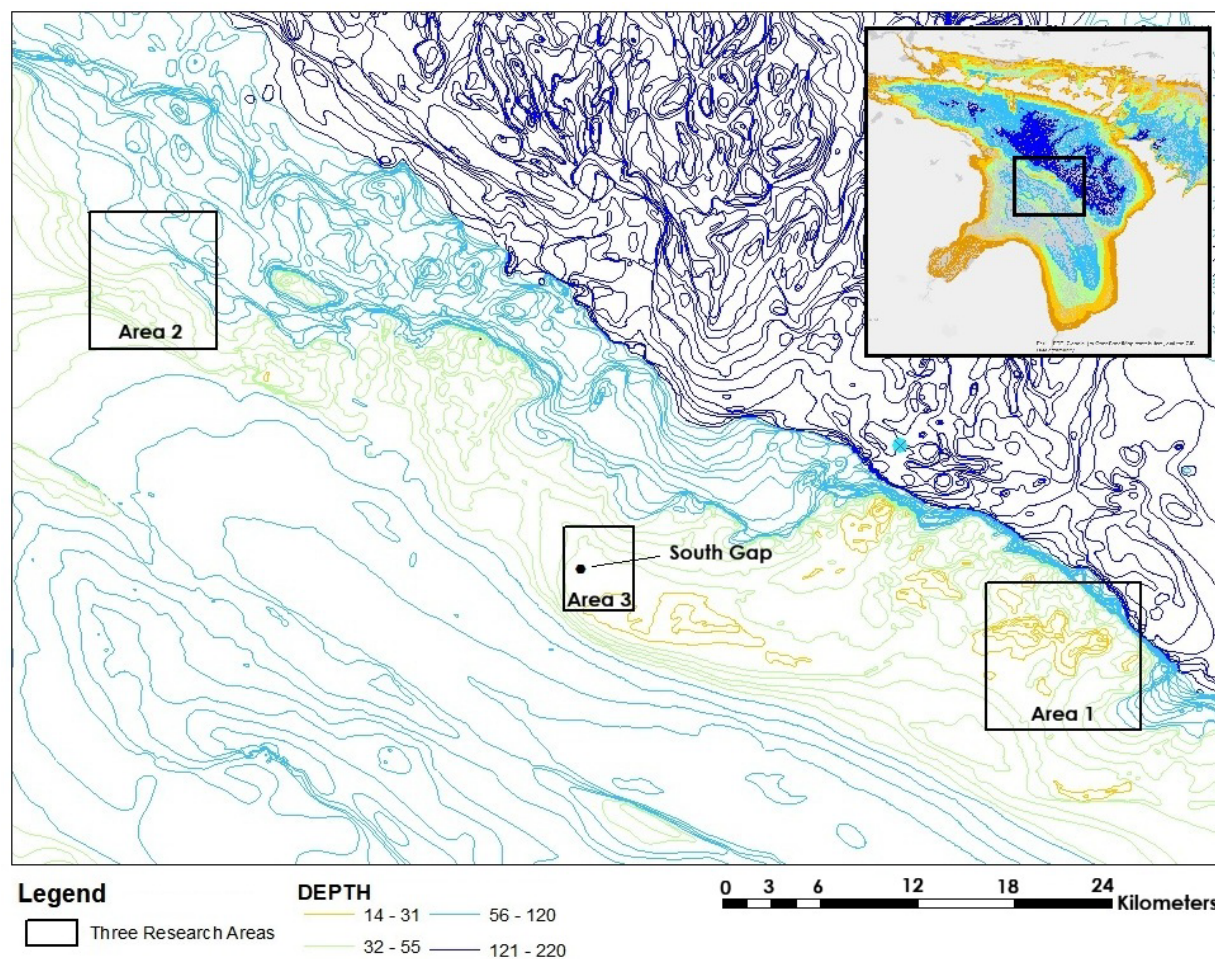


Figure 7.1 Map of the Huron Basin during the Lake Stanley period showing the location of the South Gap site within Area 3.

This chapter will describe a new field research project and subsequent analysis of the recovered data from the South Gap site. This will begin with a background section describing the work that had been done at the South Gap site before the project described here was initiated in 2020, and then the work performed during the course of this investigation from 2020 - 2022. Next, the methodology for the new field research project and the data it produced will be described. This will include a description of the two-part sonar image project. The first involves a side-scan sonar imaging project of the larger Gap locality with an autonomous underwater vehicle (AUV). This produced an acoustic image of the site features both cultural and natural, effectively serving as map of the Gap locality and the South Gap site at its southern end. This was followed by more fine-grained sonar mapping at the South Gap site with a sector scan sonar device that creates more detailed images of local site features, including hunting blinds, from a

fixed position on the lake floor from. The sector scan and AUV sonar images provided the necessary data to initiate a sampling regime via scuba that targeted specific areas around the South Gap site near specific cultural and natural features.

Next, the laboratory procedures for processing the recovered sediment samples into fractions and identifying any botanical, faunal, and cultural remains will be described. The data collected in the lab and in the field are subject to an analysis consisting of two parts, including an analysis of site function focusing on the spatial arrangement of natural and cultural site features that make up hunting complex at its core, and a functional analysis of the lithic assemblage recovered from the South Gap site.

7.2 Background

7.2.1 Previous research at South Gap

The South Gap site at the southern end of the Gap locality was discovered in the Summer of 2010 by researchers searching the lake floor for archaeological sites using a remotely operated vehicle (ROV). Two prominent, and isolated ‘V’ shaped stone structures are what first caught the attention of researchers and alerted them to the archaeological potential of the site (O’Shea 2015a: 118-119; O’Shea *et al.* 2013). The first sediment samples from the site were collected in 2011 and focused on areas near the observed structures. The site was subsequently sampled on eight separate days from 8/18/2011 - 7/17/2019 producing a total of 38 samples (table 7.1) that vary in volume from 0.2-liter vials to 20-liter buckets.

Table 7.1 Number of samples taken from the South Gap before 2020 with dates.

Number of Sample	Date	Site
11 samples	8/18/2011	South Gap
8 Samples	8/19/2011	South Gap
5 Samples	7/22/2012	South Gap
4 Samples	5/17/2013	South Gap
4 Samples	5/19/2013	South Gap
1 Samples	6/12/2013	South Gap
4 Samples	8/19/2013	South Gap
1 Sample	7/17/2019	South Gap
38 Total Samples	8 days	1 Site

During the sampling regime researchers also identified several other stone structures at the site (table 7.2). For the purposes of this analysis, they have categorized into several types (see Chapter 5 for details on the stone construction typology). There are three main types of stone hunting blinds found at the site including V-shaped blinds, 3-5 stone clusters, and two rock blinds. There is also a drive lane at the South Gap site composed of two stone lines made up of the rocks that were moved out of the drive lane area. From these data, it can be determined that that several site features, including both cultural and natural, were likely used in tandem as part of a constructed hunting complex, where the drive lane is used to funnel animals toward a series of hunting blinds where concealed hunters could wait. Researchers also noted that this complex also takes advantage of the long sinus esker that runs through the site serving as a natural barrier and drive line. Notably, the Ash Gap site about 250 meters northwest of South Gap utilizes the same landform and also has a complex of documented hunting structures (see *expectation 3* in Chapter 6)

Table 7.2 Types and counts of stone structures identified at the South Gap site before 2020.

Type	Count	Description
V-Shaped blind	5	3-5 isolated rocks in a V shape.
3-5 Stone clusters	8	3-5 isolated rocks not necessarily in a V shape.
2 Rock clusters	3	Two touching isolated rocks.
Rock Lane	1	A rock line that forms a drive lane with a natural feature or another stone line.

Data from the South Gap site was first published in 2013 by O’Shea *et al.* and provided the initial report about the V-shaped blind that first alerted researchers to the archaeological potential of the site. This blind is referred to as “V-Cluster” and was subsequently reported in 2015 by O’Shea in an edited volume by Sonnenburg, Lemke, and O’Shea. Moreover, a report including the two obsidian flakes from South Gap was first provided by Lemke (2015: 142) in a chapter in the same volume, although they were initially identified as chert. These artifacts combined with a net sinker constituted the limited lithic assemblage from the site that existed before the project described here was initiated in 2020 (table 7.3).

Table 7.3 Stone tools recovered from the South Gap site before 2020.

Specimen no.	Artifact Type	Sample Name	Depth m	Technology	Material
105-1	Flake	DA-1	31.7	Biface Flake	Obsidian
105-2	Flake	DA-1	31.7	Biface Flake	Obsidian
19-1	Net Sinker	Bag 2	32	Net Sinker	Quartzite, Yellow

In 2021 O’Shea *et al.* reported geochemical sourcing results from the two obsidian flakes from sample DA-1 recovered on 5/17/2013. Results indicate that the flakes derive from the Wagontire source in central Oregon (O’Shea *et al.* 2021; Riebe *et al.* 2022) (figure 7.2). These flakes were removed from a highly curated biface that was likely utilized in the hunting and/or

subsequent processing of animals at the site. The flakes were likely deposited as the biface was being reshaped and/or resharpened after it was broken or dulled after use. The sourcing results indicate that the people utilizing the South Gap site had at least some social connection with people across the Northern Plains (O'Shea *et al.* 2021).

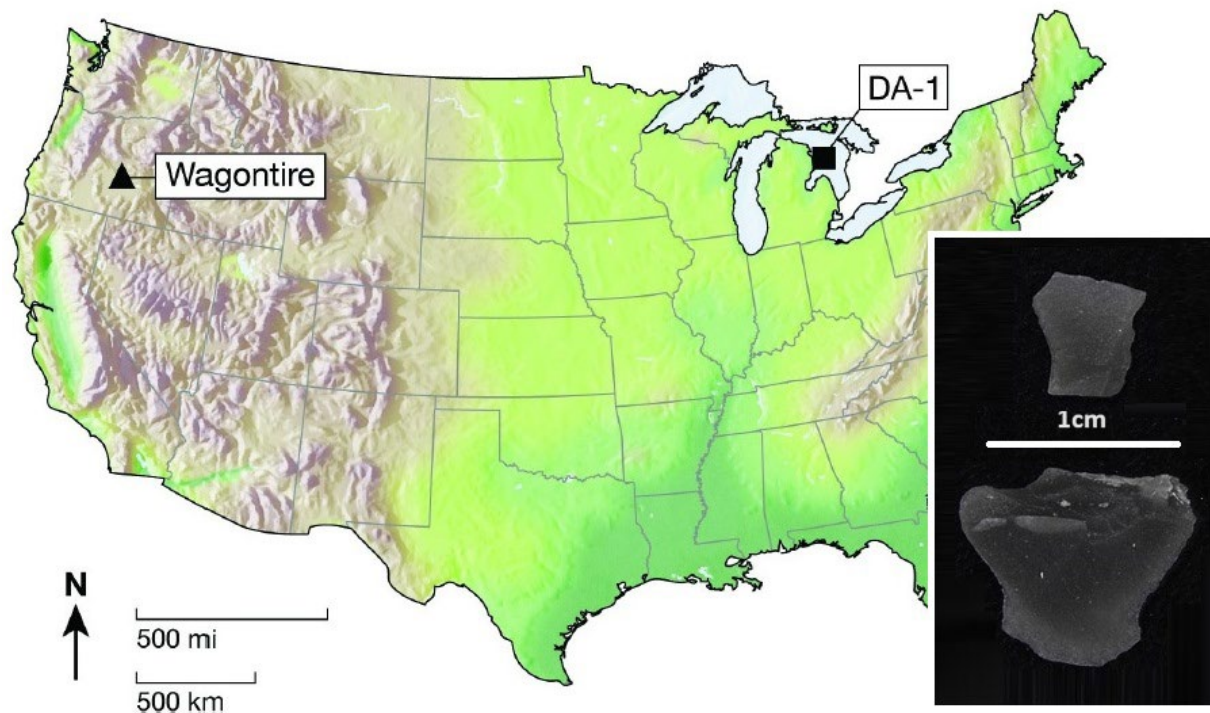


Figure 7.2 A map showing the find location of the obsidian flakes in Lake Huron and its geological source at Wagontire in central Oregon. After (O'Shea et al. 2021).

After several years of periodic visits and sampling, in 2018 it was determined necessary to create a more detailed map of natural and cultural site features to guide future investigation and help provide context for the data collected to that point. Considering that the site is 55 kilometers offshore and more than 30 meters below water, traditional methods such as using satellite imagery, LiDAR from the USGS, or flying a drone to collect these data was not possible for this site. It was determined that side-scan sonar would be the best method to produce the necessary map. In 2009 a map of Area 3 had been created using a towed side-scan sonar (O'Shea 2015b: 109, 2021). This produced an acoustic image of the area that showed relatively large geological features such as the system of eskers; however, the cultural features were not visible

at the available resolution. In 2013, preliminary scanning sonar work was done in the larger Gap locality with South Gap at its southern end. The resulting acoustic image showed the general configuration of the topography along with some large glacial erratic, but none of the structures were obviously visible.

Attempts at creating a higher resolution sonar image or map of the Gap locality with an AUV took place during the summers of 2018 and 2019, however in both instances the mapping failed to capture the hunting structure associated with the central drive area first observed in 2011 by ROV and subsequently sampled (table 7.1). This situation left researchers with only a hand drawn map of the South Gap site made by divers at depth, although most other portions of the larger Gap locality were imaged successfully providing the first detailed maps of lake bottom features at the Gap locality. The maps\acoustic images revealed a mosaic of post glacial landscape features, including eskers, ground moraine, glacial erratics and glacial till.

7.2.2 New research at South Gap

The new research presented here is a multi-staged project that aimed to assess the nature of the occupation of the South Gap site on the AAR, including how lithic technology was used in tandem with constructed and natural site features to facilitate caribou hunting and other associated activities. The project began by assessing existing data to determine if there was further potential for learning about new aspects of foraging behavior at the site. The review focused on the data described above and provided confidence that a new field research project could provide additional data for testing foraging models if there was still sediment from the sites that could be sampled. For this reason, three sediment samples were taken in the Summer of 2020 near the sample location where the two obsidian flakes were recovered. Although, no artifacts were recovered in these samples, the test showed that there was enough sediment at the site that future sampling would possibly produce additional cultural material.

After testing for the presence of sampleable sediment at the South Gap site, a map of site features needed to be created, as the two previous attempts in 2018 and 2019 had failed to capture the initially observed V-shaped blinds and the find location for the two obsidian flakes. This was accomplished on 6/28/2021 by contracting Jamey Anderson from Michigan Technical University to conduct a side-scan sonar mapping project with an autonomous underwater vehicle (AUV) (see figure 7.3 in the section titled *Sonar mapping with AUV*). This produced an acoustic

map showing the desired site features including the V-shaped hunting blinds, the find location of the obsidian flakes, and the large esker running through the site.

Guided by the new acoustic map of the site, additional sampling via scuba took place between 2020 - 2022, producing 14 additional samples. This sampling regime focused on collecting additional sediment from the obsidian find location, from near the drive lane leading to the series of V-shaped blinds, and from the portion of the site east of the hunting drive complex. The samples were then taken to the Research Museums Center (RMC) at the University of Michigan for processing that involved separating the sample into three different fractions (i.e., 1/4 in., 1/8 in., and less than 1/8 in.). All artifacts and botanical remain including charcoal, vegetation, and possible bone were separated from the processed sample.

Finally, an analysis of the combined new and existing data was conducted. This includes a functional analysis of the site layout, describing how cultural and natural site features were used together to facilitate hunting of caribou, and a functional analysis of the recovered lithic assemblage to describe the system of technological organization used at the site.

7.3 Methods and materials

The *Methods and Materials* section will describe the processes involved in the progressive stages of investigation of the South Gap site and present the materials produced by each. This includes descriptions of field work, laboratory procedures, and analytical methods. First, a description of the AUV sonar mapping project will be provided, followed by the finer grained, sector scan sonar mapping that occurred the following summer. Next, the sediment sampling portion of the investigation will be described, which was guided in part by the results of the sonar mapping projects. This constitutes the final portion of the field work, and the final two sections will describe the laboratory procedures for separating the samples into fractions, identifying cultural and botanical remains, and explaining the analytical methods.

7.3.1 Sonar mapping with an automated underwater vehicle

An area map (or acoustic image) of the Gap locality was made with an IVAR 3 AUV side-scan sonar device on Monday June 28th, 2021. The system was operated by Jamey Anderson from the Great Lakes Research Center at Michigan Technological University. The AUV was

preprogrammed to drive a set of transects over the study area of a specified length and at a specific height above the lake bottom to create linear swaths of acoustic data that can be stitched together to make an image of the entire area. For this project, we chose to run two sets of transects, the first is composed of six 900 meter long transects running north-south with the AUV operating three meters above the lake bottom, allowing us to see constructed hunting features comprised of rocks around a half a meter in diameter. This process created a map covering 450,00 square meter area (figure 7.3a). The second set consisted of fourteen 300 meter long transects running east-west taken three meters from the lake bottom covering a similar amount of area. This attempt was less successful as it failed to capture one of the transects (figure 7.3b). The first map with transects oriented north-south provided better images of the esker system running through the Gap locality, because the eskers are also running north-south and the transects each resulted in a continuous image of the eskers that could be stitched together.

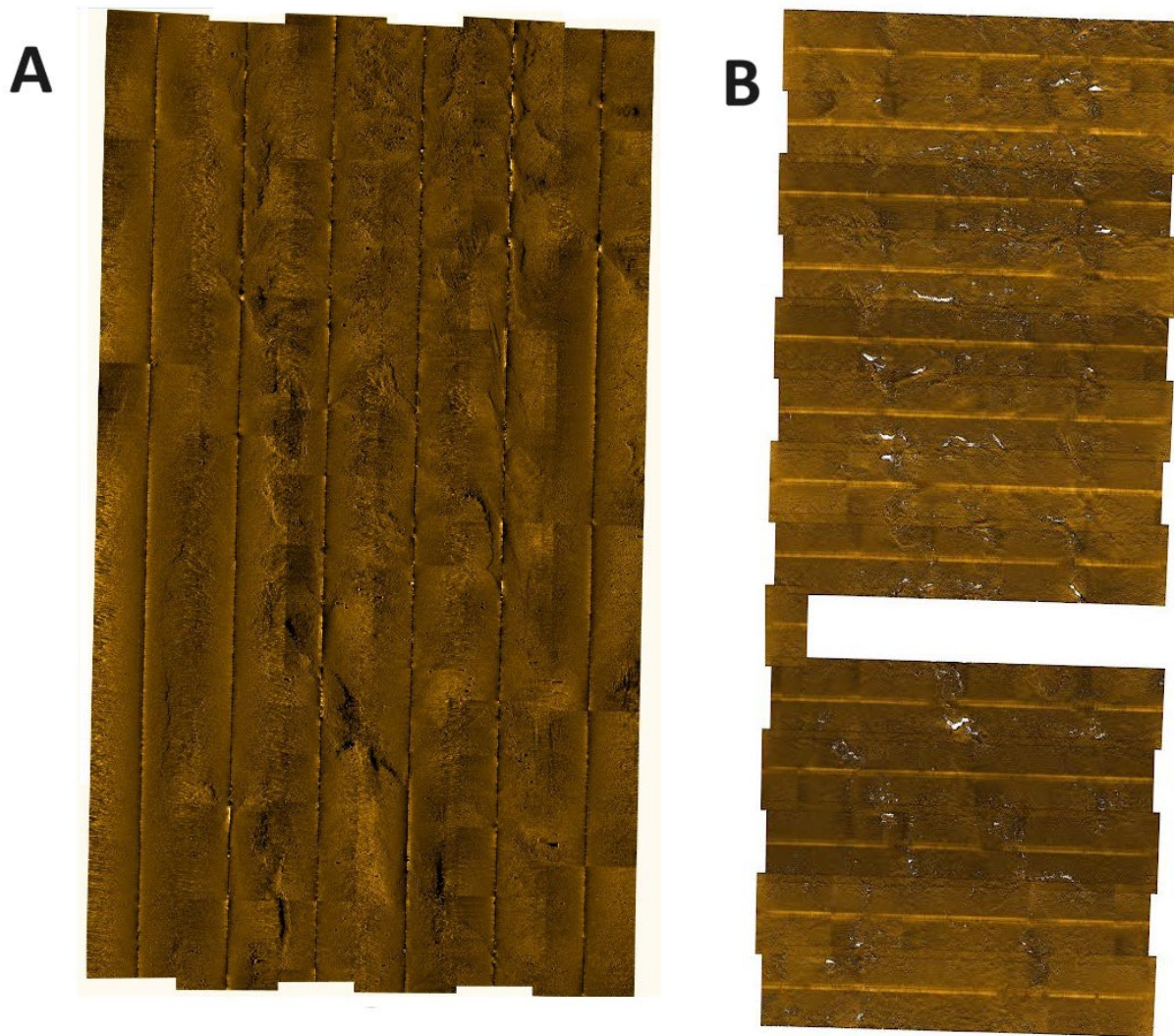


Figure 7.3 Two AUV sonar maps with transects in perpendicular directions at the Gap Locality. A) AUV map of the Gap locality with transects running north-south. B) AUV sonar map of the Gap locality with transects running east-west with one swath missing.

The two maps together provide precise data about the spatial relationship of natural and cultural features at the Gap locality, including the mosaic of hunting structures and eskers that were known to exist before the mapping project began. This includes the central drive area at the South Gap site where the first V-shaped blinds were recorded, and the location where the two obsidian flakes were recovered. Each of the previous attempts at sonar mapping of the Gap locality and the South Gap site at its southern end, failed to capture acoustic images of this key area. These data have facilitated a very precise sampling regime where several specific areas next to relevant features were sampled by scuba divers. These data also facilitated a precise

spatial analysis of cultural and natural features that will serve to characterize the function of site. Finally, the mapping project revealed one additional two-rock cluster that may have been a hunting blind at the north end of the central drive area and is referred to as Bee blind bringing the total number of plausible documented structures to 17.

7.3.2 Sonar mapping with sector scan

On July 10th 2022, the summer following the AUV mapping project, smaller areas of interest within the South Gap site were imaged with sector scan sonar. This scanning sonar unit hangs within a large tripod and is lowered from the deck of the boat, before coming to rest in a fixed place on the lake floor making an acoustic image of the surrounding features. This process was used to create circular images with variable ranges from 100 - 5 meters in diameter (figure 7.4). Although the sector scan is capable of scanning larger areas, this range produced images of the desired features at South Gap. The acoustic signal from the sector scan produced more fine-grained -higher resolution- images of cultural and natural features than the larger map made with the AUV.

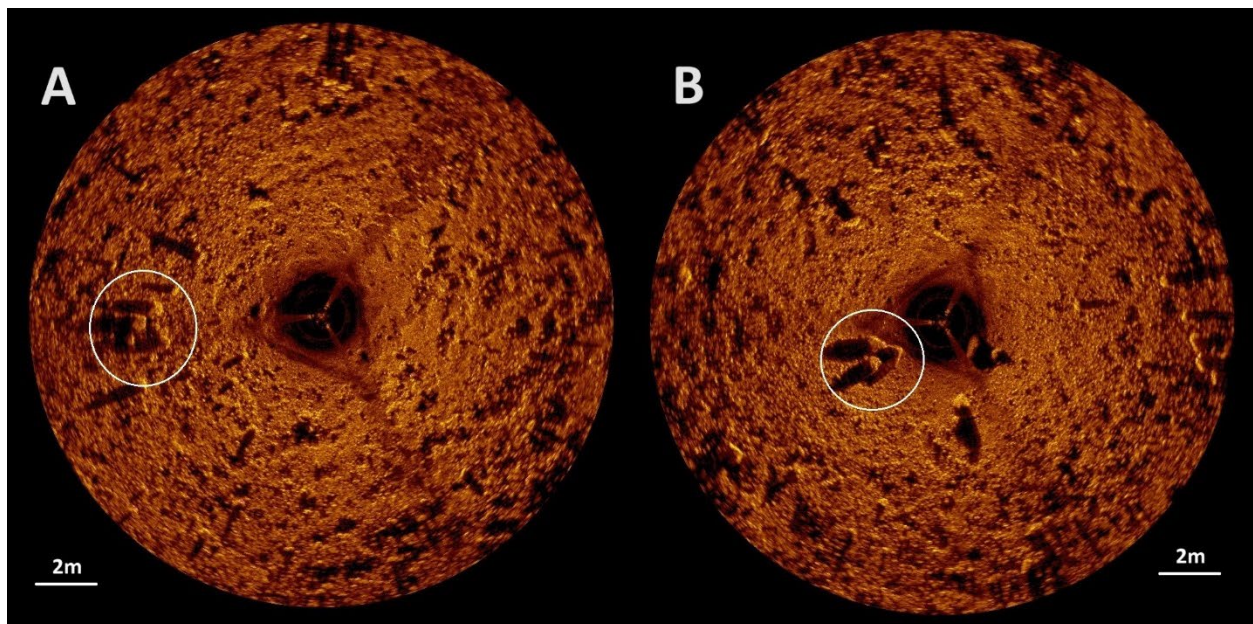


Figure 7.4 Sector scan acoustic images of two of the V shaped blinds on the east side of the esker at South Gap A) Rockpile Cairn, and B) TV Blind.

At the South Gap site, this process targeted areas around the series of hunting blinds on the east side of the esker, including the two initially observed structures (TV Blind and V-Cluster), as well as the drive lane at the north end of the esker running through the site. This process was successful and was able to capture images showing the precise morphology of the rocks in these structures (figure 7.4). The process also captured detailed images of a blind positioned between the two initially identified V-shaped blinds and is referred to as Rockpile Cairn. Before the sector scan project, the precise morphology of this feature was ambiguous as it was covered in algae and zebra mussels making it difficult to classify. It is now understood to be a third V-shaped blind in the eastern portion of the sites (figure 7.4a). In this and other cases the sector scan provided an important complement to the AUV images and to photos of the structures taken from underwater. Images from optical cameras taken under Lake Huron suffer from a number of limitations compared to the sector scan sonar, including the need for light which is not consistent for sites submerged below 24 meters or more of lake water. The presence of algae and fine sediment in the water column and on rocks is also a primary limitation to photos taken underwater, however this does not affect the scanning sonar to the same degree as sound waves penetrate through organic material and reflect off the harder rock surfaces.

7.3.3 Sonar guided sampling via scuba

Guided by the acoustic maps produced with the AUV and sector scan projects, divers targeted specific areas within the site to recover sediment samples and possibly artifacts from the lake floor. The sampling process involved scuba divers taking 20-liter buckets (5-gallons) from the surface to the lake floor and filling them with sediment using hand scoops. To get the filled sample buckets to the surface, divers fill a lift bag with air from an extra small tank until the bag is inflated and rises to the surface (figure 7.5). The sample buckets are tethered to the boat by a line and reel so that once they are on the surface, the sample can be reeled in and placed on the back deck of the boat. Additionally, several samples were collected in 1-gallon Ziplock bags taken to depth and filled with sediment from different locations by divers, before being placed into a 5-gallon bucket and lifted to the surface with the inflatable bag.



Figure 7.5 Show diver Tyler Shultz filling a lift back attached to a sediment sample to bring it to the surface. Photo credit John O'Shea.

On 8/23/2020 the first samples from the South Gap site associated with the new research project described here were recovered to assess the further potential for the site to produce data that could be compared to other sites in the GLR and on the AAR (table 7.4). Although the samples did not produce artifacts, there was a significant amount of sediment recovered and observed by the divers to suggest that there was potential to recover additional artifacts from the

site. In 2021 between July and August, five samples from the South Gap site were recovered by divers John O'Shea and Tyler Shultz. These samples targeted areas adjacent to the three V-Shaped hunting blinds in the central drive area (CS, F-4, F-5), including the spot where the obsidian flakes were recovered (BO-1, BO-1-2) (figure 7.6). Two additional samples were recovered from other sites: F-2 from Dragon and F-3 from A4WOD2, to obtain sediment samples to assess background geology from other sites to compare to the South Gap samples, and to potentially recover additional artifacts. Seven additional samples were recovered from the South Gap site in 2022 by divers John O'Shea and Jason Shaw. These samples targeted sediment patches near the esker and in the potential drive lane at the north end of the esker leading to the blinds (EP-1, SHAW-22-1, OSHEA-22-1, OSHEA-22-2, DY-1, ET-1, EW-1) (figure 7.6).

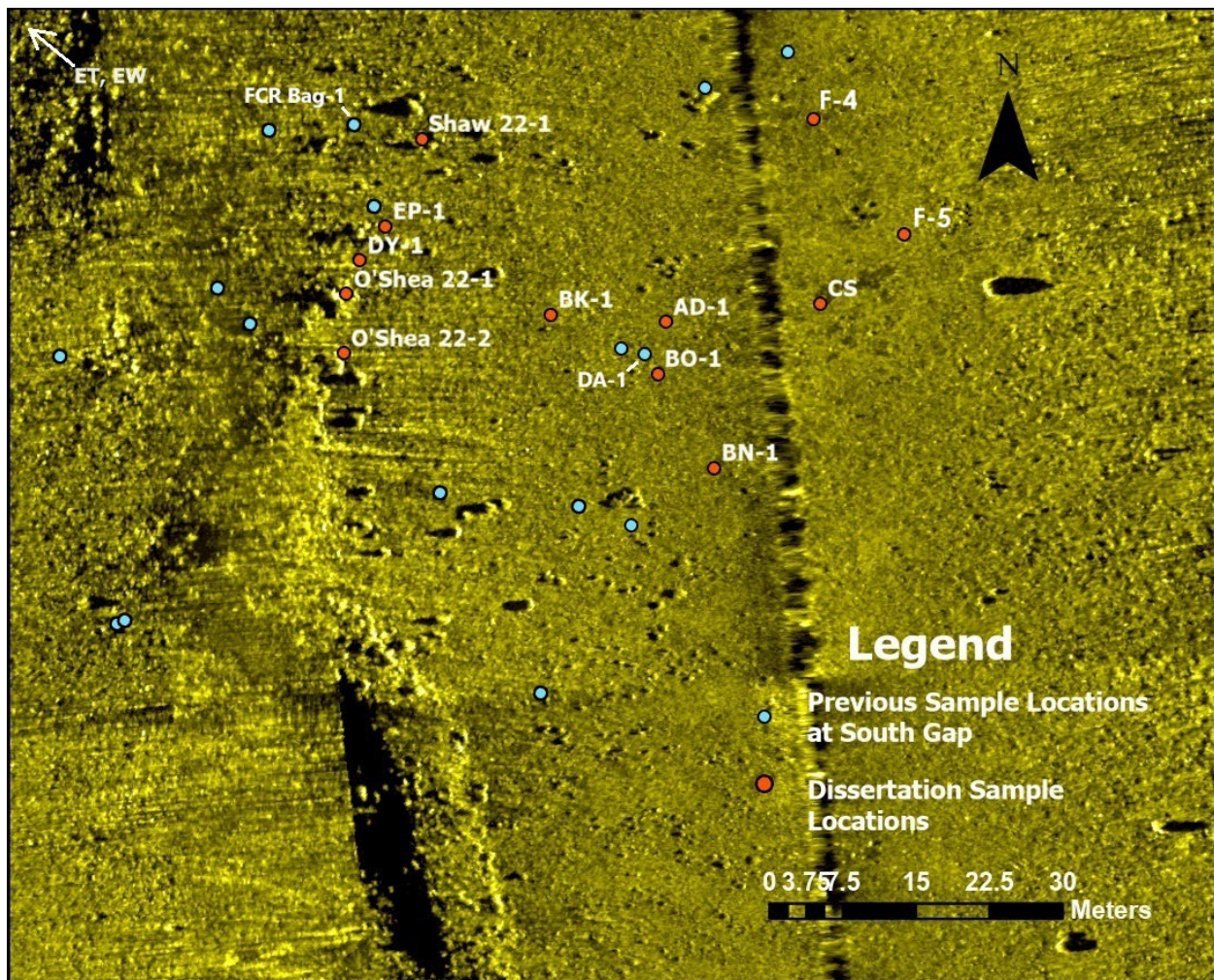


Figure 7.6 Map of sample locations at the South Gap drive area, and the location of previous samples.

Table 7.4 Table of samples collected during the South Gap site investigation.

Sample no.	Date	Area	Site	Sample Name	Depth m	Sample Type
313	8/23/2020	3	South Gap	AD-1	31.1	Bulk Bucket, Vial
316	9/19/2020	3	South Gap	BN-1	32.3	Bulk Bucket
315	9/19/2020	3	South Gap	BK-1	32.3	Bulk Bucket
324	7/27/2021	3	South Gap	BO-1	31.7	Bulk Bucket and Mesh bag
325	7/28/2021	3	South Gap	BO-1-2	31.1	Bulk Bucket
326	7/28/2021	3	South Gap	CS	31.4	Bulk Mesh, Vial
329	8/20/2021	3	South Gap	F-4	32.9	Bulk bucket, Vial
330	8/20/2021	3	South Gap	F-5	32.9	Bulk bucket, Vial
332	8/10/2022	3	South Gap	EP-1	32.9	Bulk scooped Ziplock gallon bag
333	8/10/2022	3	South Gap	SHAW-22-1	32.9	Bulk scooped Ziplock gallon bag, Vial
334	8/13/2022	3	South Gap	DY-1	31.4	Bulk scooped Ziplock gallon bag s
337	8/13/2022	3	South Gap	ET-1	30.8	Bulk scooped Ziplock gallon bag, Vial
338	8/13/2022	3	South Gap	EW-1	30.8	Bulk scooped Ziplock gallon bag
335	8/13/2022	3	South Gap	OSHEA-22-1	31.4	Bulk scooped Ziplock gallon bag, Vial
336	8/13/2022	3	South Gap	OSHEA-22-2	31.4	Bulk scooped Ziplock gallon bag

7.3.4 Laboratory sample processing procedures

Each sediment sample was brought to the RMC at the University of Michigan in Ann Arbor a few days after they were collected. The sediment is usually in the form of a mix of gravel, sand, clay, larger rocks, and mussels with a course, “paste” like consistency. First, the samples are spread out on window screen and placed under a fume hood for 1 or 2 days until dry. A small amount of sediment that falls through the window screen is lost during this step, although most of the fine fraction stays on the screen as dry clay material. Mussels are picked out of the sediment by hand at this point and throughout the process. Once dry, the clayey sediment is broken up and put through a series of nested screens with the largest being 1/4 in., then an 1/8 in., and 2mm window screen. After the two smallest fractions were combined into a single sample, this process produces three fractions (1/4 in., 1/8 in., and less than 1/8 in.).

Potential cultural and botanical remains were separated from the processed sediment samples. This process involved inspecting each rock in the 1/4 inch and larger fraction and separating specimens that appear likely to have been the product of cultural process. Many of the artifacts recovered from the AAR are expedient in nature and are usually made from local cobbles. This often makes it difficult to distinguish cultural items from the background glacial till. Even with these difficulties six artifacts were recovered during the course of this investigation, including a scraper (324-2) and a backed microblade (324-1) from sample BO-1. In sample F-5, a bipolar core (330-2), a flake from a biface (330-4), and two microblades (330-1, 330-3) were recovered (table 7.5). For the purposes of this analysis, each artifact has been analyzed to determine the type of stone that it was made from and the technology it represents, to facilitate a comparison with other assemblages in North America.

Table 7.5 List of artifacts recovered from the South Gap site after 2020.

I.D.	Artifact Type	Sample Name	Depth m	Technology	Material
324-1	Microblade, backed	B0-1	31.7	Bipolar Flake, Modified	Chert, Gray
324-2	Scraper	B0-1	31.7	Modified Stone	Chert, Honey
330-1	Microblade	F-5	31.7	Microblade	Chert, Honey
330-2	Bipolar Core	F-5	32.9	Core, Micro	Chert, Gray
330-3	Microblade	F-5	32.9	Microblade	Chert, Mottled
330-4	Flake	F-5	32.9	Biface Flake	Chert, Honey

7.4 Analysis and results

The analysis of recovered data from the South Gap site will proceed in two parts. This first will consist of a spatial analysis of cultural and natural site features to assess how the site functioned as a caribou hunting complex. This will describe how the arrangement of constructed hunting architecture served to channel migrating animals along certain routes that led them to a series of blinds where concealed hunters would lie in wait. The possibility that the orientation of select site features is suggestive of use during certain seasons will also be explored. The second part of the analysis will focus on describing the cultural material and providing an interpretation of function for each tool and of the assemblage as a whole. This will aid in the interpretation of the sites' function and the activities being performed.

7.5 Spatial analysis

7.5.1 Natural advantageous setting

Sonar images from the AUV surveys of the Gap locality show a large esker about 10-20 meters wide running for about 400 meters north to south before taking a turn to the east and ending. The esker picks up again about 50 meters south after the turn east, creating a gap in the

esker that would have been one of the only places that caribou could cross from the west side to the east side before continuing along the AAR (figure 7.7). This large sinuous mass of rock would have created a predictable path for migrating caribou to follow north and south on annual migrations. The turn to the east would have guided animals following the esker to the central drive area of the South Gap site (figure 7.7). This advantageous natural setting would have been a predictable place to intercept caribou on yearly migrations. Here, people constructed several features, such as hunting blinds out of locally occurring stone to further enhance an already advantageous hunting site.

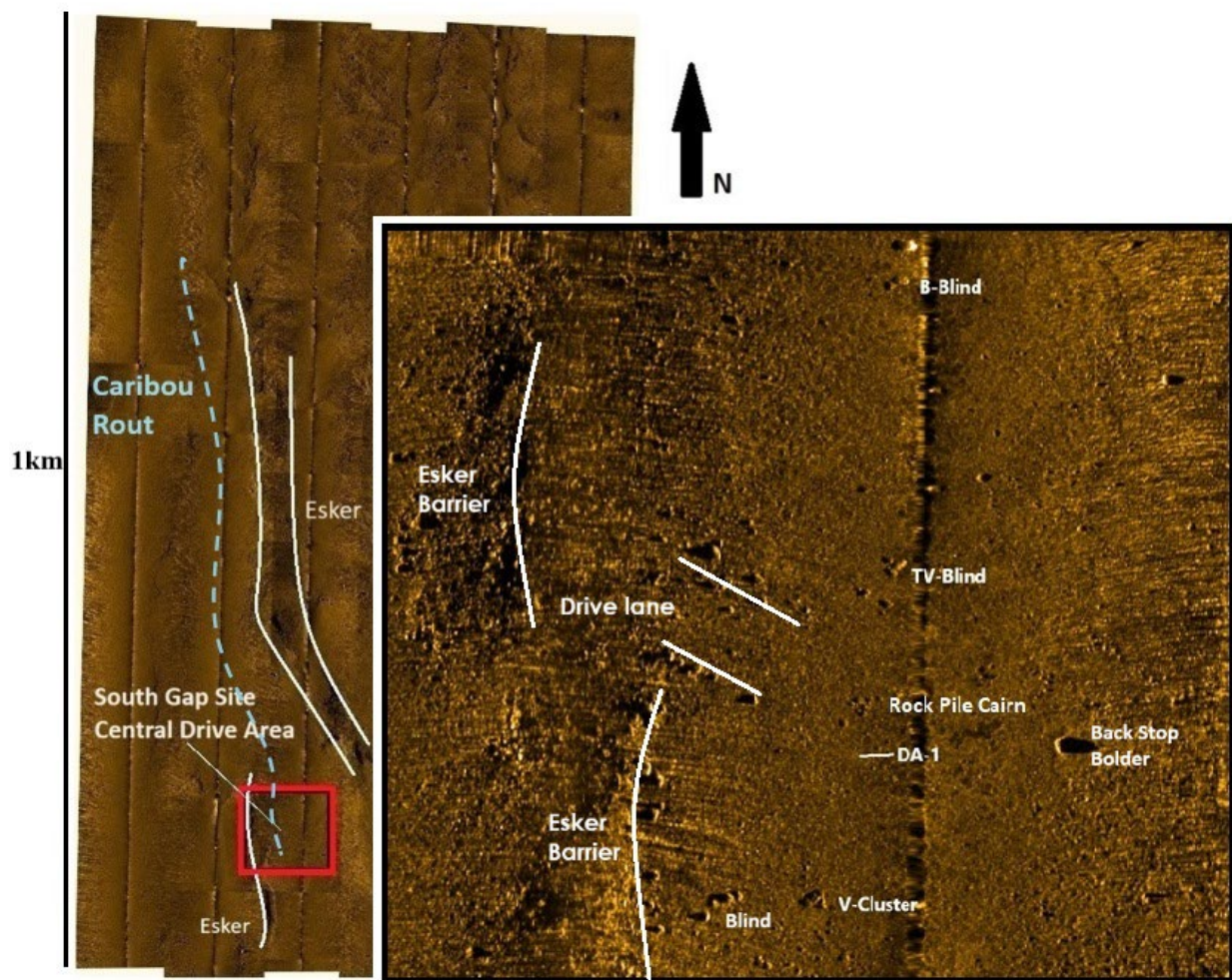


Figure 7.7 Shows the esker leading to the South Gap site and the central drive area at the center of the South Gap site, including the series of three V-shaped blinds, the drive lane leading to them, sample DA-1 (sample that contained the two obsidian flakes), and the natural esker that serves as a barrier to migrating animals.

7.5.2 Cultural modification to the site and the central drive area

The central drive area of the South Gap site contains a series of hunting blinds on the east side of the esker just after the gap where it picks back up and continues running north to south. A drive lane was constructed at this location consisting of two lines of rocks about 15 meters long oriented northwest to southeast, created by pushing rocks out of the drive area such that they form two parallel linear piles about 8 meters apart (figure 7.7). This drive lane leads directly to the series of three blinds (TV-Blind, Rock Pile Cairn, and V-Cluster) where concealed hunters could wait for approaching caribou. After the gap, the esker continues south for about 100 meters. This provides a barrier that keeps animals trapped between the esker and the blinds (figure 7.7). This would serve as the kill area by effectively slowing down the caribou and forcing them to move past the series of blinds. Moreover, the large boulder just east of the hunting structures likely served as a sort of ‘back stop’ to conceal hunters charged with finishing off wounded animals or scare them back toward the blinds (figure 7.7).

The southernmost V-shaped blind in the central drive area (V-Cluster) points north and was likely used to hunt animals moving south during the autumn migration. This likely coincides with the season when the drive lane was in use as its position and orientation suggest that it was used to channel animals moving south along the esker. The northern most V-shaped blind in the central drive area (TV-Blind) on the other hand, is just north of the drive lane and would not necessarily be in position to take advantage of animals moving south though the drive lane. However, it seems to have functioned as a part of hunting complex in the central drive area (figure 7.7), likely operated by a person preventing animals from moving north after exiting the drive lane. It is not impossible, however, that the orientation of TV-Blind is designed to take advantage of animals moving north during the spring migration through the same area. If this was the case, it would suggest that the site was in use during multiple seasons and that the complex of structures was likely built up over many periodic visits to the site.

7.5.3 The western portion of the site

The portion of the site west of the esker is similar to the central drive area on the east side in that several hunting blinds were constructed alongside of the esker to facilitate seasonal

caribou hunting during their annual migrations. However, there is no drive lane or apparent complex of structures that were used in tandem. Rather, there are several discontinuous, scattered rock clusters thought to be blinds that were likely used independently. This includes two potential blinds at the southern portion of the esker where it ends and allows animals to cross to the other side, similar to the gap in the esker at the central drive area (figure 7.8). Blinds on the west side of the esker could have been used during the spring or fall migrations targeting animals moving along the esker in either direction.

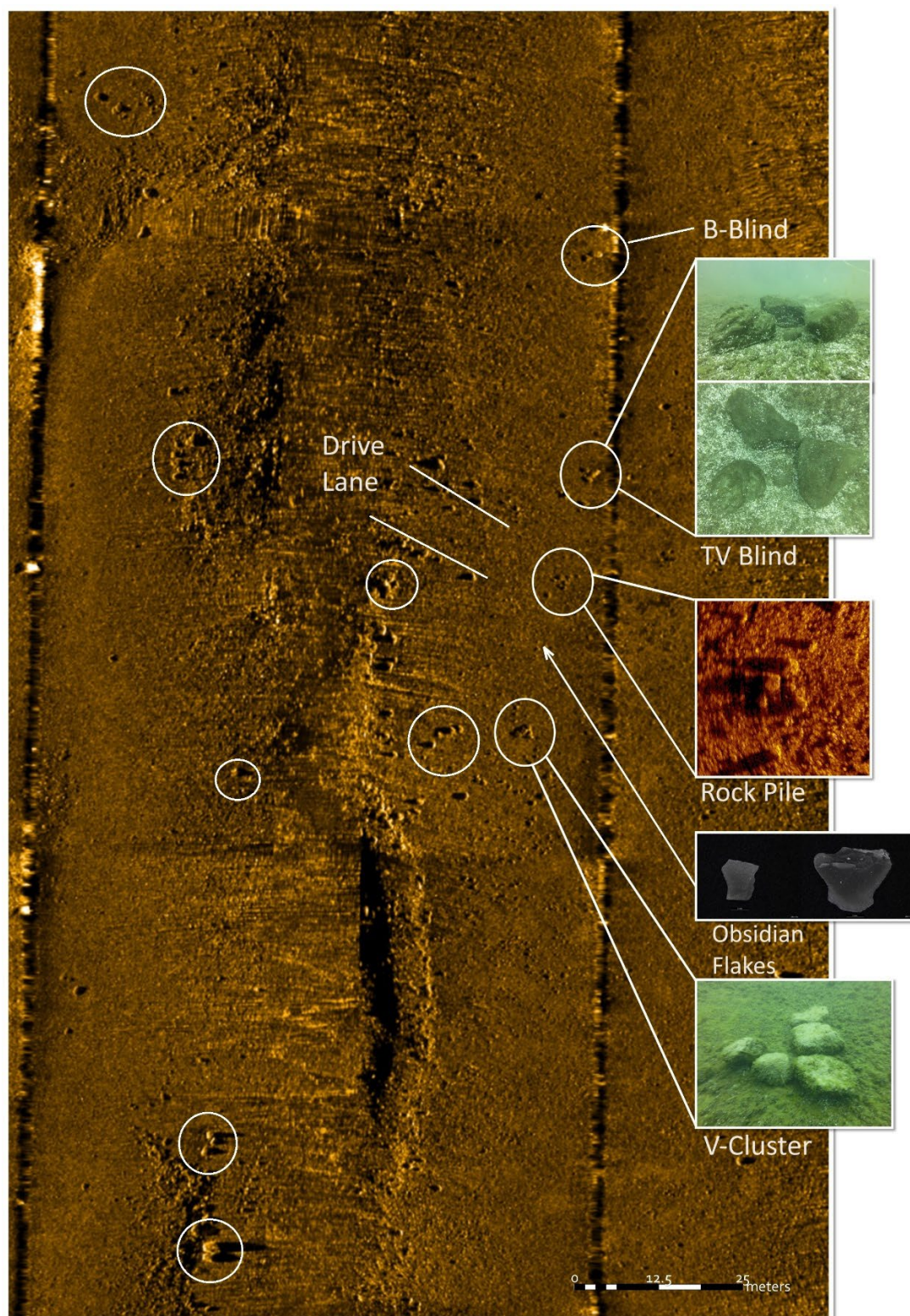


Figure 7.8 Sonar map showing the esker at the South Gap site and the complex of hunting structures surrounding it. It also shows the location of the obsidian flakes, and several potential hunting blinds.

Taken together, the evidence for cultural niche construction in the form of constructed hunting features suggests that the site has a complex history of occupation. The scatter of blinds on both sides of the esker was likely created independently over many years of periodic visits. The central drive area, on the other hand, could have been constructed over one or few visits as the different features were likely used as together by several people as a hunting complex. The analysis of the recovered lithic assemblage presented below will provide complementary data for the interpretation of site function.

7.6 Analysis of South Gap site lithic assemblage

7.6.1 Function

Of the nine recovered lithic specimens from the South Gap site, eight are likely related to hunting and subsequent animal processing activities. This includes three potential micro-blades (324-1, 330-1, 330-3), two potential bipolar microblade cores (330-2, 328-1), one scraper (324-2), and three flakes from a bifacial edge (105-1, 105-2, 330-4). The ninth artifact is a likely net sinker (19-1) and suggests that activities beyond caribou hunting and processing that took place at the site or perhaps derives from a later occupation. Other than the two obsidian flakes from central Oregon, all of the flaked stone artifacts from South Gap are made from local chert cobbles illustrating the *ad hoc* nature of the lithic assemblage. The two obsidian flakes that derive from a biface serve to illustrate that highly curated bifacial technological was employed alongside the *ad hoc* production of small and expedient tools on the AAR.

The microblade portion of the assemblage consists of three bipolar reduced specimens (figure 7.9) that could have been used as working edge components in composite hunting and/or processing tools. Specimen 330-1 is a likely microblade produced with a bipolar reduction from local honey colored chert (figure 7.9). It has two abutting facets creating a central ridge down the back –hafted portion– of the blade. These were likely the result of previous bipolar smashing events. The working edge is created from the two converging faces and shows abrasion consistent with use as a knife and/or projectile.

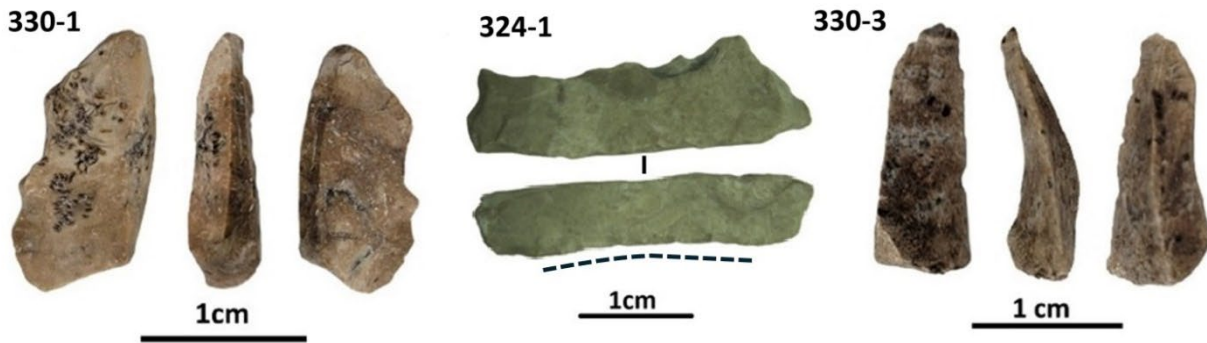


Figure 7.9 Microblade assembled from the South Gap site. The dashed line on specimen 324-1 indicates modification along the edge.

Specimen 324-1 is a likely microblade made from local chert with a squared edge that has been modified along one side to make it parallel to the other (dashed line in figure 7.9). Similar to specimen (330-1), the working edge is a product of two converging faces originating from each of the edges. This would have been a sharp, acute edge before it was used as a projectile and/or knife that caused abrasion. Specimen 330-3 is a probable microblade or piece of bipolar debitage on local honey colored chert (figure 7.9). The specimen seems to represent a removal of a ridge running down a local chert cobble with bipolar percussion. It has a smooth, curved ventral face and a central ridge running down the other side. This side seems to represent the natural surface of the outside of a cobble. The flake is triangular cross section with a thicker, wider end and a smaller end with remnants of the striking platform.

The blade core portion of the assemblage is represented by two specimens on local chert (328-1, 330-2) that likely represent different strategies for creating flakes and blades. Specimen 328-1 is a bipolar core made from a honey-colored chert cobble (figure 7.10). The specimen is roughly two sided with an unmodified cortical side and a flaked side. There is apparent battering on opposing ends of the specimen that leads to flake scars that meet in the middle of the flaked face (indicated with arrows). One edge (indicated with dashed lines) has been modified and potentially used as a chopper and/or scraper. This additional function may help explain why it was not further reduced. Specimen 330-2 is likely an exhausted microblade core (figure 7.10). It is conical shaped with six facets around the top that represent unidirectional microblade removals running down the cone. One facet, however, represents a final episode of bipolar

reduction, as the flake detached from the bottom appears to represent an attempt to get a final microblade or flake from a mostly exhausted core.



Figure 7.10 Core assemblage from South Gap. The arrows indicate the direction of flake removals, and the dashed line represents a modified edge potentially used as a scraper or chopper.

Together these two microblade cores show how the technological system of creating small and expedient tools *ad hoc* from local cobbles can function dynamically, where the function of a tool can change as it is reduced. For example, a larger core can produce flakes for animal processing, before being modified into a chopper, scraper, and/or wedge. From there, it can be further reduced into a small core to create microblades for use as inset components in hunting and processing tools. Notably, exhausted microblade cores are commonly used as wedges around the world and are often referred to by the French term *pièce esquillée* (de Sonneville-Bordes & Perrot 1956; Brun-Ricalens 2006).

The only scraper from South Gap (324-2) is made from a heavily rounded corner of a large squarish block of honey colored chert (figure 7.11). The specimen is roughly triangular in outline with a natural, rounded face and a more freshly broken face. Two of the three edges are blocky while one is a bifacial edge where the two faces converge. One of the blocky edges is natural and unmodified, while the other is the working edge that shows retouch along nearly its entire length. The working edge is abraded and visibly smoothed from use. An interesting feature of this specimen is that it has a bifacial edge. It is important to note that flakes from this edge would look similar to traditional flakes from a biface, such as the two obsidian flakes from the

site, and could produce a false signal for the presence of bifaces. In this case, the acute edge likely served a portion of the haft.



Figure 7.11 Shows the scraper (234-2) from South Gap. Dashed lines indicate the visibly abraded and smoothed edge from use as a scraper.

Evidence for the use of bifacial technology at South Gap comes from three specimens, the two obsidian flakes that were sourced to central Oregon (O'Shea *et al.* 2021), and one partial flake from an acute edge on local honey colored chert (330-4) (figure 7.12). The two obsidian flakes represent careful resharpening of a highly curated biface. The larger specimen (105-1) is a mostly complete, roughly triangular, biface thinning flake made from a black and translucent obsidian with a sub-vitreous texture (figure 7.12). The flake has clear ventral and dorsal faces with evidence of flake scars from an earlier stage of reduction on the latter. One lateral edge leading to a crushed platform is feathered in termination, while the other is step fractured, possibly from two or three failed percussion flake removal strikes, or perhaps from use (O'Shea *et al.* 2021: 2). The second obsidian flake (105-2) is a very small and thin, translucent flake on the same obsidian as the larger specimen (105-1) (O'Shea *et al.* 2021). The morphology is consistent with light percussion, or pressure flaking on an acute bifacial edge. The flake has clear ventral and dorsal faces and an intact lipped platform. It is likely that this flake was removed in sequence with the other obsidian flake (105-1) along the same edge of the same tool.



Figure 7.12 Assemblage of flakes from a bifacial edge South Gap.

Specimen 330-4 is likely the distal portion of a flake on local honey colored chert (figure 7.12). The platform end of the flake is broken off and not recovered. The specimen appears to be from a tool with an acute bifacial edge, however flaking on the dorsal face is obscured with mussel attachments and it is not clear whether it was removed from a traditional biface, or if it derives from a more expedient tools with an acute edge, such as described for the scraper (324-2).

The net sinker (19-1) is the only artifact not related to the hunting of terrestrial animals or subsequent processing (figure 7.13). An artifact with this function suggests use of the site during a season conducive to fishing, such as spring or summer; it seems unlikely that people would be fishing at the same time that they were intercepting and processing caribou during the autumn migration. It could be the case that people are storing less portable tools to use in other seasons however, there is not a body of water at the site. It is possible that the net sinker is related to later uses of the site when water levels are higher and fishable bodies of water may be closer in proximity.



Figure 7.13 Potential net sinker from the South Gap site.

In total, the lithic assemblage from South Gap shows a mix of technological and provisioning strategies used by the foragers of the AAR, including use of local chert cobbles to produce dynamic microlithic tool *ad hoc* that are light weight and multifunctioning. However, more typical bifacial technology that is commonly found at hunter-gatherer sites in the Great Lakes region is also represented by the two obsidian flakes. This mix of strategies is commonly

reported for Late Pleistocene and Early Holocene sites in northwestern north America such as in British Columbia, the Yukon, and Alaska (Magne *et al.* 2020; Magne 2023).

7.6.2 Context

Eight of the nine recovered artifacts were collected from two samples and represent small concentrations of artifacts within the site. One area is located between V-Cluster and the Rock Pile Cairn included the two obsidian flakes (105-1, 105-2) from sample DA-1 collected in 2013, the scraper with a bifacial haft made from a modified local cobble (324-1), and a microblade (324-2) collected from sample BO-1 in 2021 (figure 7.6). The second is located about 20 meters east of Rock Pile Cairn and is represented by sample F-5 that contained two microblades (330-1, 330-23), a bipolar microblade core (330-2), and a flake from a bifacial edge (330-4) (figure 7.6). Notably, both of these areas are in open spaces without cultural or natural structures to provide a trap for sediment that could potentially move along the lake floor from underwater currents. This suggests that these artifacts are more or less in their primary position, very near their discard location, thus representing resharpening of hunting weapons within a kill area while it was being actively used. Further, the two obsidian flakes are small, thin, and brittle. That they have received very little post depositional abrasion, or rounding strongly suggests that they have not been transported along the lake floor very far if at all.

7.7 Conclusions

Years of research at the South Gap site demonstrate that it forms part of a remarkably well-preserved, constructed hunting landscape on the AAR. This landscape consists of a mosaic of cultural and natural features, punctuated by pockets of cultural deposits that represent activity areas and sediment traps. South Gap itself occupies a key bottleneck created by a gap between two eskers, where hunters built a series of stone blinds to conceal themselves from migrating caribou and improve their chances of a successful kill.

The site's stone tool assemblage reflects diverse technologies and dynamic reduction strategies, including highly curated bifaces, microblades produced through bipolar reduction, and expedient small tools whose functions shifted as they were reduced. Taken together, these data

suggest a flexible yet patterned foraging strategy that aligns closely with the expectations of the Early Holocene Adaptations model outlined in Chapter 4 and evaluated in Chapters 5 and 6.

Comparable patterns are evident at other relatively well-developed AAR sites such as Drop 45 and Dragon, where curated bifacial tools occur alongside expedient tools, and where natural barriers were consistently used to guide animals toward constructed hunting features. The convergence of these patterns across multiple sites strengthens confidence in the interpretations offered here and underscores the South Gap site's significance for understanding Early Holocene foraging strategies on the AAR.

Chapter 8 Concluding Discussions

8.1 Introduction

This dissertation examined the global convergence of adaptive strategies among foragers in post-glacial environments during the Pleistocene Holocene Transition (PHT), including the use of small tools, high residential mobility, the construction of hunting and storage features, and the development of long-distance social networks. To explore how these broader patterns played out locally, this research focused on a case study of the Alpena-Amberley Ridge (AAR) in the Lake Huron Basin. This case study considered who may have exploited the AAR and where similar subsistence strategies occurred elsewhere during the PHT. While such foraging strategies have independently emerged many times across the globe, their particular expression on the AAR provides evidence for possible social connections with groups in northwestern North America. Although we can never know the names of these people or how they identified themselves, we can reconstruct aspects of their society that were likely culturally transmitted and indicative of broader networks of interaction.

This dissertation developed and then critically applied the Early Holocene Adaptations (EHA) foraging model for groups occupying new and unknown landscapes at the time of the PHT (see Chapter 4). Although the body of theory was created with data from Late and Terminal Pleistocene sites in recently deglaciated landscapes, it applied well to the post-glacial landscape of the AAR (see Chapter 2). The EHA model presents ten expectations that relate to four aspects or domains of foraging systems, including technological organization, niche construction, residential mobility, and social networks. Each of these four domains of foraging lifeways vary from region to region globally, and from group to group to accommodate the idiosyncratic needs dictated by unique environmental and social conditions.

In order to systematically evaluate variability in these four domains across the landscape of the AAR, a simple rule-based framework was developed using four nested scales for analysis; the AAR as a whole, three research areas, six site clusters, and 31 individual sites (see Chapter 4). By critically applying the expectations of the EHA foraging model at each scale, key

mechanisms of the foraging system were inferred including a pattern of high residential mobility that changed along with dynamic conditions of the climate. Once the climate began to stabilize, key locations seem to have been used regularly within preplanned routes and often incorporated complex stone hunting structures and stockpiling of food and tools.

Ultimately, the results show that subsistence practices on the AAR are most similar to those of contemporary foraging groups across northwestern North America, predominantly from Alaska to British Columbia and Alberta. Foragers from these areas share a suite of behaviors associated with the four domains of the EHA model and were part of a broader set of adaptive strategies for subsisting in semi-Arctic, post-glacial settings. The AAR thus represents a rare and well-preserved example of how mobile hunter-gatherers modified their landscapes, coordinated movements, and maintained social networks in response to shifting ecological conditions at the end of the last Ice Age. The incredible preservation of an entire archaeological landscape dating to the PHT has proven exceedingly valuable for understanding landscape use, including modification, site distribution and seasonal differences, associated with highly mobile caribou hunting societies in North America.

The remainder of this chapter will provide a series of discussions amplifying the conclusions that can be drawn from the analyses presented in the previous chapters. First, the overall character of the AAR adaptation will be considered, with an emphasis on the four most thoroughly studied sites. These sites have been sampled the most on the AAR and show clear evidence for elaborated stone constructions. Second, the strategies evident at the four sites will be compared to a terrestrial example of a Holocene caribou hunting landscape from the southwest Yukon, to demonstrate the consistency in foraging strategies spanning across the Interior Plains of Canada with the AAR at its southeastern edge (Bowyer 2011: 172; Hare *et al.* 2004, Hare *et al.* 2012; Stewart 2015). This leads to a discussion of a potential interaction zone where northern adapted people who commonly use microlithic technology met and interacted with people from more open plains to the west who primarily used large bifacial tools. It will be suggested that the Huron Basin may be similar to an area in the northwest around the Coastal Ranges where people using Plano technology shared the same space and often the same sites with microlithic tool users from the north (Magne *et al.* 2020; Magne 2023). Finally, the chapter concludes with some thoughts on the problem of conducting hunter-gatherer anthropology at underwater sites in the Great Lakes.

8.2 An assessment of foraging strategies on the AAR.

This discussion of foraging strategies on the AAR focuses on four of the best studied sites: South Gap, Drop 45, Funnel, and Dragon (see Chapter 6) (figure 8.1). These four sites appear to have been visited more frequently than others and experienced increased elaboration over time. For this reason, they are four of the most sampled sites on the AAR (see *expectation f*, Chapter 5). Together these sites contain the most complex hunting structures yet identified on the AAR and collectively account for over 80 percent of the recovered lithic artifacts. They offer rare insights into caribou hunting strategies that are otherwise poorly or not at all preserved in terrestrial contexts in the Great Lakes Region (GLR). Each site presents unique but consistent evidence of foraging behavior, including curated and expedient tools, pre-planned hunting strategies, and seasonal mobility.

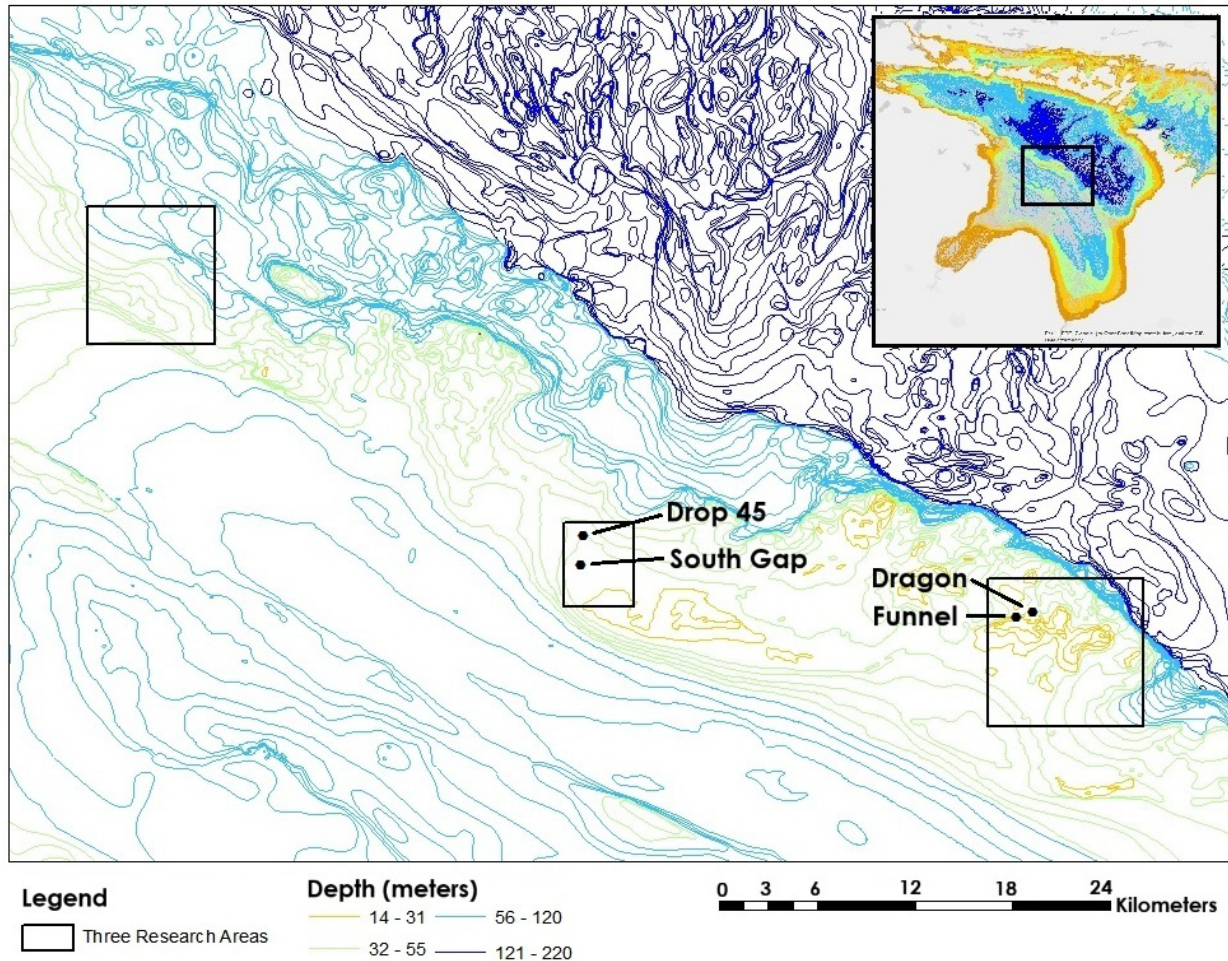


Figure 8.1 Map of the four relatively well studied sites discussed in this chapter.

This discussion provides a comparison of data from the four sites to examine variation in niche construction behaviors, technological organization, and social networks, by time-period and season of use. Considering that the AAR was only exposed during the Lake Stanley lowstand from about 11,200 Cal. B.P - 7,500 Cal. B.P (Lewis *et al.* 2005: 201) the time frame for the sites can be limited to this period, however it can be further divided into three periods; early (ca. 11,200 - 10,000 Cal. B.P), middle (ca. 10,000 - 8,500 Cal. B.P), and late (ca. 8,500 - 7,500 Cal. B.P) (see Chapter 2). Elevation (depth) will be used as a measure of potential relative age with the deeper Drop 45 site being inundated earlier than the other three and thus may preserve an earlier record of occupation. Differences in seasonal use for each site will be considered as indicated by the published interpretations of the orientation of site features (Lemke & O'Shea

2017). The discussion is organized beginning with a review of data for each site followed by a comparative discussion.

8.2.1 The Drop 45 site (20AL104)

At approximately 36.6 meters below the modern lake surface, the Drop 45 site potentially represents an early phase of occupation, possibly during the Early Lake Stanley period (11,200 - 10,000 Cal. B.P) (see Chapter 2). This period is associated with the terminal Pleistocene and is characterized by a less stable climate and more variable caribou migration routes (see Chapter 4). However, despite the potentially less predictable caribou migration routes, the site seems to have been used repeatedly. This is likely due to its position within a natural bottleneck that would have forced migrating caribou to go near or through the site when crossing the AAR.

Although the Drop 45 site is potentially earlier than the other three at higher elevations, the assemblage of 30 artifacts reveals a striking consistency with the technological strategies seen at other sites on the AAR. It includes flakes from biface refurbishment, microblade fragments, several scrapers, and wedges: all indicative of a light-weight tool kit consisting of highly curated bifaces, and expedient bipolar reduced tools. This kind of diverse tool kit would be suitable for planned and/or opportunistic processing activities.

The Drop 45 site is situated between a raised cobble surface and a boggy swale created a natural causeway leading into a cul-de-sac kill zone (O'Shea *et al.* 2014: 6913) (see *expectation* 3). One stone line about 30 meters long was constructed parallel to a natural scarp to create an 8-meter-wide drive lane at the end of the natural causeway. This feature enhanced the already advantageous natural setting and guided prey into a predictable place to be killed (O'Shea *et al.* 2014). The orientation of the drive feature and the absence of meat caches suggest the site was used primarily in the spring (Lemke & O'Shea 2017: 377-378), when food preservation was less feasible.

Data from the Drop 45 site can also provide important insights for understanding mobility and social networks during what was potentially a relatively early occupational phases of the AAR. One artifact from the site, a thumb nail scraper and graver on Bayport chert sources to Saginaw Bay about 150 kilometers to the south. This indicates north - south movement likely representing seasonal mobility routes typical of earlier Late Pleistocene groups in the GLR (see Ellis 2011). This contrasts with the potentially later dating South Gap site, where materials have

been shown to move much further distances west to east (O'Shea *et al.* 2021). Thus, evidence from the Drop 45 site supports the broader model of increasingly complex and distant social networks from the Late Pleistocene through the Early Holocene in the GLR (Ellis 2011).

8.2.2 The Dragon site (20AA230)

The Dragon site is about 32.9 meters below the current lake surface and likely dates to the Middle Lake Stanley period (10,000 - 8,500 Cal. B.P) that seems to be the main period of exploitation on AAR (see *expectation d*). This site appears to have been used during multiple seasons, including fall and spring, and exhibits the most evidence for both stockpiling of tools and caching of meat (Lemke & O'Shea 2017: 376-378; Lemke 2015b: 281; O'Shea *et al.* 2013: 5) (see *expectation 2*). Foraging strategies that can be deduced from the site's data show a system consistent with long-term planning in terms of mobility and provisioning in the context of increasing environmental stability at the onset of the Holocene.

A total of 17 artifacts were recovered from the Dragon site, similar to other sites on the AAR, and display a mix of bifacial debitage and expedient bipolar reduced tools. Larger curated tools, such as a ground stone axe and a quartzite chopper, were found alongside the other smaller tools and suggest stockpiling behavior (following *expectation 2*). Additionally, evidence for meat caching was recovered in the form of a cervid tooth fragment found within a constructed blind (Lemke 2015b: 281). This suggests that meat was stored at the site during the fall to be consumed the following winter or spring (O'Shea *et al.* 2013). This reflects a system of high residential mobility and a foraging strategy that relied on returning to provisioned sites year after year. Caches of food and tools would provide a degree of certainty and security after long periods of absence, particularly when arriving at the site after a harsh winter.

The Dragon site also offers insight into landscape use, feature construction, and hunting strategy. Prey were guided to the site along a natural limestone scarp with karstic springs that likely supported a freshwater stream in front of it (see *expectation 3*). The natural drive line combined with strategically placed blinds, helped people effectively direct caribou along the scarp toward a series of blinds that were very likely also used as meat caches (Lemke 2015b: 281; O'Shea *et al.* 2013). The clustering of both large and small artifacts within the site (following *expectations 2*), combined with evidence for meat caching, strongly supports the notion of habitual seasonal use within a well-developed and pre-planned foraging system.

8.2.3 The South Gap site (20AA232)

Located about 32.3 meters below the modern lake surface and potentially dating to the Middle Lake Stanley period (10,000 - 8,500 Cal. B.P.), the South Gap site –likely used primarily in the fall and possibly summer– (Lemke & O’Shea 2017: 377-378), provides a complement to the Dragon site (see Chapter 7 for a discussion of the investigation into the South Gap site). However, it only has limited evidence for potential food caching in the form of a V-shaped blind (Rock Pile Cairn) that has a scatter of rocks around it that may have been piled up to form a meat cache container. Moreover, the site’s multiple simple hunting features –some of which seem to have functioned together while others seem to be operated independently– likely reflect a frequently use hunting site. Similar to the Dragon and Drop 45 sites, South Gap’s artifact assemblage shows a blend of bifacial debitage and bipolar tools. Although some clustering of tools was observed, the distribution and nature of materials appears more consistent with task-specific activity areas –hunting and subsequent animal processing– rather than long-term provisioning (see *expectation 2*). Samples from different portions of the site yielded combinations of used and broken microblades, scrapers, biface flakes, and a bipolar core suggesting that butchering, tool maintenance, and small-scale tool production occurred locally.

The South Gap site offers yet another example of how local topography was strategically integrated into seasonal hunting practices on the AAR. A prominent north - south running esker functioned as a natural drive line, that people used to guide animals along a specific route toward a series of strategically placed stone blinds. This is the same system of eskers that the Drop 45 site (2 kilometers north of the South Gap site) is constructed within. Three stone blinds at the South Gap site were constructed about 20 meters apart parallel to the esker and form a central drive area leading to a kill zone (see Chapter 7). Considering that two flakes that source to central Oregon were recovered from the central drive area (O’Shea *et al.* 2021), it seems plausible that the site served as a communal hunting location where people from other portions of the GLR would meet. This would be an ideal setting to strengthen vital social networks and feed a gathering of people.

Moreover, the South Gap site provides insight into shifting patterns of long-distance interaction during the early Holocene. While earlier Late Pleistocene exchange networks (potentially identified at Drop 45) were primarily oriented north - south and remained largely local in scale, i.e., within a couple hundred kilometers (Ellis 2011). South Gap, yielded two

flakes from bifacial refurbishment that source nearly 2,000 km to the west (O'Shea *et al.* 2021). This indicates long-distance east–west connections and situates South Gap at the eastern edge of a nearly continent-wide exchange network during the PHT.

8.2.4 The Funnel site (20AA231)

The Funnel site, about 24.4 meters below the lake current surface, is the highest elevation, and thus, potentially the latest used site among the four. The site features a constructed drive complex and represents a cohesive hunting system, likely built in a single episode rather than piecemeal over time. The complex consists of a stone line of six boulders next to a linear cluster of boulders to form a funnel shape with a gap of about 5 meters and a boulder placed in the middle (see *expectation 3*). There is also a 3-rock cluster and a standing stone about 10 meters in front of the funnel and toward the edge of the drive area that likely served as stations for people to guide animals into the funnel feature (O'Shea 2015a: 126; O'Shea *et al.* 2013: 4,7).

Similar to the other three, the Funnel site takes advantage of natural linear features to guide caribou along predictable routes. The site is situated between two natural barriers; a bolder field to the southwest and a 1 meter drop off to the northeast formed from a natural limestone scarp (O'Shea 2015a: 126) (see *expectation 3*). Multiple individuals would have been required to operate the site efficiently, including participants positioned at the periphery to drive animals into the funnel feature (O'Shea 2015a: 126). The absence of stacked stone caches and the orientation of the site's layout suggests use in the spring and further supports the idea that food preservation was not a goal here (O'Shea 2015a: 126). Instead, the site appears to have served a specialized seasonal hunting site within a broader foraging system involving high residential mobility. Considering the orientation of the drive complex, it seems most likely that it was designed for use in the spring (Lemke & O'Shea 2017: 377-378)

The drive complex is built on scoured limestone bedrock without any glacial till. This is surely part of the reason that the site largely lacks stone tools. This situation suggests that any cultural material was removed along with all the other sediment during scouring, however one quartzite chopper was recovered. Its presence supports the idea that the Funnel site functioned as a hunting complex and subsequent processing area. Other tools used at the site likely included a mix of highly curated bifacial tools and more expedient bipolar reduced tools, similar to the other three sites.

8.2.5 Summary of evidence from the four sites

Across the four sites, the archaeological evidence supports the interpretation of systematic foraging on the AAR involving repeated seasonal movement, return visits to certain locations, and strategic provisioning of tools and food. In this way, these sites serve as key locations on the landscape where people can be tracked along their yearly foraging patterns. The Dragon site, likely used in fall and spring, shows the strongest evidence for stockpiling and caching, with both curated tools and food stored across seasons. This suggests that the site was an important node in a regular mobility network. In contrast, spring sites like Drop 45 and Funnel are focused more on immediate resource extraction, with less emphasis on long-term provisioning or caching (table 8.1).

Table 8.1 Shows data for the four sites under consideration here used to discuss differences in foraging behavior.

Site	Elevation (Potential relative age)	Seasonality	Provisioning strategy	Use of Natural linear feature
Funnel	24.4 m (Late)	Spring	N/A	yes
South Gap	32.3 m (Middle)	Fall/Summer	Ad Hoc, Individual	yes
Dragon	32.9 m (Middle)	Fall/Spring/Summer	Ad Hoc, Place	yes
Drop 45	36.6 m (Early)	Spring/Summer	Ad Hoc, Individual	yes

Technologically, each site with more than one artifact contains a mix of bifacial debitage and microlithic tools, confirming a shared strategy for hunting and processing activities. However, spatial clustering and artifact types seem to vary, reflecting differences in site function, provisioning, and seasonal use (table 8.1). Moreover, although the Dragon and South Gap sites are at the same elevation and are potentially similar in age and seasonality, the Dragon site assemblage seems to lack evidence for microblade fragments associated with hunting on site (table 8.2). Considering that the South Gap site consists of more than a dozen potential constructed hunting features, it may have been more orientated towards resource extraction than

the Dragon site. Although the Dragon site seems likely to be used partly as a hunting site (table 8.2), the artifact assemblage seems to represent other activities related to the use of larger tools, such as making kayaks, sleds, or fish nets. Notably, the constructed stone features at the Drop 45 site seem reflective of a habitual hunting site –similar to South Gap– and contain evidence for microblade use on site (table 2) and lacks larger stockpiled tools and caches.

Table 8.2 Shows the number of microblades and microblade fragments recovered from the Drop 45, South Gap, and Dragon sites.

Site	Drop 45	South Gap	Dragon
Number of microblades or fragments	9	3	0

Additionally, raw material sources show potential changes in social networks from the Late Pleistocene to the Early Holocene. Data from Drop 45 –being a potentially earlier site associated with early Lake Stanley (11,200 - 10,000 Cal. B.P)– suggests local, north-south movement associated with yearly migration routes in the Terminal Pleistocene. On the other hand, at South Gap –that may date later than Drop 45– tentative evidence of long-distance westward connections is identified, consistent with broader regional shifts in exchange and mobility patterns, though based on only three lithic specimens. However, during writing of this dissertation in 2025, several more obsidian micro-flakes have been identified at a site about 5 km from South Gap and at a higher elevation. This provides additional evidence for the assessment of regional shifts in exchange and mobility associated with the onset of the Holocene (J. O’Shea, personal communication, 9/23/2025)

8.3 A terrestrial example of Holocene caribou hunting from the southwest Yukon

An important observation from the AAR is that the strategy of building hunting architecture alongside natural linear features on the landscape such as eskers and scarps unites the four sites discussed above. A terrestrial example of this same niche construction strategy can be found in the Yukon territory in Canada. This landscape presents a post-glacial setting with similar features to the AAR (Bunbury & Gajewski 2009; Fritz *et al.* 2012; Lenz *et al.* 2013). Here, ice patches that are now melting due to anthropogenic climate change have been found to

contain very well-preserved cultural material dating throughout the Holocene (Hare *et al.* 2012: 129-130). A team of researchers from the Arctic Institute of America worked to identify archaeological sites near ice patches between 1997 and 2012 and have identified 43 ice patches with associated cultural material over this period (Kuzyk *et al.* 1999; Hare *et al.* 2012). These sites preserve an extraordinary record of caribou –and other animals– hunting in a post glacial landscape for at least 8,500 years (Hare *et al.* 2012: 121). The preserved material has allowed archaeologists to examine the organic portions of ancient hunting technology in incredible detail. The cultural assemblage contains dart points slotted for inset microblade use, and hafted bifaces from the Archaic period. Alongside artifacts such as these at least one site, referred to as the Friday Creek Ice Patch site (JcUu-1), has a series of three stone hunting blinds made from the local glacial till (Bowyer 2011: 175); similar to the stone hunting structures on the AAR.

The Friday Creek Ice Patch site is located on the Friday Creek Plateau in southwestern Yukon, north of the Watson River, near Alligator Lake (Bowyer 2011: 172; Hare *et al.* 2004, Hare *et al.* 2012). The site has striking similarities to the four sites discussed here, including a series of three hunting blinds that are spaced about 20 meters apart along a natural ice patch that would have served as a barrier that channeled migrating animals such as caribou along a predictable route (Bowyer 2011: 175) (figure 8,2).

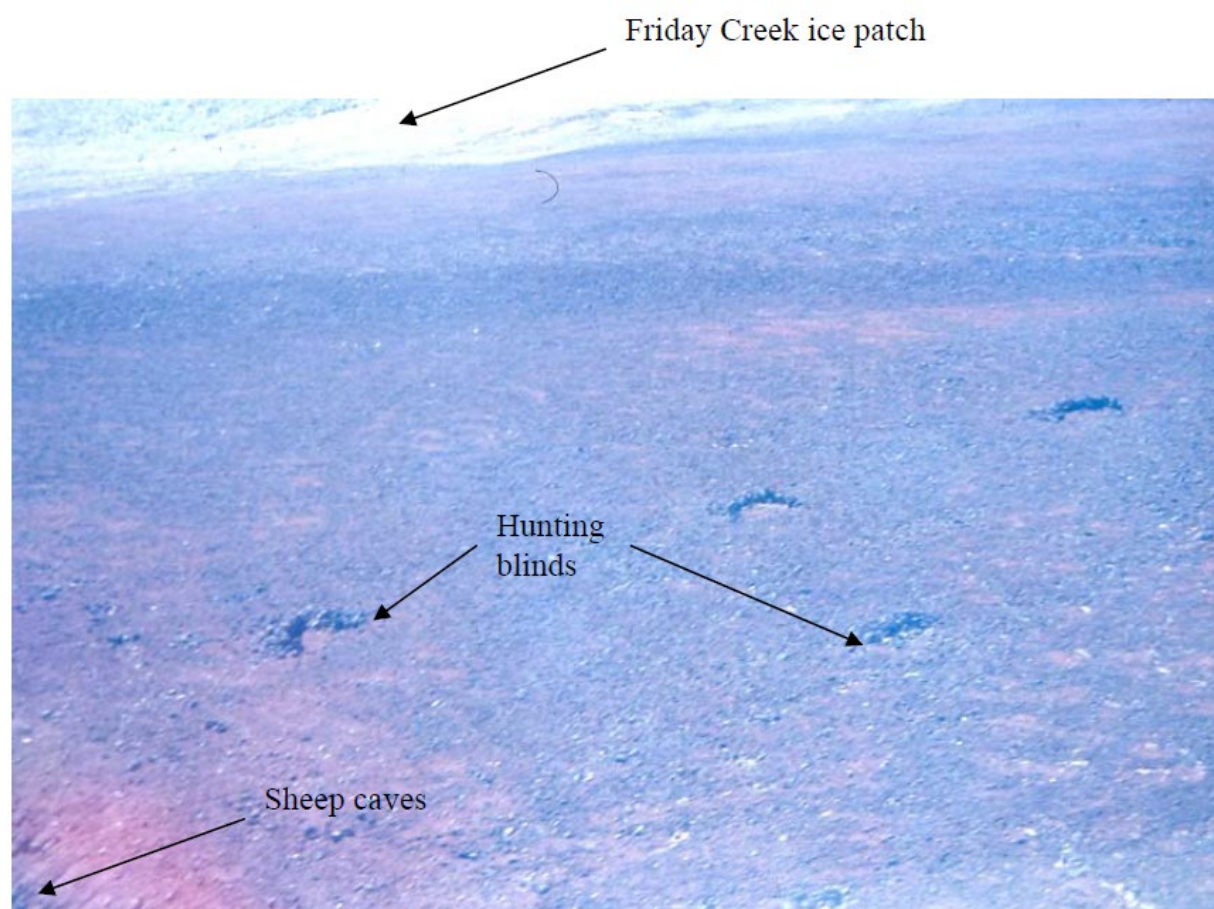


Figure 8.2 Photo of the hunting structures at the Friday Creek Ice Patch site from Boyer (2011: 175).

Although the presence of archaic caribou on the AAR has not yet been established from physical remains, it is well established in the Yukon, with dozens of dates on caribou bone and dung between $8,360 \pm 60$ ^{14}C . yr B.P [ca. 9,250 Cal. B.P] and ca.190 Cal. B.P (Hare *et al.* 2012: 131-132). This matches the time frame of the dated hunting artifacts recovered from sites in the area and is a strong indication that the stone structure associated with the dated cultural material were used as blinds for hunting caribou (Hare *et al.* 2012; Hare *et al.* 2004; Bowyer 2011). This notion is confirmed at least for the early historic period in the Yukon as native hunters have given accounts from their grandparents about the prevalence of caribou and the role that they played in the culture and subsistence (Cruikshank 1981, 1992; Boyer 2011: 36-39).

8.3.1 Archaic hunting technology in the southwest Yukon

The cultural assemblages from sites identified by the Yukon team have a strong representation of hunting technology in the form of dart and arrow shafts, many with bifacial stone points still attached. Microblade technology is represented by two organic (ivory or bone) points, slotted for inset bladelets, and one microblade core. Unfortunately, the core could not be dated as it was found on the surface associated with historic artifacts, although it is likely Archaic in age. However, the slotted points are reported to date to 4,360 $\pm$ 40 ^{14}C . yr B.P [ca. 4,847 Cal. B.P], and 7,310 $\pm$ 50 ^{14}C . yr B.P [ca. 8,022 Cal. B.P] (Hare *et al.* 2012; Hare *et al.* 2004) (figure 8.3). The latter date is the earliest for a projectile point reported from the Yukon research project and suggests that microblade technology was more prevalent in the Early Archaic than in subsequent periods (Hare *et al.* 2012; Hare *et al.* 2004; Bowyer 2011). Additionally, there was a medial section of a fore shaft found at the same site, reported to date 8,360 $\pm$ 60 ^{14}C . yr B.P [ca. 9,250 Cal. B.P] (Hare *et al.* 2012: 130). These dates overlap with late Lake Stanley lowstand on the AAR that allowed human and animal occupation (see Chapter 2). The environmental context of the Yukon sites within a post glacial, arctic landscape (Kuzyk *et al.* 1999; Wahl *et al.* 1987), the prey species involved, the presence of stone hunting blinds, and microlithic hunting weapons are very similar to the pattern being uncovered for the exploitation of the AAR at the four sites discussed above. Moreover, there are dozens of sites that fit this pattern identified by the Yukon team (Hare *et al.* 2012) and suggests that the subsistence system was facilitated by high residential mobility, similar to the strategy identified on the AAR.

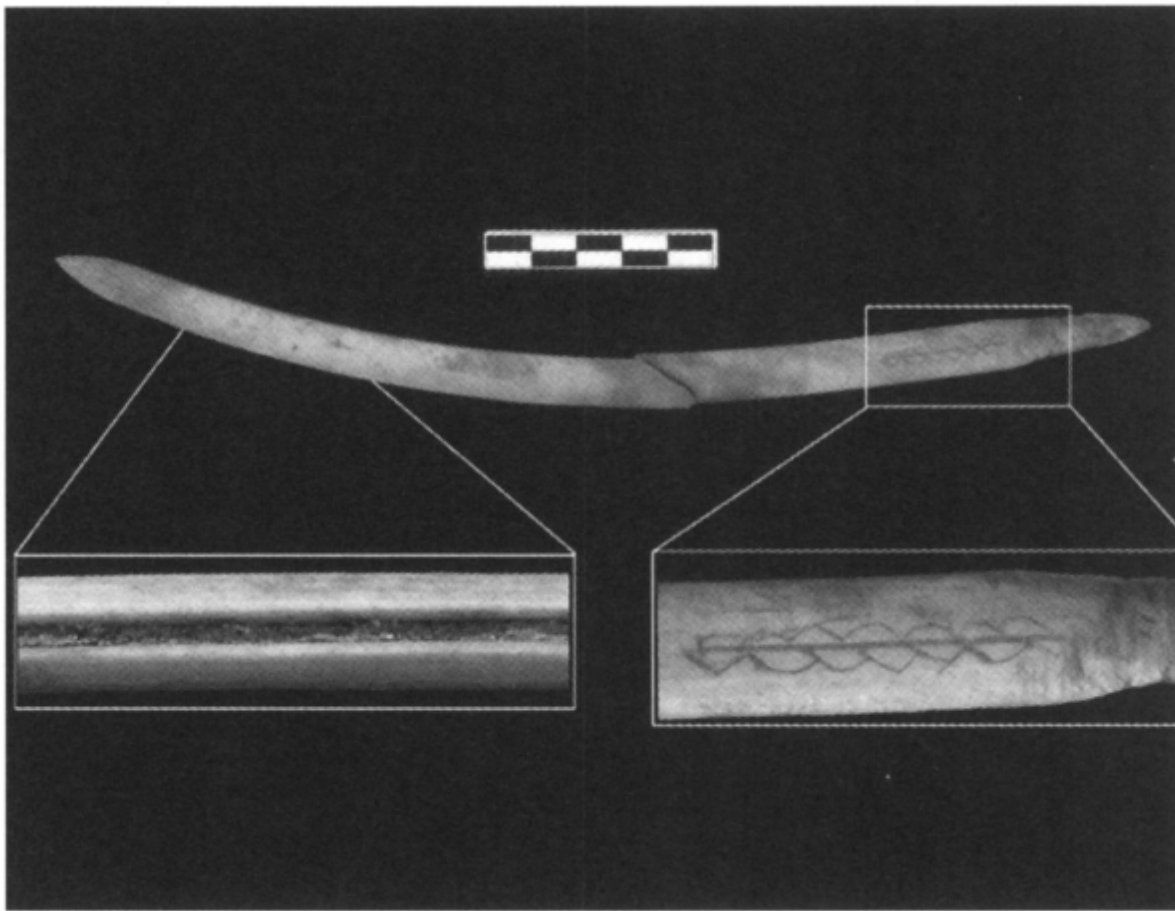


Figure 8.3 Shows an image from Hare et al. (2004: 266) of a bone dart point slotted for inset microblade use from the Yukon dated to $7,310 \pm 50$ ^{14}C . yr B.P [ca.8,022 Cal. B.P.].

Similarities in foraging strategies and environmental conditions between southern Yukon and the AAR suggests that the GLR was situated at the southeastern edge of a region of shared technological and hunting traditions that extended across the Interior Plains to the Coastal Ranges during the Early Holocene. This included the strategy of constructing stone hunting blinds alongside natural linear barriers that serve as drive lines as documented at the Friday Creek Ice Patch site (JcUu-1) (Bowyer 2011: 172; Hare *et al.* 2004, Hare *et al.* 2012). Understanding this spatial and temporal continuity in foraging strategies provides a foundation for examining how the AAR's central location in North America positioned it within an interaction zone where northern and western foraging using Plano technology would overlap.

8.4 Discussion of the potential North America interaction zone

The GLR's position just east of the center of the North American continent placed it at the intersection of Arctic landscapes to the northwest and temperate landscapes to the south and east during the PHT. The foraging systems and associated technological strategies employed in these two areas are fundamentally different from the earlier Late Pleistocene period through the Middle Holocene. People from the northern tradition regularly incorporates the use of microlithic tools into their tool kits beginning with the earliest evidence of Yubetsu microblade technology at Swan Point through a succession of industries terminating with the Arctic Small Tool tradition of the Middle Holocene (see Chapter 3). This relatively central location situates the AAR within a larger interaction zone running west - east near what is today the Canada and US border (figure 8.4). In the far west –spanning today's Washington state, Idaho, British Columbia, and Alberta– Late Denali (microlithic) tool users who hunted caribou and other game in Arctic, post-glacial landscapes overlapped with Cody Complex bison hunting societies from the Plains (Mage *et al.* 2020; Magne 2023).

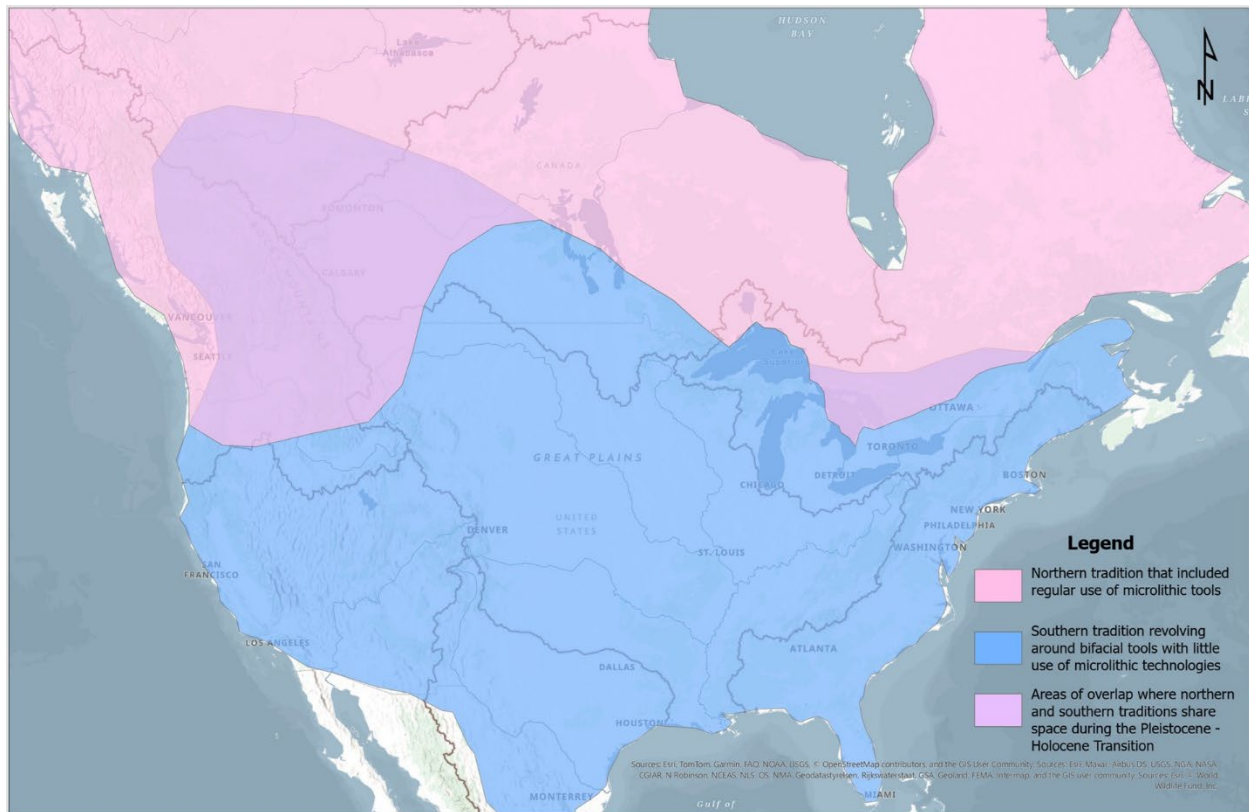


Figure 8.4 Map of North America showing the extent of the northern (habitual microlithic tools users) and southern foraging traditions (emphasis on bifacial technologies with limited use of microlithic tools) and where they overlap during the PHT. Note the similarity to map figure 9.5 in Lemke & O'Shea 2019: 167, that shows a schematic of later Pleistocene technological traditions.

The upper GLR, and the Lake Huron Basin in particular, seem to represent an eastern interaction zone (figure 8.4). Here, similar to in the west, microlithic tool users and bifacial tool users may have converged, with the AAR serving as a possible seasonal meeting place for inhabitants of the GLR (figure 8.4). There are notable differences, however, between the archaeology of the AAR and that of the western interaction zone, including that the lithic assemblages from the AAR lack evidence for the classic *Campus* microblade cores that characterize the Late Denali complex (Clark 2001, 1992; Waber 2010; Magne 1996), and no diagnostic bifacial tools have been found. The evidence for bifacial tools comes from biface refurbishment flakes, including two on Wagonfire obsidian from central Oregon (O'Shea *et al.* 2021), that establish social connections across the Plains to the far west. The additional obsidian micro-flakes recovered about 5 km from South Gap in 2025 (J. O'Shea, personal

communication, 9/23/2025) support this argument, although the specific technology that the flakes derive from has not yet been assessed. The microlithic tools recovered from the AAR are mostly expedient, bipolar produced microlithic technologies including scrapers, wedges, microblades, and burins.

Additional evidence for the exploitation of the Great Lakes by Plano users can be found at the Cummings site on the northwest coast of Lake Superior, associated with the Lakehead complex (Arnold 1985; Dawson 1983; Markham 2012), and the Sheguiandah site on Manitoulin Island in the Lake Huron Basin (Julig & Beaton 2015; Julig 2002a,b). Data from these sites suggests that Plains groups may have gathered at the Northwest coast of Lake Superior during the spring, dispersed through the upper Great Lakes to exploit summer and fall resources, before returning south for the winter. This model echoes Quimby's (1960) "aqua-plano" model, in which Plains-derived Plano technology users are thought to have become adapted to the resource-rich environments of the Great Lakes while continuing to use technology from the Plains.

8.5 After the AAR and the proliferation of Small Tool cultures

As the retreat of the Laurentide Ice Sheet continued, the newly exposed lands north of the GLR offered classic postglacial environments consisting of eskers, moraines, kettle lakes, and glacial tills. This landscape later became home to the Arctic Small Tool tradition (5,000 - 3,000 Cal. B.P.), that stretched from Alaska to Greenland (Bielawski 1988). These foragers employed small tools made from local glacial gravels, similar to technological strategies described by the EHA model for the AAR and other post-glacial settings around the world.

In Tremayne's (2015b) analysis of the Arctic Small Tool assemblage recovered from Matcharak Lake in Alaska, he describes it as technology designed to maximize utility, portability, and relatively rapid production. Moreover, this technological system is described as an adaptive feature designed to facilitate high residential mobility in an environment with limited access to raw material sources and within an economy that specialized on caribou hunting (Tremayne 2015b). This situation is again very similar to the strategies described in the EHA model and applied to data from the AAR during the course of this dissertation.

It seems likely that AAR foragers may have adopted a subsistence strategy involving small tools, high mobility, and constructed stone hunting features that had roots in earlier Late

Denali traditions. This subsistence pattern would later continue as the Arctic Small Tool tradition. This places the AAR not only central to the North American content, but also central to the story of the spread of microlithic technology across northern North America that began in the Late Pleistocene and continued through the Early Holocene, as the final bits of glacial ice retreated and the Canadian shield became fully habitable.

8.6 Implications for the peopling of North America

Considering that there is a meeting of two traditions from two different directions during PHT in North America, it brings up the question of whether there is a shared ancestry between these groups. A brief examination of the preceding Late Pleistocene period when fluted points are ubiquitous in southern portion of North America can set the stage for the interaction of cultures highlighted in this chapter. While populations in the lower 48 during the PHT appear to have been descendants of the widespread Clovis culture (Moreno-Mayar *et al.* 2018; Raghavan *et al.* 2016; Rasmussen *et al.* 2014; Posth *et al.* 2018; Reich *et al.* 2012; Lindo *et al.* 2017), Late Denali technology in western Canada appears to have developed *in situ* from the inhabitants of Swan Point, who employed Yubetsu technology by at least 14,200 Cal. B.P (Reuther *et al.* 2023). This predates Clovis by a millennium and implies that Denali and Clovis groups were not directly related but shared a common ancestor at Swan Point. The divergence likely occurred just before Clovis times, with one branch moving rapidly south along the Pacific coast, periodically moving inland via river valleys, and reaching as far as Monte Verde, Chile, by 14,550 Cal B.P (Pino & Dillehay 2023). The dates are largely in agreement and indicate that the colonization of the West coast of North America happened sometime before 14,550 Cal. B.P.

However, the peopling of the Americas did not end after Clovis technology proliferated from coast to coast, rather there were vast expanses of land in the north still covered by glacial ice that would be subject to progressive colonization through the Early Holocene. By the end of this period, the North American continent had been fully colonized, and regionally bound populations had begun to emerge. As ecosystems continued to develop during the later portion of the Early Holocene, temperate climates continued to move north bringing with it people adapted to those ecosystems, while the remaining ice sheets melted and exposed new post-glacial landscapes that would be colonized by northern adapted foragers. This sets the stage for a meeting of two distinctly American cultures and provides important details for the story of the

colonization of North America that is too often characterized as a single branching tree with Clovis users alone at the base.

8.7 Conclusions

This dissertation has shown that the subsistence strategy employed on the AAR does not represent an isolated anomaly but instead occupies a central position within the broader history of North American hunter-gatherer adaptations. Evidence from sites such as Drop 45, Dragon, South Gap, and Funnel link the microlithic tool users of the Terminal Pleistocene with the Small Tool users of the Middle Holocene in northern North America. The AAR fills a critical gap, both geographically and temporally, between these two traditions, representing the southeasternmost expression of a northern adapted foraging system that relied on microlithic tools and operated within an arctic refugium during a period of rapid climatic warming.

The results of the EHA model tests in Chapter 5 support the expectation that small tools were created *ad hoc* with a bipolar reduction method from local gravels. However, it may be the case that the use of small tools on the AAR is overstated relative to the use of bifacial tools in the current model. There would have been selective pressures from the size of the raw materials on the AAR that limited the creation of bifacial tools and may have led to foragers curating them longer than they otherwise would. This would result in little to no lithic scatters related to creating bifaces and only small scatters or isolated flakes associated with bifacial refurbishment. In sum, it seems likely that the technological strategy employed on the AAR was more similar to other portions of the GLR than it appears. However, the unique environment on the AAR facilitated different technological strategies involving the local raw materials and post glacial landscape features. The selective pressures by the local environment may help explain the divergence between datasets from terrestrial and submerged sites.

However, taken together, these similarities suggest more than simple convergence: they likely point to cultural connectivity within a shared ecological zone, whether through shared ancestry, interaction, or convergent adaptation between AAR foragers and those of the northwest of the continent. By situating the AAR within the broader context of North America during the PHT, this dissertation highlights its significance as a key place for understanding the potential interaction of northern microlithic and southern biface-dominated traditions. This meeting of technological systems coincides with a period of cultural diversification in the Early Holocene

and marks a major transitional period where continent scale foraging patterns give way to regional adapted populations. These developments likely contributed to the technological and organizational diversity seen in the Northern Archaic and Arctic Small Tool traditions of the Middle Holocene, where microlithic and bifacial strategies were combined in different ways (Tremayne 2015b; Bielawski 1988; Anderson 2005; Slobodin 2019; Davis & Knecht 2005)

Importantly, I found little evidence that resource uncertainty was the primary factor driving site distribution on the AAR, contrary to what is often suggested in the literature on foraging in new and unfamiliar environments (see Chapter 4). Instead, the pattern of site distribution reflects a mix of short-term occupations –represented by one or two stone features or just a few discarded tools– and sites that were repeatedly used over multiple years. The latter are marked by more complex stone features, including multiple structures and caches, suggesting that people planned on returning to these locations in following seasons or years. This indicates that the foraging system employed by AAR foragers was well developed, in terms of preplanned logistical movements that placed people where the resources were when they were there. This includes balancing movements between subsistence resources that are only periodically available at certain locations and lithic resources that would always be available at certain places. Considering that during at least middle Lake Stanley, animal migration routes seemed to be predictable and certain locations remained advantageous, the AAR landscape seems to have been conducive to such a strategy.

8.8 Reflections and recommendations for future directions

Conducting the present analysis provided insights into the archaeological record of the GLR but also an awareness of methodological challenges posed by submerged sites. The collection, assessment, and interpretation of archaeological data from underwater contexts poses significant and diverse challenges compared to terrestrial sites. A primary challenge is the inherently small sample size that is a direct consequence of the difficulty accessing submerged sites. They are often located far offshore or at significant depths, making both survey and excavation labor-intensive and time constrained. Unlike terrestrial projects, where satellite imagery, LiDAR datasets, and prior research can guide sampling strategies, underwater projects frequently begin with minimal geographic and geomorphic context, lacking even basic maps or visual documentation of site features.

Another primary difference between submerged and terrestrial sites archaeology is that underwater sites are often located within larger submerged landscapes (O'Shea 2023; Galanidou *et al.* 2020; Benjamin & Bailey 2017; Gusick & Faught 2011; Ford 2011; Gusick & Davis 2010; Bailey & Flemming 2008; Benjamin 2010; Faught 2004), raising critical questions about where to focus excavation efforts and for how long. This is opposed to terrestrial landscapes are often fragmented by modern development. Deciding how to allocate limited resources –to what extent are efforts focused on individual sites versus to spread across the landscape– requires consideration based on specific research questions.

Logistical limitations also play a central role in shaping underwater archaeological research. Sample collection is often dictated by restrictive time windows related to the weather, specialized equipment, and strict safety protocols, which collectively reduce the amount of material that can be recovered. Weather also has a disproportionate influence on underwater operations, with storms, currents, and limited underwater visibility often forcing delays or cancellations. Depth of the water is also a major limiting factor with increasingly expensive equipment and safety concerns as sites get deeper. This results in less time on site, and increased safety measures, as depth increases leading to smaller sample sizes.

The element of risk in underwater archaeology cannot be overstated. As sites increase in distance from shore or in depth, the level of danger escalates. Emergency response and medical assistance are less accessible, requiring teams to operate under heightened safety protocols that further limit time on site and increase operational complexity. These hazards, combined with the specialized equipment and training required, substantially elevate project costs, often limiting the scope of research to what is feasible within funding constraints.

From a broader methodological perspective, the challenges identified here highlight the importance of developing frameworks for working with inherently small sample sizes that are likely to be spread around a sizable landscape. Creating multiple nested scales for analysis helped to organize data such that small sample sizes could be mitigated by combining them into successively larger datasets (see Chapter 5). If interpretations are consistent at each scale, then you can be reasonably confident in the interpretations. Although, caution should always be exercised when drawing big conclusions from small sample sizes as is done in this chapter.

Very importantly however, submerged sites often provide more complete context for artifacts in terms of often occurring as parts of larger landscapes. Moreover, submerged sites and

landscapes are likely to have relatively good preservation of organic environmental indicators and provide unique opportunities for underwater archaeologists. In these settings, the context of recovered and documented cultural materials greatly enhances the interpretations that can be drawn. Additionally, different questions can be addressed at underwater sites and provide an invaluable complement to terrestrial investigations. Based on these realities, the relatively small sample sizes associated with collecting data far offshore in Lake Huron can be more than overcome.

For research questions related to human-environment interaction, mobility, and cultural niche construction submerged landscapes in the GLR offer valuable settings. For questions related to technological change over time and social networks, the small sample sizes and limited ability to conduct precise stratigraphic excavations (as is routinely done on land) greatly limit what can be learned. However, newly utilized sub-bottom profile results may be able to identify areas where this kind of investigation could be done. Ultimately, the benefits and limitations of submerged landscape archaeology must be weighed for specific research questions, available time, and funding.

Appendices

Appendix 1: Lithic Specimens

I.D.	Description	Site	Multi-function	Small tool tech	Stone type	Reduction	Depth m.
265-1	Scraper	A2RLIN	0	0	Chert, Honey	Bipolar	34.1
52-1	Microblade	Ash_Gap	0	1	Chert, Honey	Bipolar	32.3
28-2	Scraper (End-Scraper)	Dragon	0	1	Chert, Gray	Modified Stone	31.7
300-4	Flake Tool	Dragon	1	0	Chert, Honey	Biface	33.5
300-5	Flake Tool	Dragon	1	0	Chert, Honey	Biface	33.5
299-3	Flake	Dragon	1	0	Chert, Honey	Biface	33.5
299-1	Burin	Dragon	1	1	Chert, Honey	Bipolar	33.5
300-3	Core	Dragon	1	1	Chert, Honey	Bipolar	33.5
48-2	Core	Dragon	1	1	Chert, Honey	Bipolar	31.7
299-16	Flake Tool	Dragon	0	1	Chert, Honey	Modified Stone	33.5
299-6	Flake Tool	Dragon	0	1	Chert, Honey	Modified Stone	33.5
299-13	Flake	Dragon	0	0	Chert, Limstoney	Biface	33.5
299-19	Flake	Dragon	1	0	Chert, Mottled	Bipolar	33.5
299-2	Groundstone tool	Dragon	1	0	Granite, Diorite	Ground Stone	33.5
299-21	Net Sinker	Dragon	0	0	Granite, Diorite	Modified Stone	33.5
300-7	Wedge	Dragon	0	1	Quartzite, Brown	Modified Stone	33.5
299-9	Wedge	Dragon	1	1	Quartzite, Orange	Bipolar	33.5
299-22	Hammer Stone	Dragon	0	0	Quartzite, Orange	Modified Stone	33.5
299-8	Chopper	Dragon	0	0	Quartzite, White	Modified Stone	33.5
287-1	Net sinker	Drop 45	0	1	Basalt	Modified Stone	36.9

131-1	Scraper	Drop 45	1	1	Chert, Bayport	Bipolar	36.6
154-1	Flake	Drop 45	1	0	Chert, Black	Biface	36.6
139-3	Flake Fragment	Drop 45	0	1	Chert, Gary	Biface	36.6
204-1	Microblade	Drop 45	0	0	Chert, Gray	Biface	36.6
277-1	Microblade (Fragment)	Drop 45	0	1	Chert, Gray	Bipolar	36.9
156-1	Flake	Drop 45	1	0	Chert, Honey	Biface	36.6
175-2	Flake	Drop 45	1	0	Chert, Honey	Biface	36.0
139-1	Flake	Drop 45	1	0	Chert, Honey	Biface	36.6
138-7	Flake	Drop 45	0	0	Chert, Honey	Biface	36.6
295-3	Core (Bipolar)	Drop 45	1	1	Chert, Honey	Bipolar	36.9
131-4	Blade Frag	Drop 45	0	1	Chert, Honey	Bipolar	36.6
296-1	Microblade	Drop 45	0	1	Chert, Honey	Bipolar	36.9
131-2	Microblade (Fragment)	Drop 45	0	1	Chert, Honey	Bipolar	36.6
170-1	Microblade (Orange Slice)	Drop 45	0	1	Chert, Honey	Bipolar	36.6
162-1	Scraper (Blade)	Drop 45	1	1	Chert, Honey	Bipolar	36.0
293-1	Wedge	Drop 45	1	1	Chert, Honey	Bipolar	36.9
283-1	Borer	Drop 45	0	1	Chert, Honey	Modified Stone	36.9
286-1	Borer/Drill	Drop 45	0	1	Chert, Honey	Modified Stone	36.9
287-4	Scraper	Drop 45	0	1	Chert, Honey	Modified Stone	36.9
139-4	Scraper (Split Pebble)	Drop 45	0	1	Chert, Honey	Modified Stone	36.6
287-2	Wedge	Drop 45	1	1	Chert, Honey	Modified Stone	36.9
287-7	Core	Drop 45	1	1	Chert, Honey	Unidirectional microblade	36.9
293-2	Micro-blade fragment	Drop 45	0	1	Chert, Honey	Unidirectional microblade	36.9
165-1	Flake	Drop 45	0	0	Chert, Light Gray	Biface	36.6
167-1	Flake (Probable Modification)	Drop 45	1	1	Chert, Light Gray	Biface	35.4
286-2	Core (Microblade)	Drop 45	0	1	Chert, Mottled	Bipolar	36.9
138-1	Microblade	Drop 45	0	1	Chert, Mottled	Bipolar	36.6
138-4	Flake	Drop 45	0	0	Chert, White	Biface	36.6
287-3	Scraper	Drop 45	0	1	Chert, White	Modified Stone	36.9

269-1	Chopper	Funnel	0	0	Quartzite, White	Modified Stone	25.6
305-2	Scraper	Gap Con0	0	1	Chert, Honey	Modified Stone	32.3
305-1	Scraper	Gap Con0	1	0	Quartzite, White	Biface	32.3
311-1	Flake	GapX01	0	0	Chert, Honey	Biface	34.1
312-1	Utilized Flake	GapX01	0	1	Chert, Mottled	Bipolar	34.1
310-1	Core	GapX02	1	1	Chert, Honey	Bipolar	32.3
309-1	Scraper / Borer	GapX02	0	1	Chert, Honey	Modified Stone	32.3
148-1	Flake	High ground	0	0	Chert, Honey	Biface	33.5
148-2	Flake	High ground	0	0	Chert, White	Biface	33.5
219-1	Flake	Lake Shore NW	0	0	Chert, Gray	Biface	29.0
330-2	Core (Bipolar)	South Gap	1	1	Chert, Gray	Bipolar	32.9
324-1	Microblade, backed	South Gap	1	1	Chert, Gray	Bipolar	31.7
330-4	Flake	South Gap	1	0	Chert, Honey	Biface	32.9
330-1	Microblade	South Gap	0	1	Chert, Honey	Bipolar	31.7
324-2	Scraper	South Gap	1	1	Chert, Honey	Modified Stone	31.7
330-3	Microblade	South Gap	0	1	Chert, Mottled	Bipolar	32.9
105-1	Flake	South Gap	0	0	Obsidian	Biface	31.7
105-2	Flake	South Gap	0	0	Obsidian	Biface	31.7
19-1	Net Sinker	South Gap	0	0	Quartzite, Yellow	Modified Stone	32.0
228-2	Core (Bipolar)	Wood_6	1	1	Chert, Honey	Bipolar	33.5
228-1	Core/Wedge	Wood_6	1	1	Chert, Honey	Bipolar	33.5

I.D.	Length (mm)	Width (mm)	Thickness (mm)	Weight (g)
105-1	7.31	6.5	1.64	0.07
105-2	2.3	2.93	0.42	0.01
131-1	10.9	10.2	3.6	0.45
131-2	6.1	3.8	1.1	0.033
131-4	5.1	3	1	0.08
138-1	15.2	5.5	2.2	0.24
138-4	4.6	4.5	1	0.023
138-7	6.4	4.6	1	0.028

139-1	11	9.3	2.7	2.9
139-3	7.4	5	1.1	0.07
139-4	19.1	13.9	8.5	2.4
148-1	7.3	4.8	0.8	0.05
148-2	5.2	3.8	1.1	0.03
154-1	14.9	7.1	3.9	0.44
156-1	21	11.2	4.7	1.06
162-1	6.03	5	2.12	0.087
165-1	6.4	4.7	1.4	0.05
167-1	10.3	5.9	1.8	0.1
170-1	10.6	4.2	4.1	0.2
175-2	12.1	8.8	2	0.25
19-1	11.9	7.2	8.4	555
204-1	9.3	4.4	1.2	0.06
219-1	10.6	7.2	1.7	0.13
228-1	10.7	10.9	8.8	1.3
228-2	17.9	9.8	6.5	1.25
265-1	33	31.5	13	14.2
269-1	82	60.1	58.4	396.9
277-1	10.6	5	2.5	0.17
28-2	9.8	9	4.9	0.51
283-1	21.7	16.3	8.3	2.58
286-1	20.8	11.3	7.7	1.5
286-2	8.8	6.6	4	0.24
287-1	63.7	44.7	43.4	196
287-2	25.3	11.3	10.4	3.2
287-3	19.1	16.3	8.5	3
287-4	11.5	7.8	3.6	0.45
287-7	9.9	4.2	7	0.43
293-1	17.7	14	9.6	2.5
293-2	9.1	5.4	2.1	0.09
295-3	15	6	4.2	0.25
296-1	15.3	6.2	3.5	0.27
299-1	14	9.1	3.9	0.6
299-13	20.5	20.3	5.5	1.67
299-16	9.1	8.9	2.4	0.32
299-19	10.8	9.2	4.4	0.35
299-2	48.7	40	20.3	61.8
299-21	80.6	44.4	40.6	204.4
299-22	62.3	59.3	46.6	193.6
299-3	10.7	9	3	0.24
299-6	14.2	10.1	4.7	0.87

299-8	80.1	61.5	51.5	397.3
299-9	13.8	10.7	11	2.17
300-3	26.7	29.4	22.3	27.92
300-4	12.1	7.6	4.4	0.5
300-5	14.03	6.35	6.35	4.4
300-7	13.4	8.8	8.4	1.37
305-1	24.2	23.9		7.2
305-2	11.8	11.7	3.9	0.41
309-1	21.5	17.2	9.7	3.8
310-1	12.2	15.7	9	3.27
311-1	11.5	8.1	2.5	0.21
312-1	14.1	10.6	4.1	0.61
324-1	16.8	6.1	2.8	0.32
324-2	52.7	28.5	13.1	16.1
330-1	15.4	8	3.9	0.45
330-2	9.1	13	6.6	0.82
330-3	12.2	5.5	2.7	0.18
330-4	16.4	9.3	1.9	0.3
48-2	38.1	33.1	24.4	26.44
52-1	10.9	3.9	3.3	0.16

Appendix 2: Stone Constructions

Date	Type	Topography	Site	Depth m.
4/28/2010	Rock Lane	Rocky terrain	Funnel	22.9
6/17/2010	V-Blind	Rocky terrain	Dragon	32.9
6/15/2011	3-5 Stone Cluster	Esker site	Con_4	34.1
6/15/2011	3-5 Stone Cluster	NA	NA	40.2
7/19/2011	3-5 Stone Cluster	Rocky terrain	Outcrop_2	33.5
7/19/2011	Stone Circle	Rocky terrain	Outcrop_2	33.5
7/20/2011	Rock Lane	Marshy site	Spruce	33.8
8/18/2011	3-5 Stone Cluster	Esker site	South Gap	32.0
8/19/2011	Stone Circle	Esker site	Ash_Gap	32.6
8/19/2011	V-Blind	Esker site	South Gap	29.6
8/20/2011	V-Blind	Rocky terrain	Overlook	35.4
8/20/2011	V-Blind	Rocky terrain	Overlook	35.4
8/20/2011	3-5 Stone Cluster	Marshy site	SC_LOC	34.7
8/20/2011	3-5 Stone Cluster	Marshy site	SC_LOC	35.4
5/17/2012	3-5 Stone Cluster	Esker site	Ash_Gap	31.7
5/17/2012	Rock Line	Esker site	Ash_Gap	31.7
5/17/2012	V-Blind	Esker site	Ash_Gap	31.4
5/17/2012	Rock Line	Lake edge	Wood_6	32.3
5/17/2012	Stone Circle	Lake edge	Wood_6	32.3
5/17/2012	Stone Circle	Lake edge	Wood_6	31.7
5/23/2012	3-5 Stone Cluster	Lake edge	1st WD	41.8
5/23/2012	Stone Circle	Lake edge	1st WD	34.1
5/23/2012	3-5 Stone Cluster	Marshy site	Spruce	34.1
5/23/2012	3-5 Stone Cluster	Marshy site	Spruce	34.1
5/23/2012	3-5 Stone Cluster	Marshy site	Spruce	33.2
5/23/2012	Standing Stone	Marshy site	Spruce	32.9
5/23/2012	Standing Stone	Marshy site	Spruce	33.2
6/27/2012	Rectangular Enclosure	Esker site	Ash_Gap	31.1
6/27/2012	V-Blind	Esker site	Ash_Gap	31.1
6/27/2012	V-Blind	Esker site	Ash_Gap	31.1
6/28/2012	3-5 Stone Cluster	Marshy site	Spruce	34.1
6/28/2012	3-5 Stone Cluster	Marshy site	Spruce	33.5
6/28/2012	Rock Line	Marshy site	Spruce	33.5
6/29/2012	3-5 Stone Cluster	Lake edge	River_1	33.2
6/29/2012	Rock Lane	Lake edge	River_1	33.2

6/30/2012	3-5 Stone Cluster	Marshy site	Big Rock	29.6
6/30/2012	Rock Line	Marshy site	Big Rock	29.6
8/13/2012	3-5 Stone Cluster	Lake edge	Overlook A1	29.0
8/13/2012	Rock Line	Lake edge	Overlook A1	30.8
9/28/2012	3-5 Stone Cluster	Esker site	Ash Gap	30.5
9/28/2012	Rock Line	Esker site	Ash Gap	30.5
9/28/2012	3-5 Stone Cluster	Lake edge	Mid-crossing	31.7
9/28/2012	3-5 Stone Cluster	Lake edge	Mid-crossing	32.0
9/28/2012	3-5 Stone Cluster	NA	NA	30.5
5/8/2013	3-5 Stone Cluster	Esker site	South Gap	32.3
5/9/2013	Rectangular Enclosure	Esker site	Coral 1	30.2
5/9/2013	V-Blind	Esker site	Coral 1	30.2
5/9/2013	3-5 Stone Cluster	Lake edge	Top_HT	29.0
5/9/2013	3-5 Stone Cluster	Lake edge	Top_HT	27.7
5/9/2013	Rectangular Enclosure	Lake edge	Top_HT	29.9
5/9/2013	Rock Lane	Lake edge	Top_HT	28.7
5/9/2013	V-Blind	Lake edge	Top_HT	28.7
5/17/2013	V-Blind	Esker site	South Gap	31.7
5/19/2013	3-5 Stone Cluster	Esker site	South Gap	32.0
6/5/2013	Stone Circle	Lake edge	Wood 6	33.5
6/11/2013	3-5 Stone Cluster	Esker site	Ash Gap	32.0
6/11/2013	Rock Line	Esker site	Ash Gap	32.0
6/11/2013	V-Blind	Esker site	Ash Gap	32.0
6/12/2013	3-5 Stone Cluster	Rocky terrain	New Fun	30.8
6/12/2013	Rock Line	Rocky terrain	New Fun	30.8
6/12/2013	V-Blind	Rocky terrain	New Fun	30.8
6/12/2013	V-Blind	Esker site	South Gap	31.1
8/19/2013	3-5 Stone Cluster	Esker site	South Gap	31.7
8/19/2013	V-Blind	Esker site	South Gap	31.7
9/27/2013	3-5 Stone Cluster	NA	NA	31.7
9/27/2013	Stone Circle	Marshy site	SC_LOC	32.0
5/6/2014	3-5 Stone Cluster	NA	NA	38.4
5/6/2014	Rock Line	Marshy site	Rock_LN	38.4
5/6/2014	Rock Line	Marshy site	Rock_LN	38.4
8/3/2014	V-Blind	Esker site	Ash Gap	31.7
8/3/2014	2 Rock Cluster	Marshy site	SC_LOC	31.1
8/3/2014	3-5 Stone Cluster	Marshy site	SC_LOC	32.6
8/10/2014	V-Blind	Lake edge	Wood 6	32.6
8/22/2014	Rock Line	Lake edge	Wood 6	32.0
9/25/2014	Rock Lane	Esker site	Con 4	31.7

9/25/2014	V-Blind	Esker site	Con 4	31.7
9/25/2014	Stone Circle	Marshy site	Con 6	30.5
9/25/2014	3-5 Stone Cluster	NA	NA	35.1
9/25/2014	Rock Line	Marshy site	Con 6	33.2
9/25/2014	Rock Line	NA	NA	36.3
9/27/2014	3-5 Stone Cluster	Marshy site	Con 6	32.0
9/27/2014	3-5 Stone Cluster	Marshy site	Con 6	33.2
9/27/2014	3-5 Stone Cluster	Marshy site	Con 6	32.0
9/27/2014	3-5 Stone Cluster	Marshy site	Con 6	31.7
9/27/2014	Stone Circle	Marshy site	Con 6	31.7
9/27/2014	Stone Circle	Marshy site	Con 6	31.7
9/27/2014	Stone Circle	NA	NA	33.5
9/28/2014	Rectangular Enclosure	Rocky terrain	Con 1	39.0
10/6/2015	Standing Stone	Rocky terrain	Dragon	32.9
5/25/2016	Rectangular Enclosure	NA	NA	28.7
5/25/2016	Rock Line	NA	NA	30.5
5/25/2016	Standing Stone	Rocky terrain	Outcrop 2	30.2
6/2/2016	3-5 Stone Cluster	Marshy site	A2RLIN	32.9
6/2/2016	3-5 Stone Cluster	Marshy site	A2RLIN	32.0
6/2/2016	Rock Line	Marshy site	A2RLIN	32.9
6/13/2016	Rectangular Enclosure	Rocky terrain	Con 1	39.6
6/23/2016	2 Rock Cluster	Marshy site	A2NPNT	32.6
6/23/2016	Rock Line	Marshy site	A2RLIN	34.1
8/1/2016	2 Rock Cluster	Marshy site	A2RLIN	32.6
8/2/2016	3-5 Stone Cluster	Marshy site	A2NPNT	35.4
8/2/2016	Rock Line	Marshy site	A2NPNT	35.4
8/2/2016	Standing Stone	Marshy site	A2NPNT	35.4
10/2/2016	3-5 Stone Cluster	Esker site	Pick 1	30.5
10/2/2016	3-5 Stone Cluster	Esker site	Pick 1	30.5
10/2/2016	Rock Line	Esker site	Pick 1	30.5
10/2/2016	3-5 Stone Cluster	Marshy site	Rock LN	30.5
6/3/2017	Stone Circle	NA	NA	33.5
7/22/2017	V-Blind	Esker site	South Gap	32.6
7/30/2017	3-5 Stone Cluster	Esker site	South Gap	32.6
7/31/2017	Stone Circle	Esker site	Con 4	33.8
7/31/2017	3-5 Stone Cluster	Marshy site	Con 6	35.1
9/10/2017	2 Rock Cluster	Esker site	Drop 45	35.1
9/10/2017	3-5 Stone Cluster	Esker site	Drop 45	35.1
7/15/2018	2 Rock Cluster	Rocky terrain	Con 1	41.1
7/15/2018	3-5 Stone Cluster	Esker site	GapX03	32.0
7/31/2018	3-5 Stone Cluster	Esker site	Drop 45	33.5
7/31/2018	3-5 Stone Cluster	Esker site	Drop 45	36.6
7/31/2018	3-5 Stone Cluster	Esker site	Drop 45	36.6
7/31/2018	3-5 Stone Cluster	Esker site	Drop 45	36.6

7/31/2018	Rock Lane	Esker site	Drop 45	36.6
7/31/2018	Standing Stone	Rocky terrain	Funnel	24.4
8/1/2018	3-5 Stone Cluster	Rocky terrain	Overlook	34.1
8/10/2018	Stone Circle	Lake edge	Top_HT	29.3
8/19/2018	Rock Line	Rocky terrain	Dragon	32.9
8/20/2018	3-5 Stone Cluster	Esker site	Ash_Gap	32.9
8/20/2018	3-5 Stone Cluster	Esker site	Ash_Gap	32.9
8/20/2018	Rock Line	Esker site	Ash_Gap	32.9
8/20/2018	V-Blind	Esker site	Ash_Gap	32.9
9/14/2018	3-5 Stone Cluster	Lake edge	Gap Con0	32.0
9/14/2018	Rock Lane	Lake edge	Gap Con0	32.6
9/15/2018	3-5 Stone Cluster	NA	NA	33.5
7/9/2019	V-Blind	Rocky terrain	GapX02	32.0
7/9/2019	V-Blind	Rocky terrain	GapX02	32.0
7/9/2019	V-Blind	Esker site	GapX03	32.0
7/9/2019	3-5 Stone Cluster	NA	NA	37.2
7/17/2019	3-5 Stone Cluster	Rocky terrain	GapX02	32.3
7/17/2019	2 Rock Cluster	Esker site	South Gap	32.0
8/31/2019	3-5 Stone Cluster	Rocky terrain	Dragon	33.5
8/31/2019	Stacked Stones	Rocky terrain	Dragon	32.0
8/31/2019	Rock Line	Rocky terrain	Funnel	24.4
8/31/2019	V-Blind	NA	NA	19.8
9/16/2019	3-5 Stone Cluster	Rocky terrain	GapX01	34.1
8/1/2020	2 Rock Cluster	NA	NA	42.7
8/1/2020	3-5 Stone Cluster	NA	NA	39.9
8/1/2020	3-5 Stone Cluster	NA	NA	42.7
8/1/2020	3-5 Stone Cluster	NA	NA	51.8
8/1/2020	Rock Line	NA	NA	56.7
8/1/2020	Stone Circle	NA	NA	56.7
8/13/2020	Rock Line	Esker site	Coral 1	29.0
8/13/2020	3-5 Stone Cluster	Esker site	Gap ND	31.7
8/13/2020	3-5 Stone Cluster	Esker site	Gap ND	31.7
8/13/2020	3-5 Stone Cluster	Esker site	Gap ND	31.7
8/13/2020	3-5 Stone Cluster	Esker site	Gap ND	31.7
8/13/2020	2 Rock Cluster	Esker site	South Gap	31.7
8/13/2020	3-5 Stone Cluster	Esker site	South Gap	31.7
8/13/2020	3-5 Stone Cluster	Esker site	South Gap	31.4
8/13/2020	Rock Lane	Esker site	South Gap	31.7
6/30/2021	2 Rock Cluster	Lake edge	N Choke	38.7
6/30/2021	2 Rock Cluster	Lake edge	N Choke	38.4
6/30/2021	3-5 Stone Cluster	Lake edge	N Choke	38.7
7/16/2021	3-5 Stone Cluster	Marshy site	Swampy	32.6
7/17/2021	2 Rock Cluster	Rocky terrain	SM_Gap	31.1
7/17/2021	2 Rock Cluster	Rocky terrain	SM_Gap	31.1

7/17/2021	V-Blind	Rocky terrain	SM Gap	30.8
7/17/2021	V-Blind	Rocky terrain	SM Gap	31.1
7/17/2021	3-5 Stone Cluster	Marshy site	Swampy	31.7
7/26/2021	3-5 Stone Cluster	Rocky terrain	SM Gap	30.5
7/26/2021	2 Rock Cluster	Esker site	South Gap	32.0
8/4/2021	3-5 Stone Cluster	Rocky terrain	NARLINE	25.0
8/4/2021	3-5 Stone Cluster	Rocky terrain	NARLINE	24.4
8/4/2021	3-5 Stone Cluster	Rocky terrain	NARLINE	25.6
8/4/2021	Rock Line	Rocky terrain	NARLINE	24.4
8/19/2021	2 Rock Cluster	Rocky terrain	Dragon	31.4
8/19/2021	3-5 Stone Cluster	Rocky terrain	Dragon	31.1
8/19/2021	3-5 Stone Cluster	Rocky terrain	Dragon	30.8
7/8/2022	3-5 Stone Cluster	NA	NA	32.0
7/9/2022	Rock Line	Lake edge site	Twins	31.4
7/9/2022	V-Blind	Lake edge site	Twins	31.4
8/5/2022	3-5 Stone Cluster	Rocky terrain	Funnel	23.8
8/5/2022	3-5 Stone Cluster	Rocky terrain	Funnel	25.0
8/5/2022	3-5 Stone Cluster	Lake edge	Mid-crossing	32.3
8/5/2022	3-5 Stone Cluster	Lake edge	Mid-crossing	32.0
8/13/2022	3-5 Stone Cluster	Esker site	South Gap	31.1
8/18/2022	3-5 Stone Cluster	Esker site	Gap ND	31.4
8/18/2022	3-5 Stone Cluster	Esker site	Gap ND	30.5
8/19/2022	3-5 Stone Cluster	Marshy site	A4BOX2	26.5
8/19/2022	Rock Line	Marshy site	A4BOX2	26.5
8/19/2022	Stone Circle	Marshy site	A4BOX2	26.5

Appendix 3: Sediment Samples

I.D.	Date	Site	Collection Method	Vol. (l)	Depth m.
AJ-1	6/13/2011	Funnel	Scuba Bulk	4.5	25.6
AA-1	6/14/2011	Dragon	Scuba Bulk	4.5	31.7
AF-1	6/14/2011	Dragon	Scuba Bulk	4.5	31.7
AM-1	6/14/2011	Dragon	Scuba Bulk	4.5	31.7
AR-1	6/14/2011	Dragon	Scuba Bulk	4.5	31.7
AL-1	6/14/2011	Funnel	Bulk Grab	4.5	25.6
AL-1-1	6/14/2011	Funnel	Scuba Bulk	4.5	24.7
AT-1	6/14/2011	Funnel	Scuba Bulk	4.5	24.7
BM-1	6/14/2011	Funnel	Scuba Bulk	4.5	24.7
BY-1a	6/14/2011	Funnel	Scuba Bulk	4.5	24.7
Falls 1	6/15/2011	N/A	Ponar	2	28.3
Inland Lake 1	6/15/2011	N/A	Ponar	2	36.6
Russ Dive 1	6/16/2011	Funnel	Bulk Grab	4.5	29.0
Russ Dive 3	6/16/2011	Funnel	Bulk Grab	4.5	29.0
Till Area 1 and 2	6/16/2011	N/A	Ponar	2	40.2
Vial 1	7/20/2011	Lakeshore NW	Scuba Vial	0.2	29.0
Vial 2	7/20/2011	Lakeshore NW	Scuba Vial	0.2	33.2
BB-1	8/18/2011	South Gap	Scuba Bulk	4.5	32.0
BF-1	8/18/2011	South Gap	Scuba Bulk	4.5	32.0
BW-1	8/18/2011	South Gap	Scuba Bulk	4.5	32.0
CH-1	8/19/2011	South Gap	Scuba Bulk	4.5	32.6
CN-1	8/20/2011	SC LOC	Scuba Bulk	4.5	34.7
52312	5/23/2012	Spruce	Ponar	2	35.1
CC-1	6/27/2012	Ash Gap	Scuba Bulk	4.5	32.3
CF-1	6/27/2012	Ash Gap	Scuba Bulk	4.5	32.3
CI-1	6/27/2012	Ash Gap	Scuba Bulk	4.5	32.3
CQ-1	6/27/2012	Ash Gap	Scuba Bulk	4.5	32.3
62712A	6/28/2012	Spruce	Scuba Bulk	4.5	35.1
62812B	6/28/2012	Spruce	Scuba Bulk	4.5	35.1
62812E	6/28/2012	Spruce	Scuba Bulk	4.5	35.1
BP-1b	6/28/2012	Spruce	Scuba Bulk	4.5	35.1
BY-1b	6/28/2012	Spruce	Scuba Bulk	4.5	35.1
CO-1	6/28/2012	Spruce	Scuba Bulk	4.5	35.1

62812A	6/28/2012	Spruce	Vial	0.2	35.1
62812F	6/29/2012	River 1	Scuba Bulk	4.5	34.7
62812G	6/29/2012	River 1	Scuba Bulk	4.5	34.7
62912B	6/29/2012	River 1	Scuba Bulk	4.5	35.1
AAR-1	6/29/2012	River 1	Scuba Vial	0.2	34.7
62812C	6/29/2012	Spruce	Scuba Bulk	4.5	35.1
62812D	6/29/2012	Spruce	Scuba Bulk	4.5	35.1
62912A	6/29/2012	Spruce	Scuba Bulk	4.5	35.1
CM-1	7/15/2012	Spruce	Scuba Bulk	4.5	35.1
7-22-12-3	7/22/2012	South Gap	Scuba Bulk	4.5	32.0
7-22-12-4 bag 1	7/22/2012	South Gap	Scuba Bulk	4.5	32.0
6-28-12E2	7/22/2012	N/A	Scuba Bulk	4.5	35.1
7-15-12-1	7/22/2012	N/A	Scuba Bulk	4.5	35.1
7-22-12-1	7/22/2012	N/A	Scuba Bulk	4.5	35.1
7-22-12-2	7/22/2012	N/A	Scuba Bulk	4.5	35.1
8/14/12 B	8/14/2012	Overlook A1	Scuba Bulk	4.5	34.1
8/14/12A	8/14/2012	Overlook A1	Vial	0.2	34.1
7/15/12-2	8/14/2012	N/A	Scuba Bulk	4.5	34.1
8/14/12 C	8/15/2012	Ash Gap	Scuba Bulk	4.5	31.7
8/15/12 A	8/15/2012	Ash Gap	Scuba Bulk	4.5	31.7
8/15/12 B	8/15/2012	Ash Gap	Scuba Bulk	4.5	31.7
8/15/12F	8/15/2012	Ash Gap	Scuba Bulk	4.5	31.7
9/29/12 D	9/29/2012	High Ground	Scuba Bulk	4.5	33.8
9/29/12 F	9/29/2012	High Ground	Scuba Bulk	4.5	33.8
BR-1	5/17/2013	South Gap	Scuba Bulk	4.5	31.4
DA-1	5/17/2013	South Gap	Scuba Bulk	4.5	31.7
DC-1	5/17/2013	South Gap	Scuba Bulk	4.5	31.4
DB-1	5/18/2013	Top HT	Scuba Bulk	4.5	28.3
DE-1	5/18/2013	Top HT	Scuba Bulk	4.5	28.7
DH-1	5/18/2013	Top HT	Scuba Bulk	4.5	29.0
DI-1	5/19/2013	South Gap	Scuba Bulk	4.5	31.4
DL-1	5/19/2013	South Gap	Scuba Bulk	4.5	31.4
DO-1	5/19/2013	South Gap	Scuba Bulk	4.5	31.4
DS-1	6/6/2013	Wood 6	Scuba Bulk	4.5	33.5
DT-1	6/6/2013	Wood 6	Scuba Bulk	4.5	33.5
DU-1	6/6/2013	Wood 6	Scuba Bulk	4.5	33.5
BV-1	6/11/2013	Ash Gap	Scuba Bulk	4.5	31.7
DV-1	6/11/2013	Ash Gap	Scuba Bulk	4.5	31.7
DX-1	6/12/2013	South Gap	Scuba Bulk	4.5	31.4
DQ-1	6/12/2013	N/A	Scuba Bulk	4.5	32.3
EA-1	8/17/2013	Drop 45	Scuba Bulk	4.5	36.6
EA-1-1	8/17/2013	Drop 45	Scuba Bulk	4.5	36.6
EC-1	8/17/2013	Drop 45	Scuba Bulk	4.5	36.6

EF-1	8/17/2013	N/A	Scuba Bulk	4.5	36.6
EB-1	8/18/2013	High Ground	Scuba Bulk	4.5	33.5
ED-1	8/18/2013	High Ground	Scuba Bulk	4.5	33.5
EI-1	8/18/2013	High Ground	Scuba Bulk	4.5	33.5
EK-1	8/18/2013	High Ground	Scuba Bulk	4.5	33.5
EL-1	8/18/2013	High Ground	Scuba Bulk	4.5	33.5
EN-1	8/18/2013	High Ground	Scuba Bulk	4.5	33.5
DR-1	8/19/2013	GapX01	Scuba Bulk	4.5	31.7
DR-1-1	8/19/2013	South Gap	Screen Sample	4.5	32.3
DR-1-2	8/19/2013	South Gap	Screen Sample	4.5	32.3
EE-1	8/19/2013	South Gap	Scuba Bulk	4.5	31.7
EQ-1	8/19/2013	South Gap	Scuba Bulk	4.5	31.7
DK1-1	9/25/2013	Drop 45	Scuba Screen	4.5	35.4
DK1-2	9/25/2013	Drop 45	Scuba Screen	4.5	35.4
DP-1-1	9/25/2013	Drop 45	Scuba Screen	4.5	36.6
DP-1-2	9/25/2013	Drop 45	Scuba Screen	4.5	36.6
EG-1-1	9/25/2013	Drop 45	Scuba Screen	4.5	36.6
EG1-2	9/25/2013	Drop 45	Scuba Bulk	4.5	36.6
EZ-1	9/25/2013	Drop 45	Scuba Bulk	4.5	36.6
FA-1-1	9/25/2013	Drop 45	Scuba Screen	4.5	35.4
FA-1-2	9/25/2013	Drop 45	Scuba Screen	4.5	35.4
FB-1-1	9/25/2013	Drop 45	Scuba Screen	4.5	36.6
DP-1	9/25/2013	Drop 45	Scuba Vial	0.2	36.6
EJ-1	9/26/2013	Drop 45	Scuba Bulk	4.5	36.6
EM1-1	9/26/2013	Drop 45	Scuba Bulk	4.5	36.0
EM1-2	9/26/2013	Drop 45	Scuba Bulk	4.5	36.0
EO-1-2	9/26/2013	Drop 45	Scuba Screen	4.5	36.0
FD-1-1	9/26/2013	Drop 45	Scuba Screen	4.5	36.0
FD1-2	9/26/2013	Drop 45	Scuba Screen	4.5	36.0
FE1-1	9/26/2013	Drop 45	Scuba Bulk	4.5	36.0
FE1-2	9/26/2013	Drop 45	Scuba Bulk	4.5	36.0
EO-1	9/26/2013	Drop 45	Scuba Vial	0.2	36.0
FE-1	9/26/2013	Drop 45	Scuba Vial	0.2	36.0
Ponar	9/26/2013	N/A	Ponar	2	44.2
EH-1	9/27/2013	Drop 45	Screen Sample	4.5	35.4
FG-1	9/27/2013	Drop 45	Scuba Bulk	4.5	35.4
FH-1	9/27/2013	Drop 45	Scuba Bulk	4.5	35.4
FI-1	9/27/2013	Drop 45	Scuba Bulk	4.5	35.4
FB-1	9/27/2013	Drop 45	Scuba Vial	0.2	35.4
PON-050614-1	5/6/2014	Rock Ln	Ponar	2	35.4
PON-050614-2	5/6/2014	Rock Ln	Ponar	2	35.4

PON-050614-3	5/6/2014	N/A	Ponar	2	35.1
JV-1	5/17/2014	Drop 45	Scuba Vial	0.2	35.4
KE-1	5/17/2014	Drop 45	Scuba Vial	0.2	35.4
KH-1	5/17/2014	Drop 45	Scuba Vial	0.2	35.4
JY-1	5/18/2014	Drop 45	Scuba Vial and Screen	4.5	35.4
JD-1	5/28/2014	N/A	Scuba Screen	4.5	36.3
JP-1	5/28/2014	N/A	Scuba Vial	0.2	36.3
JS-1	5/28/2014	N/A	Scuba Vial	0.2	38.4
Lift 1 D45	5/29/2014	Drop 45	Scuba Airlift	4.5	36.0
Bay	5/29/2014	N/A	Scuba Vial	0.2	5.5
PON-053014-1	5/30/2014	N/A	Ponar	2	39.9
PON-053014-2	5/30/2014	N/A	Ponar	2	39.6
PON-053014-3	5/30/2014	N/A	Ponar	2	37.8
Unit 1	5/31/2014	Drop 45	Scuba Airlift	4.5	36.3
Unit 2	5/31/2014	Drop 45	Scuba Airlift	4.5	36.3
Unit 3 Vial 1	8/1/2014	Drop 45	In Situ Vial, for Airlift	18.93	36.6
Unit 3	8/1/2014	Drop 45	Scuba Airlift	6.25	36.6
Unit 3 Vial 2	8/1/2014	Drop 45	Bucket Vial, for Airlift	6.25	36.6
Unit 4	8/2/2014	Drop 45	Scuba Airlift	1	36.6
Ash1A Unit 2	8/3/2014	Ash Gap	Scuba Airlift	3.79	32.3
Ash1A Unit 1	8/3/2014	Ash Gap	Scuba Vial	0.2	32.3
SC_LOK Unit 1	8/3/2014	N/A	Scuba Airlift	5.68	32.3
HG_RNG Unit 1	8/9/2014	High Ground	Scuba Airlift	18.93	36.6
HIGRND Unit 1	8/9/2014	High Ground	Scuba Airlift	18.93	32.3
HIGRND Unit 2	8/9/2014	High Ground	Scuba Airlift	18.93	32.3
Unit 5	8/10/2014	Drop 45	Scuba Airlift	4.73	36.6
Unit 6	8/10/2014	Drop 45	Scuba Airlift	4.5	36.6
Unit 6 Vial 2	8/10/2014	Drop 45	Bucket Vial, Scuba Airlift	4.5	36.6
Unit 7	8/21/2014	Drop 45	Scuba Airlift	18.93	36.6
Unit 8	8/21/2014	Drop 45	Scuba Airlift	18.93	36.6
JA-1	8/21/2014	Drop 45	Scuba Airlift	4.5	33.5
Wood 6 Unit 1	8/22/2014	Wood 6	Scuba Airlift	4.5	33.5

Wood 6 Unit 2	8/22/2014	Wood 6	Scuba Airlift	4.5	33.5
CON4 Ponar	9/25/2014	Con 4	Ponar	2	33.5
JG-1-1	9/26/2014	Con 6	Scuba Screen	4.5	32.6
JJ-1-1	9/26/2014	Con 6	Scuba Screen	4.5	33.5
JM-1-1	9/26/2014	Con 6	Scuba Screen	4.5	32.6
JQ-1-1	9/26/2014	Con 6	Scuba Screen	4.5	33.5
JZ-1-1	9/26/2014	Con 6	Scuba Screen	4.5	32.6
KB-1-1	9/26/2014	Con 6	Scuba Screen	4.5	33.5
JG-1	9/26/2014	Con 6	Scuba Vial	0.2	32.6
JJ-1	9/26/2014	Con 6	Scuba Vial	0.2	33.5
JQ-1	9/26/2014	Con 6	Scuba Vial	0.2	33.5
KB-1	9/26/2014	Con 6	Scuba Vial	0.2	33.5
CON1 Unit 2	9/28/2014	Con 1	Bucket/Scoop	4.5	39.6
CON1 Unit 1	9/28/2014	Con 1	Scuba Airlift	4.5	39.6
JE-1	9/28/2014	Con 1	Scuba Vial	0.2	39.6
KI-1	9/28/2014	Con 1	Scuba Vial	0.2	39.6
J3	8/9/2015	Dragon	Scuba Bulk	4.5	33.2
J4	8/9/2015	Dragon	Scuba Bulk	4.5	33.2
J1	8/9/2015	Dragon	Scuba Vial	0.2	33.2
J2	8/9/2015	Dragon	Scuba Vial	0.2	33.2
T3	6/14/2016	High Ground	Scuba Vial	4.5	33.8
JB-1	6/14/2016	High Ground	Scuba Vial	0.2	33.8
M2	6/14/2016	High Ground	Scuba Vial	0.2	34.1
T2	6/14/2016	High Ground	Scuba Vial	0.2	33.8
Wood 11 M3	6/14/2016	N/A	Scuba Vial	0.2	30.5
Wood 11 TDS	6/14/2016	N/A	Scuba Vial	0.2	30.5
JX-1	6/23/2016	A2RLIN	Scuba bag & Vial	4.5	32.6
AB-1	6/23/2016	A2RLIN	Scuba Vial	0.2	32.6
AQ-1	6/23/2016	A2RLIN	Scuba Vial	0.2	32.6
DM-1	6/23/2016	A2RLIN	Scuba Vial	0.2	32.6
DW-1	6/23/2016	A2RLIN	Scuba Vial	0.2	32.6
FC-1	6/23/2016	A2RLIN	Scuba Vial	0.2	33.5
JH-1	6/23/2016	A2RLIN	Scuba Vial	0.2	34.1
KG-1	6/23/2016	A2RLIN	Scuba Vial	0.2	32.6
KA-1	8/29/2016	A2RLIN	Scuba Bulk	12.5	34.1
JH-1-3	8/29/2016	A2RLIN	Scuba Airlift	9.5	34.1
JH-1-2	8/29/2016	A2RLIN	Scuba Airlift	1.5	34.1
JXA-1	8/29/2016	A2RLIN	Scuba Vial	0.2	34.1
FX-1	7/21/2017	Ash Gap	Scuab Vial	4.5	33.5
JC-1	7/21/2017	Ash Gap	Scuba Bulk	4	33.5
FJ-1	7/21/2017	Ash Gap	Scuba Vial	0.2	33.5

AG-1	7/31/2017	Con 4	Scuba Bulk	20	34.7
AZ-1	7/31/2017	Con 4	Scuba Vial	0.2	34.7
EX-1	7/31/2017	Con 4	Scuba Vial	0.2	34.7
AH-1	7/31/2017	Con 6	Scuba Vial	0.2	35.1
Unit 9	8/1/2017	Drop 45	Scuba Airlift	4.2	36.9
Unit 10	8/8/2017	Drop 45	Scuba Airlift	4.5	36.9
Unit 11	8/9/2017	Drop 45	Scuba Airlift	1	36.9
Unit 11B	8/10/2017	Drop 45	Scuba Airlift	18	36.9
Unit 11C	8/10/2017	Drop 45	Scuba Airlift	3	36.9
Unit 14	8/14/2017	Drop 45	Bulk Bucket	40	36.9
Unit 12B	8/14/2017	Drop 45	Bulk Bucket	20	36.9
Unit 12A	8/14/2017	Drop 45	Bulk Bucket	6.5	36.9
Unit 15	8/15/2017	Drop 45	Bulk Bucket + Vial	40.5	36.9
Unit 16	8/15/2017	Drop 45	Bulk Bucket	7	36.9
Unit 17	9/9/2017	Drop 45	Bulk Bucket	44	36.9
Unit 18	9/10/2017	Drop 45	Bulk Bag + Vial	5	36.9
none	7/31/2018	Drop 45	Scuba Vial	0.2	36.3
none	7/31/2018	Drop 45	Scuba Vial	0.2	36.3
none	7/31/2018	Drop 45	Scuba Vial	0.2	36.3
Unit 19	8/1/2018	Drop 45	Bulk Bucket	6.5	36.9
AY-1	8/1/2018	Drop 45	Bulk Bucket and Vial	1.89	37.8
Unit 20	8/8/2018	Drop 45	Bulk Bucket	7.57	36.9
Unit 21	8/8/2018	Drop 45	Scuba Bulk	4.5	36.9
BJ-1	8/10/2018	Top HT	Bulk Bucket and Vial	20	29.6
BM-1	8/10/2018	Top HT	Scuba Vial	0.2	29.6
Dragon Unit 1	8/19/2018	Dragon	Bulk Bucket	20	33.5
Dragon Unit 2	8/19/2018	Dragon	Bulk Bucket	10	33.5
Geo Sample	8/19/2018	Dragon	Vial	0.2	33.5
CK-1	8/20/2018	Ash Gap	Bulk Bucket	10	33.2
CK-1-A	9/14/2018	Ash Gap	Bulk Bucket	4.5	33.2
CK-1-B	9/14/2018	Ash Gap	Bulk Bucket	4.5	33.2
CR-1	9/15/2018	Gap Con 0	Bulk Bucket	4.5	32.3
GPCON0 Feature 1	9/15/2018	Gap Con 0	John sample hearth feature	4.5	32.3
GAPX 001	7/17/2019	GapX02	Bulk Bucket	4.5	32.3
GAPX 002	7/17/2019	GapX02	Bulk Bucket	4.5	32.3
BE-1	7/17/2019	GapX02	Vial	0.2	32.3
A3DA_1 Bulk	7/17/2019	South Gap	Bulk Bucket	20	31.1
ES-1 Dive 1	9/16/2019	GapX01	Bulk Bucket + Vial	4.5	34.1

ES-1 Dive 2	9/16/2019	GapX01	Bulk Bucket	4.5	34.1
AD-1T	8/23/2020	South Gap	Bulk Bucket + Vial	9	31.1
AD-1J	8/23/2020	South Gap	Bulk Bucket + Vial	8	31.1
BK-1	9/19/2020	South Gap	Bulk Bucket	8	32.3
BN-1	9/19/2020	South Gap	Bulk Bucket	7	32.3
BZ-1	10/3/2020	N/A	bulk small bag	2	49.1
ER-1	10/3/2020	N/A	bulk small bag	2	50.3
AO-1	7/17/2021	N/A	Vial	0.2	31.7
BO-1	7/27/2021	South Gap	Bulk Bucket and mesh bag	20	31.7
BO-1-2	7/28/2021	South Gap	Bulk Bucket	20	31.1
CS	7/28/2021	South Gap	Bulk Mesh+Vial	1	31.4
F-2	8/19/2021	Dragon	Bulk, wood	20	32.6
F-3	8/19/2021	N/A	Bulk bucket, wood, vial	20	26.8
F-4	8/20/2021	South Gap	Bulk bucket + vial	20	32.9
F-5	8/20/2021	South Gap	Bulk bucket + vial	20	32.9
EP-1	8/10/2022	South Gap	Vial	1	32.9
SHAW-22-1	8/10/2022	South Gap	Scuba Bulk	1	32.9
ET-1	8/13/2022	South Gap	Scuba Bulk + vial	1	30.8
EW-1	8/13/2022	South Gap	Scuba Bulk	1	30.8
OSHEA-22-1	8/13/2022	South Gap	Scuba Bulk	1	31.4
OSHEA-22-2	8/13/2022	South Gap	Scuba Bulk	1	31.4
DY-1	8/13/2022	South Gap	Vial	0.2	31.4
HB-1	8/18/2022	Gap ND	Bulk scooped ziplock gallon bag	1	30.8
FH-1	8/18/2022	Gap ND	Bulk scooped ziplock gallon bag	0.75	31.1
HF-1	8/18/2022	Gap ND	Bulk scooped ziplock gallon bag	0.75	30.8
FW-1	8/18/2022	Gap ND	Vial	0.2	31.1

Bibliography

A

- Ambrose, S. H. (2002). Small things remembered: origins of early microlithic industries in sub-Saharan Africa. *Archeological Papers of the American Anthropological Association*, 12(1), 9-29.
- Ambrose, S. H. (2006). Howiesons Poort lithic raw material procurement patterns and the evolution of modern human behavior: a response to Minichillo (2006). *Journal of human evolution*, 50(3), 365-369.
- Ambrose, S. H., & Lorenz, K. G. (1990). Social and ecological models for the Middle Stone Age in southern Africa. *The emergence of modern humans: An archaeological perspective*, 3-33.
- Anderson, D. D. (1970). Microblade traditions in northwestern Alaska. *Arctic Anthropology*, 7(2), 2-16.
- Anderson, D. D. (2005). The Denbigh Flint Complex in Northwest Alaska: A Spatial Analysis. *Alaska Journal of Anthropology*, 3(2), 81-8.
- Anderson, D. G. (2013). Paleoindian and archaic periods in North America. *The Cambridge World Prehistory*, Paul Bahn and Colin Renfrew, eds, 913-932.
- Anderson, D. T., Smallwood, A. M., Goodyear, A. C., & Walters, S. E. (2016). The Paleoindian and Early Archaic Hilltop Occupations at the Topper Site. *Tennessee Archaeology*, 8, 102-113.
- Anderson, D. G., & Smith, S. D. (2003). *Archaeology, History, and Predictive Modeling: Research at Fort Polk, 1972-2002*. University of Alabama Press.
- Andreev, A. A., Tarasov, P. E., Klimanov, V. A., Melles, M., Lisitsyna, O. M., & Hubberten, H. W. (2004). Vegetation and climate changes around the Lama Lake, Taymyr Peninsula, Russia during the late Pleistocene and Holocene. *Quaternary International*, 122(1), 69-84.
- Anghelinu, M., Händel, M., Niță, L., Cordoș, C., Veres, D., Hambach, U., ... & Georgescu, V. (2021). From Gravettian to Epigravettian in the Eastern Carpathians: Insights from the Bistricioara-Lutărie III archaeological site. *Quaternary International*, 587, 210-229.

Apicella, C. L., Marlowe, F. W., Fowler, J. H., & Christakis, N. A. (2012). Social networks and cooperation in hunter-gatherers. *Nature*, 481(7382), 497-501.

Arkush, B. S. (2014). Communal Pronghorn Hunting in the Great Basin: What Have We Learned Over the Last Twenty-Five Years?. *Pacific Coast Archaeological Society Quarterly*, 29, 1-19.

Arnold, T. G. (1985). *A comparison of Plano complexes*. The University of Calgary

B

Bae, K. (2010). Origin and patterns of the Upper Paleolithic industries in the Korean Peninsula and movement of modern humans in East Asia. *Quaternary International*, 211(1-2), 103-112.

Baichtal, J. F., Lesnek, A. J., Carlson, R. J., Schmuck, N. S., Smith, J. L., Landwehr, D. J., & Briner, J. P. (2021). Late Pleistocene and early Holocene sea-level history and glacial retreat interpreted from shell-bearing marine deposits of southeastern Alaska, USA. *Geosphere*, 17(6), 1590-1615.

Bailey, S. E., Weaver, T. D., & Hublin, J. J. (2009). Who made the Aurignacian and other early Upper Paleolithic industries?. *Journal of human evolution*, 57(1), 11-26.

Bailey, G. N., & Flemming, N. C. (2008). Archaeology of the continental shelf: marine resources, submerged landscapes and underwater archaeology. *Quaternary Science Reviews*, 27(23-24), 2153-2165.

Bamforth, D. B. (1986). Technological efficiency and tool curation. *American antiquity*, 51(1), 38-50.

Bamforth, D. B. (1991). *Technological Organization and Hunter-Gatherer Land Use: A California Example*. *American Antiquity*, 56(2), 216-234.

Banks, W. E., d'Errico, F., & Zilhão, J. (2013a). Human-climate interaction during the Early Upper Paleolithic: testing the hypothesis of an adaptive shift between the Proto-Aurignacian and the Early Aurignacian. *Journal of Human Evolution*, 64(1), 39-55.

Banks, W. E., d'Errico, F., & Zilhão, J. (2013b). Revisiting the chronology of the Proto-Aurignacian and the Early Aurignacian in Europe: A reply to Higham et al.'s comments on. *Journal of Human Evolution*, 65(6), 810-817.

Barshay-Szmidt, C., Normand, C., Flas, D., & Soulier, M. C. (2018). Radiocarbon dating the Aurignacian sequence at Isturitz (France): Implications for the timing and development of the Protoaurignacian and Early Aurignacian in western Europe. *Journal of Archaeological Science: Reports*, 17, 809-838.

- Beaudoin, A. B., Wright, M., & Ronaghan, B. (1996). Late quaternary landscape history and archaeology in the 'ice-free corridor': Some recent results from Alberta. *Quaternary International*, 32, 113-126.
- Belardi, J. B., Marina, F. C., Madrid, P., Barrientos, G., & Campan, P. (2017). Late Holocene guanaco hunting grounds in southern Patagonia: blinds, tactics and differential landscape use. *antiquity*, 91(357), 718-731.
- Belmiro, J., Bicho, N., Haws, J., & Cascalheira, J. (2021). The Gravettian-Solutrean transition in westernmost Iberia: New data from the sites of Vale Boi and Lapa do Picareiro. *Quaternary international*, 587, 19-40.
- Benazzi, S., Slon, V., Talamo, S., Negrino, F., Peresani, M., Bailey, S. E., ... & Hublin, J. J. (2015). The makers of the Protoaurignacian and implications for Neandertal extinction. *Science*, 348(6236), 793-796.
- Benedict, J. B. (2005). Tundra game drives: an arctic-alpine comparison. *Arctic, Antarctic, and Alpine Research*, 37(4), 425-434.
- Benjamin, J. (2010). Submerged prehistoric landscapes and underwater site discovery: Reevaluating the 'Danish Model' for international practice. *Journal of Island & Coastal Archaeology*, 5(2), 253-270.
- Benjamin, J., & Bailey, G. (2017). Coastal adaptations and submerged landscapes: Where world prehistory meets underwater archaeology. *From hunter-gatherers to farmers: Human adaptation at the end of the Pleistocene and the first part of the Holocene*, 169-83.
- Bernabo, J. C., & Webb III, T. (1977). Changing patterns in the Holocene pollen record of northeastern North America: a mapped summary. *Quaternary Research*, 8(1), 64-96.
- Bielawski, E. (1988). Paleoeskimo variability: The early arctic small-tool tradition in the central Canadian Arctic. *American Antiquity*, 53(1), 52-74.
- Binford, L. R. (1980). Willow smoke and dogs' tails: hunter-gatherer settlement systems and archaeological site formation. *American antiquity*, 45(1), 4-20.
- Binford, L. R. (1984). Butchering, sharing, and the archaeological record. *Journal of Anthropological Archaeology*, 3(3), 235-257.
- Bischoff, J. L., Soler, N., Maroto, J., & Julia, R. (1989). Abrupt Mousterian/Aurignacian boundary at c. 40 ka bp: accelerator 14C dates from L'Arbreda Cave (Catalunya, Spain). *Journal of archaeological Science*, 16(6), 563-576.
- Boldreel, L. O., Grøn, O., Tayong, R. B., Madsen, B., Bennike, O., & Andersen, M. S. (2025). A Submerged and Buried Mesolithic Site off Svanemøllen Harbor, Copenhagen, Denmark: Acoustic Detection (Human-Altered Lithic Detection) and Verification by Means of Coring. *Remote Sensing*, 17(3), 413.

- Bolian, Charles E (1980) The Early and Middle Archaic of the Lakes Region, New Hampshire. *Early and Middle Archaic Cultures in the Northeast*:115-134.
- Bousman, C. B. (2005). Coping with risk: Later Stone Age technological strategies in southern Africa. *Journal of Anthropological Archaeology*, 24(3), 285–303.
- Bowyer, V. (2011). Caribou hunting at ice patches: Seasonal mobility and long-term land-use in the southwest Yukon. University of Alberta
- Bousman, C Britt, Barry W Baker and Anne C Kerr (2004) Paleoindian archeology in Texas. *The Prehistory of Texas*:15-97.
- Bousman, C. B., Collins, M. B., Goldberg, P., Stafford, T., Guy, J., Baker, B. W., ... & Powell, J. F. (2002). The Palaeoindian–Archaic Transition in North America: New Evidence from Texas. *Antiquity*, 76(294), 980-990.
- Bradley, B. A., Collins, M. B., Hemmings, A., Shoberg, M., & Lohse, J. C. (2010). Clovis technology. *International Monographs in Prehistory*. ISBN: 978-1879621411
- Braje, T. J., & Erlandson, J. M. (2013). Human acceleration of animal and plant extinctions: A Late Pleistocene, Holocene, and Anthropocene continuum. *Anthropocene*, 4, 14-23.
- Briner, J. P., Porter, S. C., Chronologies, E. N., Range, C., Mountains, U. R., Nevada, S., & Andes, S. (2018). Neoglaciation in the American Cordilleras. *Encyclopedia of Quaternary Science, Elsevier*, 1133-1142.
- Brink, J. W. (2005). Inukshuk: caribou drive lanes on southern Victoria Island, Nunavut, Canada. *Arctic Anthropology*, 42(1), 1-28.
- Brisset, E., Burjachs, F., Navarro, B. J. B., & de Pablo, J. F. L. (2018). Socio-ecological adaptation to Early-Holocene sea-level rise in the western Mediterranean. *Global and Planetary Change*, 169, 156-167.
- Briz i Godino, I., Ahedo, V., Álvarez, M., Pal, N., Turnes, L., Santos, J. I., ... & Galán, J. M. (2018). Hunter–gatherer mobility and technological landscapes in southernmost South America: a statistical learning approach. *Royal Society Open Science*, 5(10), 180906.
- Broecker, W. S., Denton, G. H., Edwards, R. L., Cheng, H., Alley, R. B., & Putnam, A. E. (2010). Putting the Younger Dryas cold event into context. *Quaternary Science Reviews*, 29(9-10), 1078-1081.
- Broyles, B. J. (1971). *Second Preliminary Report: The St. Albans Site, Kanawha County, West Virginia, 1964-1968* (No. 3). West Virginia Geological and Economic Survey.
- Brun-Ricalens, F. L. (2006). Les pièces esquillées: état des connaissances après un siècle de reconnaissance. *PALEO. Revue d'archéologie préhistorique*, (18), 95-114.
- Busschers, F. S., Kasse, C., Van Balen, R. T., Vandenberghe, J., Cohen, K. M., Weerts, H. J. T., ... & Bunnik, F. P. M. (2007). Late Pleistocene evolution of the Rhine-Meuse system in

the southern North Sea basin: imprints of climate change, sea-level oscillation and glacio-isostasy. *Quaternary Science Reviews*, 26(25-28), 3216-3248.

Bunbury, J., & Gajewski, K. (2009). Postglacial climates inferred from a lake at treeline, southwest Yukon Territory, Canada. *Quaternary Science Reviews*, 28(3-4), 354-369.

Byram, S., & Witter, R. (1999). Wetland landscapes and archaeological sites in the Coquille Estuary, Middle Holocene to recent times. In *Changing Landscapes: Proceedings of the 3rd Annual Coquille Cultural Preservation Conference* (pp. 60-81).

C

Caldwell, J. R. (1964). Interaction spheres in prehistory. *Hopewellian studies*, 12(6), 133-143.

Carlson, R. L. (1979). The early period on the central coast of British Columbia. *Canadian Journal of Archaeology/Journal Canadien d'Archéologie*, 211-228.

Carlson, R. L. (1998). Microblade tradition. In G. Gibbon (Ed.), *Archaeology of prehistoric Native North America: An encyclopedia* New York, NY: *Garland Publishing*. 514-515.

Cascalheira, J., Bicho, N., Manne, T., & Horta, P. (2017). Cross-scale adaptive behaviors during the upper Paleolithic in Iberia: The example of Vale Boi (Southwestern Portugal). *Quaternary International*, 446, 17-30.

Chapman, J. (1977). *Archaic Period Research in the Lower Little Tennessee River Valley-: 1975: Icehouse Bottom, Harrison Branch, Thirty Acre Island, Calloway Island* (No. 18). Tennessee Valley Authority.

Chapman, R. (1981). *Archaeological theory: The emergence of hunter-gatherer territoriality*. In R. Chapman, I. Kinnes, & K. Randsborg (Eds.), *The archaeology of death* (pp. 67-79). Cambridge University Press.

Chang, Y. (2013). Human activity and lithic technology between Korea and Japan from MIS 3 to MIS 2 in the Late Paleolithic period. *Quaternary International*, 308, 13-26.

Chao, Z. H. A. O. (2022). Investigating the mobility pattern of prehistoric hunter-gatherers based on the analysis of their lithic technology characteristics. *Acta Anthropologica Sinica*, 41(02), 370.

Chin-Yee, I. J. (1980). *The yubetsu-a microblade technique in palaeolithic Japan* (Doctoral dissertation, McGill University).

Choi, H. J., Lee, H. S., & Kim, J. S. (2001). Microblade technology in the Korean Paleolithic. *Gomunhwa*, 65, 65-82.

- Chun, Chen (1984). The microlithic in China. *Journal of Anthropological Archaeology Ann Arbor, Michigan* 3(2):79-115.
- Churchill, S. E., & Smith, F. H. (2000). Makers of the early Aurignacian of Europe. *American Journal of Physical Anthropology: The Official Publication of the American Association of Physical Anthropologists*, 113(S31), 61-115.
- Clarkson, C., Petraglia, M., Harris, C., Shipton, C., & Norman, K. (2017). The South Asian Microlithic: homo sapiens dispersal or adaptive response?. In *Lithic Technological Organization and Paleoenvironmental Change: Global and Diachronic Perspectives* (pp. 37-61). Cham: Springer International Publishing.
- Clark, J. D. (1985). The microlithic industries of Africa: their antiquity and possible economic implications. In *Recent advances in Indo-Pacific prehistory* (pp. 95-103). Brill.
- Clark, D. W. (1992). A Microblade Production Station (KbTx-2) in the South Central Yukon. *Canadian Journal of Archaeology/Journal Canadien d'Archéologie*, 3-23.
- Clark, D. W. (2001). Microblade-culture systematics in the far interior Northwest. *Arctic Anthropology*, 64-80.
- Clark, D. W., Gotthardt, R. M. (1999) Occasional Papers in Archaeology No. 6. *Government of the Yukon Hude Hudan Series*.
- Clayton, L., & Teller, J. T. (1983). Chronology of lake Agassiz drainage to Lake superior. *Glacial Lake Agassiz*, 26, 291-307.
- Cochrane, G. W. (2008a). The transition from Howieson's Poort to post-Howieson's Poort industries in southern Africa. *South African Archaeological Society Goodwin Series*, 10, 157-167.
- Cochrane, G. W. G. (2008b). A comparison of middle stone age and later stone age blades from South Africa. *Journal of field archaeology*, 33(4), 429-448.
- Collins, Michael B., ed. 1979a Excavations at Four Archaic Sites in the LOT'Ter Ohio Valley, Jefferson County, Kentucky. Vol.2, Occasional papers in Anthropology No.1. Department of Anthropology, University of Kentucky.
- Collins, M.B. 1979b The Longworth-Glick Site. In Excavations at Four Archaic Sites in the Lower Ohio Valley, Jefferson County, Kentucky (Vol. 2). (M.B. Collins Editor), Department of Anthropology, University of Kentucky—Bifurcate Base component (Longworth-Glick site).
- Collins, M. B. (2004). Archeology in central Texas. *The prehistory of Texas*, 101-126.
- Cooper, L. P., Jarvis, W., Bayliss, A., Beamish, M. G., Ramsey, C. B., Browning, J., Conneller, C., Elliot, B., Fenn, T., Hamilton, W. D., Hart, J., MacLeod, A., Marshall, P., Scaife, R.,

- & Macphail, R. (2017). Making and breaking microliths: A Middle Mesolithic site at Asfordby, Leicestershire. *Proceedings of the Prehistoric Society*, 83, 43–96.
- Cooper, A., Turney, C., Hughen, K. A., Brook, B. W., McDonald, H. G., & Bradshaw, C. J. (2015). Abrupt warming events drove Late Pleistocene Holarctic megafaunal turnover. *Science*, 349(6248), 602-606.
- Counts, R. C., Murari, M. K., Owen, L. A., Mahan, S. A., & Greenan, M. (2015). Late Quaternary chronostratigraphic framework of terraces and alluvium along the lower Ohio River, southwestern Indiana and western Kentucky, USA. *Quaternary Science Reviews*, 110, 72-91.
- Courtin, J., Andreev, A. A., Raschke, E., Bala, S., Biskaborn, B. K., Liu, S., ... & Herzschuh, U. (2021). Vegetation changes in southeastern Siberia during the late Pleistocene and the Holocene. *Frontiers in Ecology and Evolution*, 9, 625096.
- Coutouly, Y. A. G., & Holmes, C. E. (2018). The microblade industry from Swan Point cultural zone 4b: Technological and cultural implications from the earliest human occupation in Alaska. *American Antiquity*, 83(4), 735-752.
- Coutouly, G., & Yan, A. (2011). Identifying pressure flaking modes at Dyuktai Cave: a case study of the Siberian Upper Paleolithic microblade tradition. *From the Yenisei to the Yukon: interpreting lithic assemblage variability in Late Pleistocene/Early Holocene Beringia*, 75-90.
- Coutouly, Y. A. G. (2012). Pressure microblade industries in Pleistocene-Holocene interior Alaska: current data and discussions. In *The emergence of pressure blade making: From origin to modern experimentation* (pp. 347-374). Boston, MA: Springer US.
- Coutouly, Y. A. G. (2016). Migrations and interactions in prehistoric Beringia: the evolution of Yakutian lithic technology. *Antiquity*, 90(349), 9-31.
- Crombé, P., & Robinson, E. (2014). European mesolithic: geography and culture. *Encyclopedia of global archaeology*. Springer, New York, 2623-2645.
- Cruikshank, J. (1981). Legend and landscape: Convergence of oral and scientific traditions in the Yukon Territory. *Arctic Anthropology*, 67-93.
- Cruikshank, J. (1992). *Life lived like a story: Life stories of three Yukon Native elders*. U of Nebraska Press.
- Cucart-Mora, C., Gómez-Puche, M., Romano, V., de Pablo, J. F. L., & Lozano, S. (2022). Reconstructing Mesolithic social networks on the Iberian Peninsula using ornaments. *Archaeological and anthropological sciences*, 14(9), 174.

D

- Dalton, A. S., Margold, M., Stokes, C. R., Tarasov, L., Dyke, A. S., Adams, R. S., ... & Wright Jr, H. E. (2020). An updated radiocarbon-based ice margin chronology for the last deglaciation of the North American Ice Sheet Complex. *Quaternary Science Reviews*, 234, 106223.
- Dart, R. A. (1929). A note on the Taungs skull. *South African Journal of Science*, 26(12), 648-658.
- Davis, M., Douglas, C., Calcote, R., Cole, K. L., Winkler, M. G., & Flakne, R. (2000). Holocene climate in the western Great Lakes national parks and lakeshores: implications for future climate change. *Conservation Biology*, 14(4), 968-983.
- Davis, R. S., & Knecht, R. A. (2005). Evidence for the Arctic Small Tool tradition in the eastern Aleutians. *Alaska J. Anthropol*, 3, 51-65.
- Davison, K., Dolukhanov, P. M., Sarson, G. R., Shukurov, A., & Zaitseva, G. I. (2009). Multiple sources of the European Neolithic: mathematical modelling constrained by radiocarbon dates. *Quaternary International*, 203(1-2), 10-18.
- Dawson, K. C. (1983). Cummins Site: A Late Paleo-Indian (Plano) Site at Thunder Bay, Ontario. *Ontario Archaeology*, 39, 3-31.
- Deacon, J. (1978). Changing patterns in the Late Pleistocene/Early Holocene prehistory of southern Africa as seen from the Nelson Bay Cave stone artifact sequence. *Quaternary Research*, 10(1), 84-111.
- Deacon, J. C. G. (1982). The later stone age in southern Cape, South Africa.
- Deacon, J. (1984). *The later stone age of southernmost Africa*. BAR Publishing.
- Deacon, H. J. (1979). Excavations at Boomplaas cave-a sequence through the upper Pleistocene and Holocene in South Africa. *World Archaeology*, 10(3), 241-257.
- Deacon, H. J., & Deacon, J. (1999). *Human beginnings in South Africa: uncovering the secrets of the Stone Age*. Bloomsbury Publishing PLC.
- Deacon, H. J., & Wurz, S. (1996). Klasies River main site, cave 2: a Howiesons Poort occurrence. *Aspects of African Archaeology*. Harare: University of Zimbabwe Publications, 213-8.
- Derevianko, A. P., & Rybin, E. P. (2003). The Dyuktai culture and its place in the Upper Paleolithic of northern Asia. *Arctic Anthropology*, 40(1), 51-69.

- de Sonneville-Bordes, D., & Perrot, J. (1956). Lexique typologique du Paléolithique supérieur, outillage lithique (suite et fin): V : Outillage à bord abattu VI : Pièces tronquées VII : Lames retouchées VIII : Pièces variées IX : Outillage lamellaire, Pointe azilienne. *Bulletin de la Société préhistorique française*, 53(2), 547–559.
- Dickson, P. S. (2011). Hi-Lo Lithic Toolkits: New Insights from the Double Take Site. *Ontario Archaeology*, (91).
- Dixon, E. J. (1985). Cultural chronology of central interior Alaska. *Arctic Anthropology*, 47-66.
- Djindjian, Francios, Kozlowski, J. K., & Bazile, Frederic (2003). Europe during the early Upper Paleolithic (40 000–30 000 BP): A synthesis. *The chronology of the Aurignacian and of the transitional technocomplexes: Dating, stratigraphies, cultural implications*, 29-48.
- Dorwin, J. T., & Warholic, D. T. (1970). Archaeological investigation of the Deep Shelter. *Rowan County, Kentucky: Rept to NPS*.
- Driskell, B. N. (1994). Stratigraphy and chronology at Dust Cave. *Journal of Alabama Archaeology*, 40(1), 17-34.
- Driscoll, K. (2011). Vein quartz in lithic traditions: an analysis based on experimental archaeology. *Journal of Archaeological Science*, 38(3), 734-745.
- Driver, J. C., Handly, M., Fladmark, K. R., Nelson, D. E., Sullivan, G. M., & Preston, R. (1996). Stratigraphy, radiocarbon dating, and culture history of Charlie Lake Cave, British Columbia. *Arctic*, 265-277.
- Dumond, D. E. (2005). The Arctic Small Tool tradition in southern Alaska. *Alaska Journal of Anthropology*, 3(2), 67-78.
- Dusseldorp, G. L. (2014). Explaining the Howiesons Poort to post-Howiesons Poort transition: a review of demographic and foraging adaptation models. *Azania: Archaeological Research in Africa*, 49(3), 317-353.
- Dyke, A. S., & Prest, V. K. (1987). Late Wisconsinan and Holocene history of the Laurentide ice sheet. *Géographie physique et Quaternaire*, 41(2), 237-263.

E

- Ebright, C. A. (1987). Quartzite petrography and its implications for prehistoric use and archeological analysis. *Archaeology of Eastern North America*, 29-45.
- Ellis, C. (2011). Measuring Paleoindian range mobility and land-use in the Great Lakes/Northeast. *Journal of Anthropological Archaeology*, 30(3), 385-401.

- Ellis, C. J., & Deller, D. B. (1982). Hi-Lo materials from southwestern Ontario. *Ontario Archaeology*, 38, 3-22.
- Ellis, C. J., & Deller, D. B. (1990). Paleo-Indians. In C. J. Ellis & N. Ferris (Eds.), *The archaeology of southern Ontario to A.D. 1650* (). London, Ontario: *Ontario Archaeological Society, Occasional Publication*, 5, 37–64
- Ellis, C., Goodyear, A. C., Morse, D. F., & Tankersley, K. B. (1998). Archaeology of the Pleistocene–Holocene transition in eastern North America. *Quaternary International*, 49, 151-166.
- Ellis, C. J., Wortner, S., & Fox, W. A. (1991). Nettling: An Overview of an Early Archaic" Kirk Corner-Notched Cluster" Site in Southwestern Ontario. *Canadian Journal of Archaeology/Journal Canadien d'Archéologie*, 1-34.
- Ellis, C. (2004) Hi-Lo: An early lithic complex in the Great Lakes region.” In *The Late Paleo-Indian Great Lakes*, edited by Lawrence J. Jackson and Andrew Hinshelwood, 57–84. Mercury Series Archaeology Paper 165. Ottawa: Canadian Museum of Civilization.
- Ellis, C. J., Carr, D. H., & Loebel, T. J. (2011). The Younger Dryas and late Pleistocene peoples of the Great Lakes region. *Quaternary International*, 242(2), 534-545.
- Elston, R. G., & Brantingham, P. J. (2002). Microlithic Technology in Northern Asia: A Risk-Minimizing Strategy of the Late Paleolithic and Early Holocene. *Archeological Papers of the American Anthropological Association*, 12(1), 103-116.
- Eren, M. I., Jennings, T. A., & Smallwood, A. M. (2013). Paleoindian unifacial stone tool ‘spurs’: intended accessories or incidental accidents?. *PloS one*, 8(11), e78419.
- Eschman, D. F., & Karrow, P. F. (1985). Huron basin glacial lakes: a review. *Quaternary evolution of the Great Lakes*, 30, 79-93.
- Esdale, J. A. (2008). A current synthesis of the Northern Archaic. *Arctic Anthropology*, 45(2), 3-38.
- Eyles, N., Zajch, A., & Doughty, M. (2015). High-resolution seismic sub-bottom reflection record of low hypsithermal lake levels in Ontario lakes. *Journal of Great Lakes Research*, 41(1), 41-52.

F

- Ford, B. (Ed.). (2011). *The archaeology of maritime landscapes* (Vol. 2). Springer Science & Business Media.

- Falcucci, A., Conard, N. J., & Peresani, M. (2017). A critical assessment of the Protoaurignacian lithic technology at Fumane Cave and its implications for the definition of the earliest Aurignacian. *PLoS One*, 12(12), e0189241.
- Faught, M. K. (2004). The underwater archaeology of paleolandscapes, Apalachee Bay, Florida. *American Antiquity*, 69(2), 275-289.
- Fedje, D.W., J. M. White, M.C. Wilson, D.E. Nelson, J.S. Vogel, and J.R. Southon. (1995) Vermilion Lakes Site: Adaptations and environments in the Canadian Rockies during the latest Pleistocene and early Holocene. *American Antiquity* 60:81-108.
- Ferguson, J. R. (2012). X-ray fluorescence of obsidian: approaches to calibration and the analysis of small samples. *Handheld XRF for art and archaeology*, 401-422.
- Fisher, L. E. (2006). Blades and microliths: changing contexts of tool production from Magdalenian to Early Mesolithic in southern Germany. *Journal of Anthropological Archaeology*, 25(2), 226-238.
- Fitting, J. E. (1963). An early post fluted point tradition in Michigan: A distributional analysis. *Michigan Archaeologist*, 9(2), 21-24.
- Fitting, James E (1964) Bifurcate-stemmed projectile points in the eastern United States. *American Antiquity* 30(1):92-94.
- Fladmark, K. R. (1996). The prehistory of Charlie Lake Cave. *Early human occupation in British Columbia*, 11-20.
- Flatman, J. (2014). Submerged Prehistoric Landscapes. In: Smith, C. (eds) Encyclopedia of Global Archaeology. Springer, New York, NY. https://doi.org/10.1007/978-1-4419-0465-2_610
- Fontes, L. M. (2016). *Economies set in stone? Magdalenian lithic technological organization and adaptation in Vasco-Cantabrian Spain*. The University of New Mexico.
- Forbis, R. G. (1978). Some facets of communal hunting. *Plains Anthropologist*, 23(82), 3-8.
- Forrest, Daniel T (1999) Beyond presence and absence: Establishing diversity in Connecticut's early Holocene archaeological. record. *Bulletin of the Archaeological. Society of Connecticut* 62:79-99.
- Foster, D. R., Oswald, W. W., Faison, E. K., Doughty, E. D., & Hansen, B. C. S. (2006). A climatic driver for abrupt mid-Holocene vegetation dynamics and the hemlock decline in New England. *Ecology*, 87(12), 2959–2966.
- Fox, W. A. (1975). The Paleo-Indian Lakehead Complex. *Canadian Archaeological Association Collected Papers, Research Report*, 6, 29-53.

- Fox, W. A. (1977). *The Lakehead Complex: New Insights*. Ministry of Culture & Recreation, Historical Planning and Research Branch.
- Fox, W. A., Deller, D. B., & Ellis, C. J. (2015). Chert Sources and Utilization in the Southern Huron Basin during the Early Holocene. *Caribou Hunting in the Upper Great Lakes: Archaeological, Ethnographic, and Paleoenvironmental Perspectives*, 67-72.
- Fredlund, G. G., Johnson, R. B., Porter, G. S., Revane, T. A., Schmidt, H. K., Overstreet, D. F., & Kolb, M. (1996). Late Pleistocene vegetation of Hebior mammoth site, southeastern Wisconsin. *Current Research in the Pleistocene*, 13, 87-89.
- Frison, G. C. (1987). Prehistoric, plains-mountain, large-mammal, communal hunting strategies. *The evolution of human hunting*, 177-223.
- Fritz, M., Herzschuh, U., Wetterich, S., Lantuit, H., De Pascale, G. P., Pollard, W. H., & Schirrmeister, L. (2012). Late glacial and Holocene sedimentation, vegetation, and climate history from easternmost Beringia (northern Yukon Territory, Canada). *Quaternary Research*, 78(3), 549-560.
- Funk, Robert E and Beth Wellman (1984) Evidence of Early Holocene occupations in the Upper Susquehanna Valley, New York State. *Archaeology of Eastern North America*:81-109.
- G**
- Gabel, W. C. (1958). The Mesolithic continuum in western Europe. *American Anthropologist*, 60(4), 658-667.
- Gadekar, C., García-Granero, J. J., Madella, M., & Ajithprasad, P. (2022). Microlithic variation and the Mesolithic occupations of western India. *Plos one*, 17(6), e0267654.
- Gaffney, D., Ford, A., & Summerhayes, G. (2015). Crossing the Pleistocene–Holocene transition in the New Guinea Highlands: Evidence from the lithic assemblage of Kiowa rockshelter. *Journal of Anthropological Archaeology*, 39, 223-246.
- Galanidou, N., Dellaporta, K., & Sakellariou, D. (2020). Greece: Unstable landscapes and underwater archaeology. In *The archaeology of Europe's drowned landscapes* (pp. 371-392). Cham: Springer International Publishing.
- Gameiro, C., Aubry, T., Almeida, F., Dimuccio, L., Gabriel, S., Gaspar, R., ... & Xavier, P. (2020). Archaeology of the Pleistocene-Holocene transition in Portugal: Synthesis and prospects. *Quaternary International*, 564, 113-137.
- Gamble, C. (1986). *The Palaeolithic settlement of Europe*. Cambridge University Press.
- García-Moreiras, I., Delgado, C., Martínez-Carreño, N., García-Gil, S., & Sobrino, C. M. (2019). Climate and vegetation changes in coastal ecosystems during the Middle Pleniglacial and

- the early Holocene: Two multi-proxy, high-resolution records from Ría de Vigo (NW Iberia). *Global and Planetary Change*, 176, 100-122.
- Garg, K., Padilla-Iglesias, C., Restrepo Ochoa, N., & Knight, V. B. (2021). Hunter–gatherer foraging networks promote information transmission. *Royal Society open science*, 8(12), 211324.
- Gauvrit R, E. (2022). Socio-economic dynamics of Magdalenian hunter-gatherers: Functional perspective. *Plos one*, 17(10), e0274819.
- Gingerich, J. A. (2019). Patterns of end scraper reduction and discard: a case study from the Paleoindian record of Eastern North America. *PaleoAmerica*, 5(3), 262-275.
- Glascock, M. D. (2006). An overview of neutron activation analysis. *Columbia, MO: University of Missouri Research Reactor (MURR)*.
- Glascock, M. D., & Neff, H. (2003). Neutron activation analysis and provenance research in archaeology. *Measurement Science and Technology*, 14(9), 1516.
- Glover, K. C., Lowell, T. V., Wiles, G. C., Pair, D., Applegate, P., & Hajdas, I. (2011). Deglaciation, basin formation and post-glacial climate change from a regional network of sediment core sites in Ohio and eastern Indiana. *Quaternary Research*, 76(3), 401-410.
- Goebel, T. (1999). Pleistocene human colonization of Siberia and peopling of the Americas: an ecological approach. *Evolutionary Anthropology: Issues, News, and Reviews: Issues, News, and Reviews*, 8(6), 208-227.
- Goebel, T. (2002). The “microblade adaptation” and recolonization of Siberia during the Late Upper Pleistocene. *Archeological Papers of the American Anthropological Association*, 12(1), 117-131.
- Goebel, T., Waters, M. R., Buvit, I., Konstantinov, M. V., & Konstantinov, A. V. (2000). Studenoe-2 and the origins of microblade technologies in the Transbaikai, Siberia. *Antiquity*, 74(285), 567-575.
- Goodyear, A. C., White, A. A., & Wilkinson, J. E. (2019). Early Archaic Projectile Point Typologies in South Carolina: Are Side and Corner Notched Points Contemporary. *South Carolina Antiquities*, 51, 107-120.
- Gore, A. K., & Graf, K. E. (2018). Technology and human response to environmental change at the Pleistocene-Holocene boundary in eastern Beringia: a view from Owl Ridge, central Alaska. *Lithic Technological Organization and Paleoenvironmental Change: Global and Diachronic Perspectives*, 203-234.

- Graf, K. E. (2009). Modern human colonization of the Siberian mammoth steppe: a view from south-central Siberia. In *Sourcebook of Paleolithic Transitions: Methods, Theories, and Interpretations* (pp. 479-501). New York, NY: Springer New York.
- Graf, K. E., Gore, A. K., Melton, J. A., Marks, T., DiPietro, L., Goebel, T., ... & Rhode, D. (2020). Recent excavations at Owl Ridge, interior Alaska: Site stratigraphy, chronology, and site formation and implications for late Pleistocene archaeology and peopling of eastern Beringia. *Geoarchaeology*, 35(1), 3-26.
- Gravina, B., Mellars, P., & Ramsey, C. B. (2005). Radiocarbon dating of interstratified Neanderthal and early modern human occupations at the Chatelperronian type-site. *Nature*, 438(7064), 51-56.
- Griggs, C. B., Lewis, C. M., & Kristovich, D. A. (2022). A late-glacial lake-effect climate regime and abundant tamarack in the Great Lakes Region, North America. *Quaternary Research*, 109, 83-101.
- Grigg, L. D., Engle, K. J., Smith, A. J., Shuman, B. N., & Mandl, M. B. (2021). A multi-proxy reconstruction of climate during the late-Pleistocene to early Holocene transition in the northeastern, USA. *Quaternary Research*, 102, 188-204.
- Grimm, E.C., (2001a). Trends and palaeoecological. problems in the vegetation and climate history of the northern Great Plains, USA. *Proceedings of the Royal Irish Academy* 101B (1–2), 47–64.
- Grimm, E. C., Lozano-García, S., Behling, H., & Markgraf, V. (2001b). Holocene vegetation and climate variability in the Americas. In *Interhemispheric climate linkages* (pp. 325-370). Academic Press.
- Grimm, E. C., & Jacobson Jr, G. L. (2004). Late-Quaternary vegetation history of the eastern United States. *The Quaternary Period in the United States*, 1, 381-402.
- Groß, D., Lübke, H., Schmölcke, U., & Zanon, M. (2019). Early Mesolithic activities at ancient lake Duvensee, northern Germany. *The Holocene*, 29(2), 197-208.
- Groman-Yaroslavski, I., Chen, H., Liu, C., Shimelmitz, R., Yeshurun, R., Liu, J., ... & Nadel, D. (2020). Versatile use of microliths as a technological advantage in the miniaturization of Late Pleistocene toolkits: The case study of Neve David, Israel. *Plos one*, 15(6), e0233340.
- Grove, M. (2009). Hunter–gatherer movement patterns: causes and constraints. *Journal of Anthropological Archaeology*, 28(2), 222-233.
- Grove, M. (2010). Logistical mobility reduces subsistence risk in hunting economies. *Journal of Archaeological Science*, 37(8), 1913-1921.

- Grove, M., Hall, H., Timbrell, L., Benton, A., & French, J. C. (2023). Moving far or moving often? A neglected axis of variation in hunter-gatherer mobility. *Journal of Archaeological Science: Reports*, 52, 104266.
- Guan, Y., Wang, X., Wang, F., Olsen, J. W., Pei, S., Zhou, Z., & Gao, X. (2020). Microblade remains from the Xishahe site, North China and their implications for the origin of microblade technology in Northeast Asia. *Quaternary International*, 535, 38-47.
- Gusick, A. E., & Davis, L. G. (2010). Exploring baja California's submerged landscapes. *Journal of California and Great Basin Anthropology*, 35-49.
- Gusick, A. E., & Faught, M. K. (2011). Prehistoric archaeology underwater: A nascent subdiscipline critical to understanding early coastal occupations and migration routes. In *Trekking the shore: Changing coastlines and the antiquity of coastal settlement* (pp. 27-50). New York, NY: Springer New York.

H

- Hall, M., & Kimura, H. (2002). Quantitative EDXRF studies of obsidian sources in northern Hokkaido. *Journal of Archaeological Science*, 29(3), 259-266.
- Halstead, P., & O'Shea, J. (1989). Introduction: cultural responses to risk and uncertainty. *Bad year economics: Cultural responses to risk and uncertainty*, 1-7.
- Hamilton, M. J., Milne, B. T., Walker, R. S., Burger, O., & Brown, J. H. (2007). The complex structure of hunter-gatherer social networks. *Proceedings of the Royal Society B: Biological Sciences*, 274(1622), 2195-2203.
- Händel, M., Thomas, R., Sprafke, T., Schulte, P., Brandl, M., Simon, U., & Einwögerer, T. (2021). Using archaeological data and sediment parameters to review the formation of the Gravettian layers at Krems-Wachtberg. *Journal of Quaternary Science*, 36(8), 1397-1413.
- Hare, P. G., Greer, S., Gotthardt, R., Farnell, R., Bowyer, V., Schweger, C., & Strand, D. (2004). Ethnographic and archaeological investigations of alpine ice patches in southwest Yukon, Canada. *Arctic*, 260-272.
- Hare, P. G., Thomas, C. D., Topper, T. N., & Gotthardt, R. M. (2012). The archaeology of Yukon ice patches: New artifacts, observations, and insights. *Arctic*, 118-135.
- Hardy, B. L., & Garufi, G. T. (1998). Identification of woodworking on stone tools through residue and use-wear analyses: experimental results. *Journal of Archaeological Science*, 25(2), 177-184.

- Hartz, S., Terberger, T., & Zhilin, M. (2010). New AMS-dates for the Upper Volga Mesolithic and the origin of microblade technology in Europe: Neue AMS-Daten zum Mesolithikum der oberen Wolga und das Aufkommen der Mikroklingentechnik in Europa. *Quartär–Internationales Jahrbuch zur Erforschung des Eiszeitalters und der Steinzeit*, 57, 155-169.
- Haas, R., & Kuhn, S. L. (2019). Forager mobility in constructed environments. *Current Anthropology*, 60(4), 499-535.
- Hayashida, F. M. (2005). Archaeology, ecological history, and conservation. *Annu. Rev. Anthropol.*, 34(1), 43-65.
- Haynes, G. (2002). *The early settlement of North America: the Clovis era*. Cambridge University Press.
- Hays, M. A., & Lucas, G. (2000). A technological and functional analysis of carinates from Le Flageolet I, Dordogne, France. *Journal of Field Archaeology*, 27(4), 455-465.
- Heap, A. D., Bryce, S., & Ryan, D. A. (2004). Facies evolution of Holocene estuaries and deltas: a large-sample statistical study from Australia. *Sedimentary Geology*, 168(1-2), 1-17.
- Hertell, E., & Tallavaara, M. (2011). Hunter–gatherer mobility and the organisation of core technology in the Mesolithic North-Eastern Europe. *Mesolithic Interfaces–Variability in Lithic Technologies in Eastern Fennoscandia*, 94-111.
- Hickson, R. N., Monroe, R. W., & Nolan, D. J. (2008). Bifurcated Base Projectile Point Assemblages from Two Sites in Jersey County, Illinois. *Illinois Archaeology: Journal of the Illinois Archaeology Survey*, 20.
- Higham, T., Compton, T., Stringer, C., Jacobi, R., Shapiro, B., Trinkaus, E., ... & Fagan, M. (2011a). The earliest evidence for anatomically modern humans in northwestern Europe. *Nature*, 479(7374), 521-524.
- Higham, T., Jacobi, R., Basell, L., Ramsey, C. B., Chiotti, L., & Nespoulet, R. (2011b). Precision dating of the Palaeolithic: A new radiocarbon chronology for the Abri Pataud (France), a key Aurignacian sequence. *Journal of human evolution*, 61(5), 549-563.
- Hirasawa, Y., & Holmes, C. E. (2017). The relationship between microblade morphology and production technology in Alaska from the perspective of the Swan Point site. *Quaternary International*, 442, 104-117.
- Hiscock, P. (1994). Technological responses to risk in Holocene Australia. *Journal of World Prehistory*, 8(3), 267-292.
- Hiscock, P. (2015a). Dynamics of knapping with bipolar techniques: modeling transitions and the implications of variability. *Lithic technology*, 40(4), 342-348.

- Hiscock, P. (2015b). Making it small in the Palaeolithic: bipolar stone-working, miniature artefacts and models of core recycling. *World Archaeology*, 47(1), 158-169.
- Hiscock, P. (2002). Pattern and context in the Holocene proliferation of backed artifacts in Australia. *Archeological Papers of the American Anthropological Association*, 12(1), 163-177.
- Hockett, B., Creger, C., Smith, B., Young, C., Carter, J., Dillingham, E., ... & Pellegrini, E. (2013). Large-scale trapping features from the Great Basin, USA: the significance of leadership and communal gatherings in ancient foraging societies. *Quaternary International*, 297, 64-78.
- Hoffecker, J. F., Powers, W. R., & Goebel, T. (1993). The colonization of Beringia and the peopling of the New World. *Science*, 259(5091), 46-53.
- Holliday, V.T., Knox, J.C., Running IV, G.L., Mandel, R.D., Ferring, C.R., 2002. The Central Lowlands and Great Plains. In: Orme, A.R. (Ed.), *The Physical Geography of North America*. Oxford University Press, New York, pp. 335–362.
- Holmes, C. E. (2001). Tanana River Valley archaeology circa 14,000 to 9,000 B.P. *Arctic Anthropology*, 38(2), 154–170.
- Holmes, C. E. (2008). The Taiga period: Holocene archaeology of the northern boreal forest, Alaska. *Alaska Journal of Anthropology*, 6(1-2), 69-81.
- Holmes, C. E. (2011). 10. The Beringian and Transitional Periods in Alaska. *From the Yenisei to the Yukon: Interpreting Lithic Assemblage Variability in Late Pleistocene/Early Holocene Beringia*, 179.
- Hori, K., Tanabe, S., Saito, Y., Haruyama, S., Nguyen, V., & Kitamura, A. (2004). Delta initiation and Holocene sea-level change: example from the Song Hong (Red River) delta, Vietnam. *Sedimentary Geology*, 164(3-4), 237-249.
- Horta, P., Cascalheira, J., & Bicho, N. (2019). The role of lithic bipolar technology in western Iberia's Upper Paleolithic: the case of Vale Boi (Southern Portugal). *Journal of Paleolithic Archaeology*, 2(2), 134-159.
- Humphreys, A. J. B. (1972). Comments on aspects of raw material usage in the Later Stone Age of the Middle Orange River area. *Goodwin Series*, (1), 46-53.
- Hunter, R. D., Panyushkina, I. P., Leavitt, S. W., Wiedenhoeft, A. C., & Zawiskie, J. (2006). A multiproxy environmental investigation of Holocene wood from a submerged conifer forest in Lake Huron, USA. *Quaternary Research*, 66(1), 67-77.

I

- Ibáñez, J. J., & Mazzucco, N. (2021). Quantitative use-wear analysis of stone tools: Measuring how the intensity of use affects the identification of the worked material. *PloS one*, 16(9), e0257266.
- Ibáñez, J. J., Ortega, D., Campos, D., Khalidi, L., & Méndez, V. (2015). Testing complex networks of interaction at the onset of the Near Eastern Neolithic using modelling of obsidian exchange. *Journal of the Royal Society Interface*, 12(107), 20150210.
- Inizan, M. L., Lechevallier, M., & Plumet, P. (1992a). A technological marker of the penetration into North America: pressure microblade debitage, its origin in the Paleolithic of North Asia and its diffusion. *MRS Online Proceedings Library (OPL)*, 267, 661.
- Inizan, M. L., Roche, H., & Tixier, J. (1992b). Technology of knapped stone: followed by a multilingual vocabulary, Arabic, English, French, German, Greek, Italian, Russian, Spanish. (*No Title*).
- Igreja, M., & Porraz, G. (2013). Functional insights into the innovative early Howiesons Poort technology at Diepkloof rock shelter (Western cape, South Africa). *Journal of Archaeological Science*, 40(9), 3475-3491.
- Irving, W. N. (1957). *An archaeological survey of the Susitna Valley*. University of Alaska.

J

- Jackson, L. J., & Hinshelwood, A. (2004). The Late Paleo-Indian Great Lakes. *Geological. and Archaeological. Investigations of Late Pleistocene and Early Holocene Environments. Mercury Series, Archaeology Paper*, 165.
- Jacobs, Z., Roberts, R. G., Galbraith, R. F., Deacon, H. J., Grun, R., Mackay, A., ... & Wadley, L. (2008). Ages for the Middle Stone Age of southern Africa: implications for human behavior and dispersal. *science*, 322(5902), 733-735.
- Janetski, J. C., Bodily, M. L., Newbold, B. A., & Yoder, D. T. (2012). The Paleoarchaic to early Archaic transition on the Colorado plateau: the archaeology of North Creek Shelter. *American Antiquity*, 77(1), 125-159.
- Janssens, L., Giemsch, L., Schmitz, R., Street, M., Van Dongen, S., & Crombé, P. (2018). A new look at an old dog: Bonn-Oberkassel reconsidered. *Journal of Archaeological Science*, 92, 126-138.
- Jennings, T. A. (2010). Exploring the San Patrice lanceolate to notched hafting transition. *Exploring Variability in Early Holocene Hunter-Gatherer Lifeways*, 97-118.

- Jochim, M. (1989). Optimization and stone tool studies: problems and potentials. *Time, energy and stone tools*, 106-111.
- Jochim, M. A. (1996). Surprises, recurring themes, and new questions in the study of the Late Glacial and Early Postglacial. In *Humans at the End of the Ice Age: The Archaeology of the Pleistocene—Holocene Transition* (pp. 357-363). Boston, MA: Springer US.
- Jochim, M. (2011). The mesolithic. *European prehistory: A survey*, Springer. Interdisciplinary Contributions to Archaeology. 125-151.
- Julig, P. J. (1984). Cummins Paleo-Indian site and its paleoenvironment, Thunder Bay, Canada. *Archaeology of Eastern North America*, 192-209.
- Julig, P. J. (1994). *The Cummins Site complex and Paleoindian occupations in the northwestern Lake Superior region* (Vol. 2). Ontario Heritage Foundation.
- Julig, P. J. (2002a). *Sheguiandah Site: Archaeological., Geological. and Palaeobotanical. Studies at a Paleoindian Site on Manitoulin Island, Ontario*. University of Ottawa Press.
- Julig, P. J. (2002b). Archaeological conclusions from the Sheguiandah Site research. *The Sheguiandah Site: Archaeological, Geological and Palaeobotanical Studies at a Paleoindian site on Manitoulin Island, Ontario*, 161, 297-311.
- Julig, P., & Beaton, G. (2015). Archaeology of the Late Paleoindian/Early Archaic in the Lake Huron region, with new data from the Sheguiandah site. *Caribou hunting in the upper Great Lakes: Archaeological, ethnographic, and paleoenvironmental perspectives. Memoirs of the Museum of Anthropology*, 57, 53-66.
- Julig, P. J., & Mahaney, W. C. (2002). Geoarchaeological. studies of the Sheguiandah Site and analysis of museum collections. *The Sheguiandah Site-Archaeological., Geological. and Palaeobotanical. Studies at a Paleoindian Site on Manitoulin Island, Ontario. Canadian Museum of Civilization, Hull-Québec, Archaeological. Survey of Canada Paper, 161(314)*, 101-137.
- Julig, P. J., McAndrews, J. H., & Mahaney, W. C. (1990). Geoarchaeology of the Cummins site on the beach of proglacial Lake Minong, Lake Superior basin, Canada. *Archaeological. Geology of North America, Geological. Society of America, Centennial Special*, 4(2), 21-49.
- Justice, N. D. (1987). *Stone age spear and arrow points of the Midcontinental and Eastern United States: A modern survey and reference*. Indiana University Press.
- Justice, N. D., & Kudlaty, S. K. (2001). *Field guide to projectile points of the Midwest*. Indiana University Press.

K

- Kanomata, Y. (2013). Similarities in tool use activities in microblade industries between Hokkaido and Northeastern Honshu: A functional analysis of lithic tools from the Akatsuki site loc.1. *J. Archaeol. Assoc.* (35), 27-48.
- Keates, S. G., Postnov, A. V., & Kuzmin, Y. V. (2019). Towards the origin of microblade technology in Northeastern Asia. *Vestnik of Saint Petersburg University. History*, 64(2), 390-414.
- Kelly, R. L. (1983). Hunter-gatherer mobility strategies. *Journal of anthropological research*, 39(3), 277-306.
- Kelly, R. L. (1995). *The lifeways of hunter-gatherers: the foraging spectrum*. Cambridge University Press.
- Kelly, R. L., & Todd, L. C. (1988). Coming into the country: Early Paleoindian hunting and mobility. *American Antiquity*, 53(2), 231-244.
- Kimura, H., & Giry, E. (2016). Human activity patterns at the Horokazawa Toma Upper Paleolithic stone tool manufacturing site in the Shirataki obsidian source area: Combining excavation with experimentation. *Quaternary International*, 397, 448-473.
- Kincare, K., & Larson, G. J. (2009). Evolution of the great lakes. *Michigan geography and geology*, 174-190.
- Kirkinen, T. (2008). 13 The Prehistory of Prescribed Fires—an Archaeological View on Slash-and-burn Cultivation and Fire History. *Fire and Forest*, 55.
- Knappett, C., & Van Der Leeuw, S. (2014). A developmental approach to ancient innovation: the potter's wheel in the Bronze Age east Mediterranean. *Pragmatics & Cognition*, 22(1), 64-92.
- Knell, E. J. (2007). *The organization of late Paleoindian Cody complex land-use on the North American Great Plains* (Doctoral dissertation, Washington State University).
- Koldehoff, B., & Walthall, J. A. (2009). Dalton and the early Holocene Midcontinent: Setting the stage. *Archaic Societies: Diversity and Complexity Across the Midcontinent*, 137-151.
- Kozłowski, J. K. (2015). The origin of the Gravettian. *Quaternary international*, 359, 3-18.
- Kozłowski, S. K. (2009). *Thinking Mesolithic*. Oxbow Books.
- Kuhn, S. L. (1994). A formal approach to the design and assembly of mobile toolkits. *American Antiquity*, 59(3), 426-442.

- Kuhn, S. L. (2002). Pioneers of Microlithization: The “Proto-Aurignacian” of Southern Europe. *Archeological Papers of the American Anthropological Association*, 12(1), 83-93.
- Kuhn, S. L. (2004). Upper Paleolithic raw material economies at Üçağızlı cave, Turkey. *Journal of Anthropological Archaeology*, 23(4), 431-448.
- Kuhn, S. L., & Elston, R. G. (2002). Introduction: thinking small globally. *Archeological Papers of the American Anthropological Association*, 12(1), 1-7.
- Kuzmin, Y. V., Kosintsev, P. A., Stepanov, A. D., Boeskorov, G. G., & Cruz, R. J. (2017). Chronology and faunal remains of the Khayrgas cave (Eastern Siberia, Russia). *Radiocarbon*, 59(2), 575-582.
- Kuzyk, G. W., Russell, D. E., Farnell, R. S., Gotthardt, R. M., Hare, P. G., & Blake, E. (1999). In pursuit of prehistoric caribou on Thandlät, southern Yukon. *Arctic* 52 (2), 214-219.

L

- Laland, K. N., Kendal, J. R., & Brown, G. R. (2007). The niche construction perspective: Implications for evolution and human behaviour. *Journal of Evolutionary Psychology*, 5(1), 51-66.
- Laland, K. N., & O’Brien, M. J. (2011). Cultural niche construction: An introduction. *Biological Theory*, 6(3), 191-202.
- Laland, K. N., Odling-Smee, F. J., & Feldman, M. W. (2001). 10 Niche Construction, Ecological Inheritance, and Cycles of Contingency in Evolution. *Cycles of contingency*, 117.
- Lambeck, K. (1990). Late Pleistocene, Holocene and present sea-levels: constraints on future change. *Global and Planetary Change*, 3(3), 205-217.
- Lambeck, K. (2001). Glacial crustal rebound, sea levels and shorelines. *Encyclopaedia of Ocean Sciences*, 2, 1157-1167.
- Lambeck, K. (2004). Sea-level change through the last glacial cycle: geophysical, glaciological and palaeogeographic consequences. *Comptes Rendus. Géoscience*, 336(7-8), 677-689.
- Lambeck, K., Rouby, H., Purcell, A., Sun, Y., & Sambridge, M. (2014). Sea level and global ice volumes from the Last Glacial Maximum to the Holocene. *Proceedings of the National Academy of Sciences*, 111(43), 15296-15303.
- Langlais, M., Costamagno, S., Laroulandie, V., Pétillon, J. M., Discamps, E., Mallye, J. B., ... & Kuntz, D. (2012). The evolution of Magdalenian societies in South-West France between

- 18,000 and 14,000 calBP: Changing environments, changing tool kits. *Quaternary international*, 272, 138-149.
- Langouët, L., & Daire, M. Y. (2009). Ancient maritime fish-traps of Brittany (France): a reappraisal of the relationship between human and coastal environment during the Holocene. *Journal of Maritime Archaeology*, 4, 131-148.
- Larsen, C. E. (1985). Lake level, uplift, and outlet incision, the Nipissing and Algoma Great Lakes. *Quaternary evolution of the Great Lakes*, 30, 63-77.
- Larsen, C. E. (1987). *Geological history of glacial Lake Algonquin and the upper Great Lakes* (No. 1801). USGPO.
- Larson, G., & Schaetzl, R. (2001). Origin and evolution of the Great Lakes. *Journal of Great Lakes Research*, 27(4), 518-546.
- Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge university press.
- Le Blanc, R. J., & Ives, J. W. (1986). The Bezya site: a wedge-shaped core assemblage from northeastern Alberta. *Canadian Journal of Archaeology/Journal Canadien d'Archéologie*, 59-98.
- Lee, C. M. (2007). *Origin and function of early Holocene microblade technology in southeast Alaska, United States of America*. University of Colorado at Boulder.
- Lee, C. M., Neeley, M., Mitchell, M. D., Kornfeld, M., & O'Connor, C. (2016). Microcores and microliths in Northwestern Plains and Rocky Mountain front lithic assemblages. *plains anthropologist*, 61(238), 136-158.
- Lee, H.-J. (2004). A study of technological context between sub-wedge shaped core and blade tool culture of Upper Paleolithic in Korea. *Gomunhwa*, 65, 65-82.
- Lee, R. E. (2013). Projectile Points and Refitted Artifacts at the Sheguiandah Site: Their Position and Meaning. *Ontario Archaeology*, (93).
- Lemke, A. K. (2015). Great Lakes Rangifer and Paleoindians: Archaeological and paleontological caribou remains from Michigan. *PaleoAmerica*, 1(3), 276-283.
- Lemke, A. K. (2015). Lithic artifacts from submerged archaeological sites on the Alpena-Amberley Ridge. In *Hunting Ancient Caribou Hunters: Archaeological Finds on the Alpena-Amberley Ridge* (pp. 139-146). University of Michigan Press.
- Lemke, A. K. (2016). *Anthropological Archaeology Underwater: Hunting Architecture and Foraging Lifeways beneath the Great Lakes* (Doctoral dissertation).

- Lemke, A. (2021). Literal niche construction: Built environments of hunter-gatherers and hunting architecture. *Journal of Anthropological Archaeology*, 62, 101276.
- Lemke, A. (2022). *The architecture of hunting: the built environment of hunter-gatherers and its impact on mobility, property, leadership, and labor*. Texas A&M University Press.
- Lemke, A., & O'Shea, J. (2017). The seasonality of prehistoric caribou hunting in northeastern North America. *PaleoAmerica*, 3(4), 374-38.
- Lemke, A., & O'Shea, J. (2019). The end of an era? Early Holocene Paleoindian caribou hunting in a Great Lakes Glacial refugium. *People and culture in ice age Americas: New dimensions in Paleoamerican Archaeology*, 156-171.
- Lennox, Paul A (1993) The Kassel and Blue Dart Sites: Two Components of the Early Archaic, Bifurcate Base Projectile Point Tradition, Waterloo County, Ontario. *Ontario Archaeology* 56:1-31.
- Lenz, J., Fritz, M., Schirrmeister, L., Lantuit, H., Wooller, M. J., Pollard, W. H., & Wetterich, S. (2013). Periglacial landscape dynamics in the western Canadian Arctic: results from a thermokarst lake record on a push moraine (Herschel Island, Yukon Territory). *Palaeogeography, Palaeoclimatology, Palaeoecology*, 381, 15-25.
- Lewis, L., Perera, N., & Petraglia, M. (2014). First technological comparison of Southern African Howiesons Poort and South Asian Microlithic industries: An exploration of inter-regional variability in microlithic assemblages. *Quaternary International*, 350, 7-25.
- Lewis, C. F. M. (1970). Recent uplift of Manitoulin Island, Ontario. *Canadian Journal of Earth Sciences*, 7(2), 665-675.
- Lewis, C. F. M. (2016). Geoscience Medallist 1. Understanding the Holocene closed-basin phases (lowstands) of the Laurentian Great Lakes and their significance. *Geoscience Canada*, 43(3), 179-198.
- Lewis, M, C. F., Blasco, S. M., & Gareau, P. L. (2005). Glacial isostatic adjustment of the Laurentian Great Lakes basin: using the empirical record of strandline deformation for reconstruction of early Holocene paleo-lakes and discovery of a hydrologically closed phase. *Géographie physique et Quaternaire*, 59(2), 187-210.
- Lewis, C. M., Moore Jr, T. C., Rea, D. K., Dettman, D. L., Smith, A. M., & Mayer, L. A. (1994). Lakes of the Huron basin: their record of runoff from the Laurentide Ice Sheet. *Quaternary Science Reviews*, 13(9-10), 891-922.
- Lindo, J., Achilli, A., Perego, U. A., Archer, D., Valdiosera, C., Petzelt, B., ... & Malhi, R. S. (2017). Ancient individuals from the North American Northwest Coast reveal 10,000 years of regional genetic continuity. *Proceedings of the National Academy of Sciences*, 114(16), 4093-4098.

- Lombard, M. (2011). Quartz-tipped arrows older than 60 ka: further use-trace evidence from Sibudu, KwaZulu-Natal, South Africa. *Journal of archaeological Science*, 38(8), 1918-1930.
- Lombard, M., & Parsons, I. (2011). What happened to the human mind after the Howiesons Poort?. *Antiquity*, 85(330), 1433-1443.
- Lombard, M., Wadley, L. Y. N., Deacon, J., Wurz, S., Parsons, I., Mohapi, M., ... & Mitchell, P. (2012). South African and Lesotho stone age sequence updated. *The South African archaeological Bulletin*, 67(195), 123-144.
- Lopinot, N. H., Ray, J. H., & Conner, M. D. (1998). *The 1997 excavations at the Big Eddy site (23CE426) in southwest Missouri* (No. CARSP2).
- Lopinot, N. H., Ray, J. H., & Conner, M. D. (Eds.). (2000). *The 1999 Excavations at the Big Eddy Site (23CE426)[in Southwest Missouri]*. Center for Archaeological Research, Southwest Missouri State University.
- Lothrop, Jonathan C, Darrin L Lowery, Arthur E Spiess and Christopher J Ellis (2016) Early human settlement of northeastern north America. *PaleoAmerica* 2(3):192-251.
- Lu, L. D. (1998). The microblade tradition in China: regional chronologies and significance in the transition to Neolithic. *Asian Perspectives*, 84-112.
- Lubinski, P. M. (1999). The communal pronghorn hunt: a review of the ethnographic and archaeological evidence. *Journal of California and Great Basin Anthropology*, 158-181.
- Lubinski, P. M., & Herren, V. (2000). An introduction to pronghorn biology, ethnography and archaeology. *Plains Anthropologist*, 45(174), 3-11.
- Luttrell, M., & Corbett, D. (2000). *Archaeological investigations on northeast Adak Island, Alaska, July 1999*. United States Fish and Wildlife Service (internal report). Anchorage, AK.

M

- Macdonald, D. A., Bartkowiak, T., & Stemp, W. J. (2020). 3D multiscale curvature analysis of tool edges as an indicator of cereal harvesting intensity. *Journal of Archaeological Science: Reports*, 33, 102523.
- Mackay, A. (2011). Potentially stylistic differences between backed artefacts from two nearby sites occupied ~ 60,000 years before present in South Africa. *Journal of Anthropological Archaeology*, 30(2), 235-245.
- Magne, M. P. (1996). Comparative analysis of microblade cores from Haida Gwaii. *Early Human Occupation in British Columbia*, 151-158.

- Magne, M. P. (2023). *Many edges to the wedges: An overview of microblade technology in western Canada*. Government of Alberta.
- Magne, M. P. R., & Fedje, D. W. (2007). The spread of microblade technology in northwestern North America. In Y. V. Kuzmin, S. G. Keates, & S. Shen (Eds.), *Origin and spread of microblade technology in Northern Asia and North America* (pp. 171–188). Archaeology Press, Simon Fraser University.
- Magne, M. P., Hughes, R. E., & Kristensen, T. J. (2020). Microblade technology, obsidian sourcing, and the Cody complex in early Holocene Alberta. *plains anthropologist*, 65(254), 88-120.
- Manne, T. (2010). *Upper Paleolithic foraging decisions and early economic intensification at Vale Boi, Southwestern Portugal*. The University of Arizona.
- Markham, S. (2012). An Introduction to the Paleoindian Projectile Point Assemblage Recovered from the Mackenzie I Site near Thunder Bay, Ontario. *Minnesota Archaeologist*, 71.
- Marreiros, J., & Bicho, N. (2013). Lithic technology variability and human ecodynamics during the Early Gravettian of Southern Iberian Peninsula. *Quaternary International*, 318, 90-101.
- Mason, R. J. (1981). *Great Lakes Archaeology*. New York: Academic Press.
- Mason, J. A., Miao, X., Hanson, P. R., Johnson, W. C., Jacobs, P. M., & Goble, R. J. (2008). Loess record of the Pleistocene–Holocene transition on the northern and central Great Plains, USA. *Quaternary Science Reviews*, 27(17-18), 1772-1783.
- Mason, O. K., Bowers, P. M., & Hopkins, D. M. (2001). The early Holocene Milankovitch thermal maximum and humans: adverse conditions for the Denali complex of eastern Beringia. *Quaternary Science Reviews*, 20(1-3), 525-548.
- McCall, G. S. (2007). Behavioral ecological models of lithic technological change during the later Middle Stone Age of South Africa. *Journal of Archaeological Science*, 34(10), 1738-1751.
- McCall, G. S., & Thomas, J. T. (2012). Still Bay and Howiesons Poort foraging strategies: recent research and models of culture change. *African Archaeological Review*, 29, 7-50.
- McQuade, M., & O'Donnell, L. (2007). Late Mesolithic fish traps from the Liffey estuary, Dublin, Ireland. *Antiquity*, 81(313), 569-584.
- McCarthy, F., McAndrews, J. H., & Papangelakis, E. (2015). Paleoenvironmental context for early Holocene caribou migration on the Alpena-Amberley Ridge. *Caribou hunting in the upper great lakes: Archaeological, ethnographic, and paleoenvironmental perspectives*, 13-30.

- Meltzer, D. J., & Holliday, V. T. (2010). Would North American paleoindians have noticed younger dryas age climate changes?. *Journal of World Prehistory*, 23(1), 1-41.
- Millard, A. R. (2006). Bayesian analysis of ESR dates, with application to Border Cave. *Quaternary Geochronology*, 1(2), 159-166.
- Mills, B. J. (2017). Social network analysis in archaeology. *Annual review of anthropology*, 46(1), 379-397.
- Minc, L. D., & Smith, K. P. (1989). The spirit of survival: cultural responses to resource variability in North Alaska. *Bad Year Economics*, 8-39.
- Mobley, C. M. (1991). The campus site: a prehistoric camp at Fairbanks, Alaska. (*No Title*).
- Mochanov, Y. A. (1980). Early migrations to America in the light of a study of the Dyuktai Paleolithic Culture in Northeast Asia. *Early Native Americans*, 119-131.
- Mohow, J. A. (1987). The Midwestern Early Archaic and the Maumee River Archaeological survey.
- Molin, F., & Wikell, R. (2008). Microblade technology in quartz during the Mesolithic in Eastern Middle Sweden. *Current Swedish Archaeology*, 137-156.
- Monaghan, G. W., Lovis, W. A., & Hambacher, M. J. (2005). Modeling archaeological site burial in southern Michigan: a geoarchaeological synthesis. (*No Title*).
- Moreno-Mayar, J. V., Vinner, L., de Barros Damgaard, P., De La Fuente, C., Chan, J., Spence, J. P., ... & Willerslev, E. (2018). Early human dispersals within the Americas. *Science*, 362(6419), eaav2621.
- Morlan, R. E. (1976). Technological characteristics of some wedge-shaped cores in northwestern North America and Northeast Asia. *Asian Perspectives*, 19(1), 96-106.
- Morse, D. (2017). *Sloan: A Paleoindian Dalton Cemetery in Arkansas*. University of Arkansas Press.
- Morse, D. (1997a) Description of the Artifacts. In *Sloan: A Paleoindian Dalton Cemetery in Arkansas*, edited by Dan F. Morse,. *Smithsonian Institution Press*, Washington D.C., 14-52
- Morrow, J. E. (2005). Projectile Point Styles. *Central States Archaeological Journal*, 52(2), 79-82.
- Morse, D. F. (1997b). An overview of the Dalton period in northeastern Arkansas and in the southeastern United States. *Sloan: a paleoindian dalton cemetery in arkansas*, 123-139.

N

- Nakazawa, Y., & Akai, F. (2017). Late-Glacial bifacial microblade core technologies in Hokkaido: An implication of human adaptation along the northern Pacific Rim. *Quaternary international*, 442, 43-54.
- Nakazawa, Y., & Akai, F. (2020). The last glacial maximum microblades from Kashiwadai 1 in Hokkaido, Japan. *Lithic Technology*, 45(3), 127-139.
- Nakazawa, Y., Izuho, M., & Akai, F. (2007). The late-glacial microblade assemblage from the Kamihoronai-Moi site in Hokkaido, northern Japan: A newly discovered Yubetsu site. *Current Research in the Pleistocene*, 24, 37-40.
- Nakazawa, Y., Izuho, M., Takakura, J., & Yamada, S. (2005). Toward an understanding of technological variability in microblade assemblages in Hokkaido, Japan. *Asian Perspectives*, 276-292.
- Nash, B., Talbot, T., Wright, H. T., Greiner, E., & Cummings, L. S. (2024). Clovis organizational dynamics at a Late Glacial campsite in the central Great Lakes: Belson site excavations 2020–2021. *Plos one*, 19(5), e0302255.
- Neeley, M. P. (2002). Going microlithic: a Levantine perspective on the adoption of microlithic technologies. *Archeological Papers of the American Anthropological Association*, 12(1), 45-55.
- Neuman, R. W. (1967). Radiocarbon-dated archaeological remains on the Northern and Central Great Plains. *American Antiquity*, 32(4), 471-486.
- Newlander, K. S. (2012). *Exchange, embedded procurement, and hunter-gatherer mobility: A case study from the North American Great Basin* (Doctoral dissertation, University of Michigan).

O

- O'Brien, M. J. (2013). *The socioeconomic organization of communal hunting: An archaeological examination of Shoshone collective action*. The University of New Mexico.
- Odling-Smee, F. J., Laland, K. N., & Feldman, M. W. (1996). Niche construction. *The American Naturalist*, 147(4), 641-648.
- Olofsson, A. (2002). Microblade Technology in Northern Sweden: Chronological and Cultural Implications. *Current Swedish Archaeology*, 73-94.
- Oksanen, E. R. (2008). *Archaeological investigations at the Icehouse site, 41HY161: A revaluation of early archaic technology, subsistence and settlement along the Balcones*

- Escarpment and Central Texas* (Unpublished thesis). Texas State University-San Marcos, San Marcos, Texas.
- Orton, J. (2006). The Later Stone Age lithic sequence at Elands Bay, Western Cape, South Africa: raw materials, artefacts and sporadic change. *Southern African Humanities*, 18(2), 1-28.
- O'Shea, J. (2015a). Constructed Features on the Alpena-Amberley Ridge. *Caribou Hunting in the Upper Great Lakes: Archaeological, Ethnographic, and Paleoenvironmental Perspectives*. Ann Arbor: University of Michigan Museum of Anthropology, 115-137.
- O'Shea, J. (2015b). Strategies and techniques for the discovery of submerged sites on the Alpena-Amberley Ridge. *Caribou Hunting in the Upper Great Lakes: Archaeological, Ethnographic, and Paleoenvironmental Perspectives*. Ann Arbor: University of Michigan Museum of Anthropology, 105-114.
- O'Shea, J. M. (2023). Micro-regional approaches for submerged site archaeology. In *Submerged Prehistory in the Americas* (pp. 103-117). Routledge.
- O'Shea, J. M., Lemke, A. K., Nash, B. S., Sonnenburg, E. P., Ferguson, J. R., Nyers, A. J., & Riebe, D. J. (2021). Central Oregon obsidian from a submerged early Holocene archaeological site beneath Lake Huron. *Plos one*, 16(5), e0250840.
- O'Shea, J., Lemke, A. K., & Reynolds, R. G. (2013). "Nobody Knows the way of the Caribou": Rangifer hunting at 45 North Latitude. *Quaternary International*, 297, 36-44.
- O'Shea, J. M., Lemke, A. K., Sonnenburg, E. P., Reynolds, R. G., & Abbott, B. D. (2014). A 9,000-year-old caribou hunting structure beneath Lake Huron. *Proceedings of the National Academy of Sciences*, 111(19), 6911-6915.
- O'Shea, J. M., & Meadows, G. A. (2009). Evidence for early hunters beneath the Great Lakes. *Proceedings of the National Academy of Sciences*, 106(25), 10120-10123.
- O'Sullivan, A. (2004). Place, memory and identity among estuarine fishing communities: interpreting the archaeology of early medieval fish weirs. *World Archaeology*, 35(3), 449-468.
- Oswald, W. W., Foster, D. R., Shuman, B. N., Doughty, E. D., Faison, E. K., Hall, B. R., ... & Truebe, S. A. (2018). Subregional variability in the response of New England vegetation to postglacial climate change. *Journal of Biogeography*, 45(10), 2375-2388.

P

- Page, A. E., Chaudhary, N., Viguier, S., Dyble, M., Thompson, J., Smith, D., ... & Migliano, A. B. (2017). Hunter-gatherer social networks and reproductive success. *Scientific reports*, 7(1), 1153.
- Panagiotopoulou, T., McCartin, M. J., Münzel, S. C., Drucker, D. G., Starkovich, B. M., Brown, S., ... & Baumann, C. (2025). Magdalenian environments and ecosystems of the northern Alpine foreland: the case of Gnirshöhle and Petersfels. *Archaeological and Anthropological Sciences*, 17(6), 125.
- Pargeter, J. (2016). Lithic miniaturization in late Pleistocene southern Africa. *Journal of Archaeological Science: Reports*, 10, 221-236.
- Pargeter, J., & Eren, M. I. (2017). Quantifying and comparing bipolar versus freehand flake morphologies, production currencies, and reduction energetics during lithic miniaturization. *Lithic Technology*, 42(2-3), 90-108.
- Pargeter, J., & Shea, J. J. (2019). Going big versus going small: Lithic miniaturization in hominin lithic technology. *Evolutionary Anthropology: Issues, News, and Reviews*, 28(2), 72-85.
- Payette, S., Eronen, M., & Jasinski, J. J. P. (2002). The circumboreal tundra-taiga interface: Late Pleistocene and Holocene changes. *Ambio*, 15-22.
- Pazan, K., Stewart, B. A., & Dewar, G. (2023). Early LGM environments accelerated the MSA/LSA transition in southern African highlands: the Robberg's emergence at Melikane (Lesotho). *Journal of Paleolithic Archaeology*, 6(1), 24.
- Pearce, E. (2014). Modelling mechanisms of social network maintenance in hunter-gatherers. *Journal of archaeological science*, 50, 403-413.
- Pei, G. (2016). Microlithic industries in China. In *Paleoanthropology and Paleolithic archaeology in the People's Republic of China* (pp. 225-242). Routledge.
- Person, M., McIntosh, J., Bense, V., & Remenda, V. H. (2007). Pleistocene hydrology of North America: The role of ice sheets in reorganizing groundwater flow systems. *Reviews of Geophysics*, 45(3).
- Peteet, D. (1995). Global younger dryas?. *Quaternary International*, 28, 93-104.
- Peterson, W. L. (1986). *Late Wisconsinan glacial history of northeastern Wisconsin and western upper Michigan* (No. 1652). USGPO.

- Petersen, J. B., Robinson, B. S., Belknap, D. F., Stark, J., & Kaplan, L. K. (1994). An Archaic and Woodland period fish weir complex in central Maine. *Archaeology of Eastern North America*, 197-222.
- Pétillon, J.-M. (2006). *Des Magdaléniens en armes: Technologie des armatures de projectile en bois de cervidé du Magdalénien supérieur de la grotte d'Isturitz (Pyrénées-Atlantiques)* (Artefacts, 10). Treignes, Belgium: Éditions du CEDARC.
- Petraglia, M., Clarkson, C., Boivin, N., Haslam, M., Korisettar, R., Chaubey, G., ... & Arnold, L. (2009). Population increase and environmental deterioration correspond with microlithic innovations in South Asia ca. 35,000 years ago. *Proceedings of the National Academy of Sciences*, 106(30), 12261-12266.
- Pino, M., & Dillehay, T. D. (2023). Monte Verde II: an assessment of new radiocarbon dates and their sedimentological context. *Antiquity*, 97(393), 524-540.
- Pinson, A. O. (1999). *Foraging in uncertain times: The effects of risk on subsistence behavior during the Pleistocene-Holocene transition in the Oregon Great Basin*. The University of New Mexico.
- Porraz, G., Texier, P. J., Archer, W., Piboule, M., Rigaud, J. P., & Tribolo, C. (2013). Technological successions in the middle stone age sequence of Diepkloof rock shelter, western Cape, South Africa. *Journal of Archaeological Science*, 40(9), 3376-3400.
- Posth, C., Nakatsuka, N., Lazaridis, I., Skoglund, P., Mallick, S., Lamnidis, T. C., ... & Reich, D. (2018). Reconstructing the deep population history of Central and South America. *Cell*, 175(5), 1185-1197.
- Potter, B. A. (2008a). Radiocarbon chronology of central Alaska: Technological continuity and economic change. *Radiocarbon*, 50(2), 181-204.
- Potter, B. A. (2008b). A first approximation of Holocene inter-assemblage variability in central Alaska. *Arctic Anthropology*, 45(2), 89-113.
- Potter, B. A. (2008c). Exploratory models of intersite variability in mid to late Holocene central Alaska. *Arctic*, 407-425.
- Potter, B. A., Holmes, C. E., & Yesner, D. R. (2013). Technology and economy among the earliest prehistoric foragers in interior eastern Beringia. *Paleoamerican odyssey*, 81-103.
- Preston, P. R. (2012). *Lithics to Landscapes: Hunter Gatherer tool use, resource exploitation and mobility during the Mesolithic of the Central Pennines, England* (Doctoral dissertation, Oxford University).
- Price, T. D. (1987). The Mesolithic of Western Europe. *Journal of World Prehistory*, 1(3), 225-305.

- Price, T. D. (1991). The mesolithic of northern Europe. *Annual review of anthropology*, 211-233.
- Puzachenko, A. Y., & Markova, A. K. (2014). Mammal diversity during the Pleistocene–Holocene transition in Eastern Europe. *Integrative Zoology*, 9(4), 461-470.

Q

- Quimby, G. I. (1960). Indian life in the Upper Great Lakes, 11,000 BC to AD 1800. (*No Title*).

R

- Raghavan, M., Steinrücken, M., Harris, K., Schiffels, S., Rasmussen, S., DeGiorgio, M., ... & Willerslev, E. (2015). Genomic evidence for the Pleistocene and recent population history of Native Americans. *Science*, 349(6250), aab3884.
- Rasmussen, M., Anzick, S. L., Waters, M. R., Skoglund, P., DeGiorgio, M., Stafford Jr, T. W., ... & Willerslev, E. (2014). The genome of a Late Pleistocene human from a Clovis burial site in western Montana. *Nature*, 506(7487), 225-229.
- Reade, H., Grimm, S. B., Tripp, J. A., Neruda, P., Nerudová, Z., Roblíčková, M., ... & Stevens, R. E. (2021). Magdalenian and Epimagdalenian chronology and palaeoenvironments at Kůlna Cave, Moravia, Czech Republic. *Archaeological and Anthropological Sciences*, 13(1), 4.
- Reuther, J. D., Holmes, C. E., Smith, G. M., Lanoe, F. B., Crass, B. A., Rowe, A. G., & Wooller, M. J. (2023). The Swan Point Site, Alaska: The chronology of a multi-component archaeological site in Eastern Beringia. *Radiocarbon*, 65(3), 693-720.
- Riebe, D. J., Lemke, A. K., Ferguson, J. R., Nyers, A. J., Sonnenburg, E. P., & Nash, B. S. (2022). Extraordinary claims require extraordinary evidence: The role of inter-laboratory collaborations in a Lake Huron archaeological discovery. *Obsidian across the Americas. Compositional studies conducted in the elemental analysis facility at the Field Museum of Natural History*, 7-16.
- Riede, F. (2008). Maglemosian Memes: technological ontogeny, craft traditions, and the evolution of northern European Barbed points. *Cultural Transmission and Archaeology. Issues and Case Studies, SAA, Washington*, 178-189.
- Rimpi, A. (2024). Hunting Pit Systems as Landscape Domestication: Large-Scale Hunting in the Arctic Regions of Sweden. *European Journal of Archaeology*, 1-19.
- Roberts, N. (2013). The Holocene: an environmental history. John Wiley & Sons.

- Robson, H. K., Little, A., Jones, A. K. G., Blockley, S., Candy, I., Matthews, I., ... & Milner, N. (2018). Scales of analysis: Evidence of fish and fish processing at Star Carr. *Journal of Archaeological Science: Reports*, 17, 895-903.
- Román, D., & Villaverde, V. (2006). Las puntas de La Gravette y las microgravettes de los yacimientos gravetienses del País Valenciano: Caracterización morfológica y tipometría y análisis de sus fracturas. In *Miscelánea en homenaje a Victoria Cabrera* (Vol. 7, 441–450). *Zona Arqueológica*.
- Rots, V. (2005). Wear traces and the interpretation of stone tools. *Journal of Field Archaeology*, 30(1), 61-73.
- Roy, P. S. (1994). Holocene estuary evolution—stratigraphic studies from southeastern Australia.
- Rowley-Conwy, P., & Piper, S. (2016). Hunter-Gatherer Variability. *Arctic*, 69, 1-14.
- Ryano, K. P., Wurz, S., van Niekerk, K. L., & Henshilwood, C. S. (2017). The technology of the early Oakhurst lithic techno-complex from Klipdrift Cave, Southern Cape, South Africa. *African Archaeological Review*, 34, 93-119.
- Rybin, E. P., Khatsenovich, A. M., Gunchinsuren, B., Olsen, J. W., & Zwyns, N. (2016). The impact of the LGM on the development of the Upper Paleolithic in Mongolia. *Quaternary International*, 425, 69-87.

S

- Sahlins, M. (1972). „1974. *Stone Age economics*. London: Tavistock.
- Sánchez-Morales, I. (2025). Reassessment of the Lithic Assemblage from Layer 6 of Mugharet el'Aliya, Morocco: Site Use and Mobility Patterns During the Middle Stone Age. *Journal of Paleolithic Archaeology*, 8(1), 16.
- Sanger, D. (1968). The High River Microblade Industry, Alberta. *Plains Anthropologist*, 13(41), 190-208.
- Sassaman, K. E. (2010). *The eastern Archaic, historicized*. Rowman Altamira.
- Saxe, A. A. (1970). *Social dimensions of mortuary practices*. (Unpublished doctoral dissertation). University of Michigan, Ann Arbor.
- Schmidt, I. (2015). Beyond Solutrean point types: Technological organization and behavioral implications. *Journal of Anthropological Research*, 71(4), 493-508.
- Seong, C. (1998). Microblade technology in Korea and adjacent Northeast Asia. *Asian Perspectives*, 245-278.

- Sellet, F. (2013). Anticipated mobility and its archaeological signature: A case study of Folsom retooling strategies. *Journal of Anthropological Archaeology*, 32(4), 383-396.
- Shackley, M. S. (2010). An introduction to X-ray fluorescence (XRF) analysis in archaeology. In *X-ray fluorescence spectrometry (XRF) in geoarchaeology* (pp. 7-44). New York, NY: Springer New York.
- Sherwood, S. C., Driskell, B. N., Randall, A. R., & Meeks, S. C. (2004). Chronology and stratigraphy at dust cave, Alabama. *American Antiquity*, 69(3), 533-554.
- Shott, M. (1986a). Technological organization and settlement mobility: an ethnographic examination. *Journal of Anthropological Research*, 42(1), 15-51.
- Shott, M. J. (1986b). *Settlement mobility and technological organization among Great Lakes Paleo-Indian foragers*. University of Michigan.
- Shott, M. J. (1999). On bipolar reduction and splintered pieces. *North American Archaeologist*, 20(3), 217-238.
- Shuman, B., Webb Iii, T., Bartlein, P., & Williams, J. W. (2002). The anatomy of a climatic oscillation: vegetation change in eastern North America during the Younger Dryas chronozone. *Quaternary Science Reviews*, 21(16-17), 1777-1791.
- Slobodin, S. B. (2019). Neolithic of the Northeast Asia and the Arctic small tool tradition of the North America. *Вестник Санкт-Петербургского университета. История*, 64(2), 415-452.
- Smallwood, A. M., Jennings, T. A., & Pevny, C. D. (2018). Expressions of ritual in the Paleoindian record of the Eastern Woodlands: Exploring the uniqueness of the Dalton cemetery at Sloan, Arkansas. *Journal of Anthropological Archaeology*, 49, 184-198.
- Smith, B. D. (2007). Niche construction and the behavioral context of plant and animal domestication. *Evolutionary anthropology: Issues, news, and reviews: Issues, News, and Reviews*, 16(5), 188-199.
- Smith, B. D. (2011). A cultural niche construction theory of initial domestication. *Biological Theory*, 6(3), 260-271.
- Smith, C.A.S., Meikle, J.C., and Roots, C.F., eds. (2004). Yukon southern lakes. In: Ecoregions of the Yukon Territory: Biophysical properties of Yukon landscapes. PARC Technical Bulletin 04-01. Summerland, British Columbia: Agriculture and Agri-food Canada. 207-218.
- Smith, B. D. (2015). Documenting human niche construction in the archaeological record. *Method and theory in paleoethnobotany*, 355-370.
- Smith, B. D., & Zeder, M. A. (2013). The onset of the Anthropocene. *Anthropocene*, 4, 8-13.

- Smith, H. L., & Goebel, T. (2018). Origins and spread of fluted-point technology in the Canadian Ice-Free Corridor and eastern Beringia. *Proceedings of the National Academy of Sciences*, 115(16), 4116-4121.
- Soler, M., and J. M. Fullola 1996 Cultural Change between Middle and Upper Paleolithic in Catalonia. In *The Last Neandertals, the First Anatomically Modern Humans*. E. Carbonell and M. Vaquero, eds. Pp. 219–250. Tarragona , Spain : Fundacio Catalana per la Recerca.
- Song, Y., Grimaldi, S., Santaniello, F., Cohen, D. J., Shi, J., & Bar-Yosef, O. (2019). Re-thinking the evolution of microblade technology in East Asia: Techno-functional understanding of the lithic assemblage from Shizitan 29 (Shanxi, China). *PloS one*, 14(2), e0212643.
- Song, Y., Cohen, D. J., Shi, J., Wu, X., Kvavadze, E., Goldberg, P., ... & Bar-Yosef, O. (2017). Environmental reconstruction and dating of Shizitan 29, Shanxi Province: An early microblade site in north China. *Journal of Archaeological Science*, 79, 19-35.
- Sonnenburg, E. (2015). 12 Ridge Submerged Landscape during the Lake Stanley Lowstand (ca. 8.4–9 kcalBP), Lake Huron. *Caribou Hunting in the Upper Great Lakes*, 57, 147.
- Sonnenburg, E. P., Boyce, J. I., & Reinhardt, E. G. (2013). Multi-proxy lake sediment record of prehistoric (Paleoindian–Archaic) archaeological paleoenvironments at Rice Lake, Ontario, Canada. *Quaternary Science Reviews*, 73, 77-92.
- Sonnenburg, E., Lemke, A. K., & O'Shea, J. M. (Eds.). (2015). *Caribou hunting in the upper Great Lakes* (Vol. 57). U of M Museum of Anthropological Archaeology.
- Sonnenburg, E., & O'Shea, J. (2017). Archaeological. Landscapes during the 10–8 ka Lake Stanley Lowstand on the Alpena-Amberley Ridge, Lake Huron. *Geoarchaeology*, 32(2), 230-247.
- Sørensen, M. (2012). The arrival and development of pressure blade technology in Southern Scandinavia. In *The emergence of pressure blade making: from origin to modern experimentation* (pp. 237-259). Boston, MA: Springer US.
- Sørensen, M., Rankama, T., Kankaanpää, J., Knutsson, K., Knutsson, H., Melvold, S., ... & Glørstad, H. (2013). The first eastern migrations of people and knowledge into Scandinavia: evidence from studies of Mesolithic technology, 9th-8th millennium BC. *Norwegian archaeological review*, 46(1), 19-56.
- Soriano, S., Villa, P., & Wadley, L. (2007). Blade technology and tool forms in the Middle Stone Age of South Africa: the Howiesons Poort and post-Howiesons Poort at rose Cottage Cave. *Journal of Archaeological Science*, 34(5), 681-703.

- Spry, C., Kurpiel, R., Foley, E., & Penzo-Kajewski, P. (2022). Revisiting the “quartz problem” in lithic studies: A review and new, open-access, experimental dataset. *Lithic Technology*, 47(2), 171-181.
- Stanley, D. J., & Warne, A. G. (1997). Holocene sea-level change and early human utilization of deltas. *GSA Today*.
- Stanzeski, A. (1998). Four Paleoindian and Early Archaic sites in Southern New Jersey. *Archaeology of Eastern North America*, 41-53.
- Stewart, A. M. (2015). Searching for archaeological evidence on the Alpena-Amberly Ridge—Is the arctic record informative. *Caribou hunting in the Upper Great Lakes*, 81-102.
- Stivrins, N., Soininen, J., Amon, L., Fontana, S. L., Gryguc, G., Heikkilä, M., ... & Seppä, H. (2016). Biotic turnover rates during the Pleistocene-Holocene transition. *Quaternary Science Reviews*, 151, 100-110.
- Stocchi, P., Spada, G., & Cianetti, S. (2005). Isostatic rebound following the Alpine deglaciation: impact on the sea level variations and vertical movements in the Mediterranean region. *Geophysical Journal International*, 162(1), 137-147.
- Stratford, D., Braun, K., & Morrissey, P. (2021). Cave and rock shelter sediments of southern Africa: a review of the chronostratigraphic and palaeoenvironmental record from Marine Isotope Stage 6 to 1. *South African Journal of Geology* 2021, 124(4), 879-914.
- Straus, L. G. (1996). The world at the end of the last Ice Age. In *Humans at the End of the Ice Age: The Archaeology of the Pleistocene—Holocene Transition* (pp. 3-9). Boston, MA: Springer US.
- Straus, L. G. (2002). Selecting small: microlithic musings for the Upper Paleolithic and Mesolithic of western Europe. *Archeological Papers of the American Anthropological Association*, 12(1), 69-81.
- Straus, L. G. (2015). The human occupation of southwestern Europe during the Last Glacial Maximum: Solutrean cultural adaptations in France and Iberia. *Journal of Anthropological Research*, 71(4), 465-492.
- Straus, L. G. (2016). Humans confront the Last Glacial Maximum in Western Europe: reflections on the Solutrean weaponry phenomenon in the broader contexts of technological change and cultural adaptation. *Quaternary International*, 425, 62-68.
- Straus, L. G., De Quirós, F. B., Valdés, V. C., & Clark, G. A. (1977). Solutrean chronology & lithic variability in vascó-cantabrian Spain. *Zephyrus*, 28.

- Surovell, T. A. (2009). *Toward a behavioral ecology of lithic technology: cases from Paleoindian archaeology*. University of Arizona Press.
- Sutton, M. Q. (1989). Late prehistoric interaction spheres in the Mojave Desert. *North American Archaeologist*, 10(2), 95-121.
- Svoboda, J. A. (2008). The mesolithic of the middle Danube and upper elbe rivers. Mesolithic Europe, *Cambridge: Cambridge University Press*, 221-237.
- Szmidt, C. C., Normand, C., Burr, G. S., Hodgins, G. W., & LaMotta, S. (2010). AMS 14C dating the Protoaurignacian/Early Aurignacian of Isturitz, France. Implications for Neanderthal–modern human interaction and the timing of technical and cultural innovations in Europe. *Journal of Archaeological Science*, 37(4), 758-768.

T

- Takakura, J. (2020). Rethinking the Disappearance of Microblade Technology in the Terminal Pleistocene of Hokkaido, Northern Japan: Looking at Archaeological and Palaeoenvironmental Evidence. *Quaternary*, 3(3), 21.
- Talbot, T., Wright, H. T., & Nash, B. (2021). The Belson site: A Paleoindian campsite on the outwash plains of the Central Great Lakes. *PaleoAmerica*, 7(1), 76-84.
- Terry, K., Buvit, I., & Konstantinov, M. V. (2016). Emergence of a microlithic complex in the Transbaikal Region of southern Siberia. *Quaternary International*, 425, 88-99.
- Thulman, D. K. (2017). Dust Cave revisited: A Bayesian reanalysis of the radiocarbon record. *American Antiquity*, 82(1), 168-182.
- Törnqvist, T. E., & Hijma, M. P. (2012). Links between early Holocene ice-sheet decay, sea-level rise and abrupt climate change. *Nature Geoscience*, 5(9), 601-606.
- Tremayne, A. H. (2015a). New evidence for the timing of Arctic Small Tool tradition coastal settlement in Northwest Alaska. *Alaska Journal of Anthropology*, 13(1), 1-18.
- Tremayne, A. H. (2015). The design of Arctic Small Tool tradition toolkits: an example from Matcharak Lake, Alaska. *North American Archaeologist*, 36(1), 1-31.
- Tribolo, C., Mercier, N., Valladas, H., Joron, J. L., Guibert, P., Lefrais, Y., ... & Lenoble, A. (2009). Thermoluminescence dating of a Stillbay–Howiesons Poort sequence at Diepkloof Rock Shelter (Western Cape, South Africa). *Journal of Archaeological Science*, 36(3), 730-739.

U

Uścińowicz, S. (2003). Relative sea level changes, glacio-isostatic rebound and shoreline displacement in the southern Baltic. *Polish Geological Institute Special Papers*, 10, 5-79.

V

Van der Wateren, F. M. (1999). Structural geology and sedimentology of the Heiligenhafen till section, Northern Germany. *Quaternary Science Reviews*, 18(14), 1625-1639.

Vasil'ev, S. A., Kuzmin, Y. V., Orlova, L. A., & Dementiev, V. N. (2002). Radiocarbon-based chronology of the Paleolithic in Siberia and its relevance to the peopling of the New World. *Radiocarbon*, 44(2), 503-530.

Villa, P., Delagnes, A., & Wadley, L. (2005). A late middle stone age artifact assemblage from Sibudu (KwaZulu-Natal): Comparisons with the European middle Paleolithic. *Journal of Archaeological Science*, 32(3), 399-422.

Villaverde, V., & Román, D. (2004). Avance al estudio de los niveles gravetienses de la Cova de les Cendres. *Archivo de Prehistoria Levantina*, 25, 19–59.

Villaverde, V., Real, C., Roman, D., Albert, R. M., Badal, E., Bel, M. Á., ... & Pérez-Ripoll, M. (2019). The early upper palaeolithic of cova de les cendres (Alicante, Spain). *Quaternary International*, 515, 92-124.

Villa, P., Soressi, M., Henshilwood, C. S., & Mourre, V. (2009). The still bay points of Blombos cave (South Africa). *Journal of Archaeological Science*, 36(2), 441-460.

W

Waber, N. H. (2010). An Experimental Pilot Study Into the Potential of Semi-crested Blades as Diagnostic Indicators of Core Preparation Method in Core-less Northwest Coast Microblade Assemblages. *vis-à-vis: Explorations in Anthropology*, 10(2).

Wadley, L. (1993). The Pleistocene later stone age south of the Limpopo river. *Journal of World Prehistory*, 7(3), 243-296.

Wadley, L. (2000). The Wilton and pre-ceramic post-classic Wilton industries at Rose Cottage Cave and their context in the South African sequence. *The South African Archaeological Bulletin*, 90-106.

Wadley, L. (2007). Announcing a still bay industry at Sibudu Cave, South Africa. *Journal of Human Evolution*, 52(6), 681-689.

- Wahl, H. E., Fraser, D.B., Harvey, R.C., and Maxwell, J.B. (1987). Climate of the Yukon. *Ottawa: Atmospheric Environment Service, Environment Canada*. Climatological Studies 40.
- Warden, L., Moros, M., Neumann, T., Shennan, S., Timpson, A., Manning, K., ... & Sinninghe Damsté, J. S. (2017). Climate induced human demographic and cultural change in northern Europe during the mid-Holocene. *Scientific reports*, 7(1), 15251.
- Walthall, J. A. (1998). Sloan: A Paleoindian Dalton Cemetery in Arkansas.
- Waters, M. R. (2019). Late Pleistocene exploration and settlement of the Americas by modern humans. *Science*, 365(6449), eaat5447.
- Waters, M. R., Pevny, C. D., Carlson, D. L., & Jennings, T. A. (2011). *Clovis lithic technology: Investigation of a stratified workshop at the Gault Site, Texas*. Texas A&M University Press.
- West, F. H. (1975). Dating the Denali complex. *Arctic Anthropology*, 76-81.
- Webb III, T. (1987). The appearance and disappearance of major vegetational assemblages: long-term vegetational dynamics in eastern North America. *Vegetatio*, 69(1), 177-187.
- Wedage, O., Picin, A., Blinkhorn, J., Douka, K., Deraniyagala, S., Kourampas, N., Perera, N., Simpson, I., Boivin, N., Petraglia, M. D., & Roberts, P. (2019). Microliths in the South Asian rainforest ~45–4 ka: New insights from Fa-Hien Lena Cave, Sri Lanka. *PLOS ONE*, 14(10), e0222606.
- Wenger, E. (1999). *Communities of practice: Learning, meaning, and identity*. Cambridge university press.
- Whallon, R. (2006). Social networks and information: Non-“utilitarian” mobility among hunter-gatherers. *Journal of anthropological archaeology*, 25(2), 259-270.
- White, A. A. (2012). *The social networks of early hunter-gatherers in midcontinental North America*. University of Michigan.
- White, A. A. (2013). Functional and stylistic variability in Paleoindian and Early Archaic projectile points from midcontinental North America. *North American Archaeologist*, 34(1), 71-108.
- White, A. (2016). A Preliminary Analysis of Haft Variability in South Carolina Kirk Points. *South Carolina Antiquities*, 48, 41-53.
- White, A. (2021). Lithic transport patterns, tool curation behavior, and group range estimates: A model-based exploration. *Journal of Computer Applications in Archaeology*, 4(1).
- Whitlock, C., Bartlein, P. J., & Watts, W. A. (1993). Vegetation history of Elk Lake. In J. P. Bradbury & W. E. Dean (Eds.), *Elk Lake, Minnesota: Evidence for Rapid Climate*

Change in the North-Central United States (Geological Society of America Special Paper 276, pp. 251–274

- Whittaker, W. E. (2016). The Palace site and the appearance of house basins in the Middle Archaic. *plains anthropologist*, 61(239), 250-272.
- Wiessner, P. (1982). Risk, reciprocity and social influences on Kung San economics. *Journal of Environmental Sciences (China) English Ed*, 61-84.
- Williams, T. J., Collins, M. B., Rodrigues, K., Rink, W. J., Velchoff, N., Keen-Zebert, A., ... & Prewitt, E. R. (2018). Evidence of an early projectile point technology in North America at the Gault Site, Texas, USA. *Science advances*, 4(7), eaar5954.
- Wilmerding, E. G., & Kay, M. (2011). Analysis of Artifacts and Debitage: Perspectives on Lithic Resource Use on Adak Island, Alaska. *Arctic anthropology*, 48(2), 52-68.
- Wilson, M. C., Visser, J., & Magne, M. P. (2011). Microblade cores from the Northwestern Plains at High River, Alberta, Canada. *Plains Anthropologist*, 56(217), 23-36.
- Winter-Livneh, R., Svoray, T., & Gilead, I. (2012). Secondary burial cemeteries, visibility and land tenure: A view from the southern Levant Chalcolithic period. *Journal of Anthropological Archaeology*, 31(4), 423-438.
- Wolf, E. R. (1982). *Europe and the People without History*. Univ of California Press.
- Woodburn, J. (1982). Egalitarian societies. *Man*, 431-451.
- Wright, D. M., Posselt, D. J., & Steiner, A. L. (2013). Sensitivity of lake-effect snowfall to lake ice cover and temperature in the Great Lakes region. *Monthly Weather Review*, 141(2), 670-689.
- Wurz, S. (1999). The Howiesons Poort backed artefacts from Klasies River: an argument for symbolic behaviour. *The South African Archaeological Bulletin*, 38-50.
- Wurz, S. (2002). Variability in the middle stone age lithic sequence, 115,000–60,000 years ago at Klasies river, South Africa. *Journal of Archaeological Science*, 29(9), 1001-1015.
- Wygal, B. T. (2018). The peopling of eastern Beringia and its archaeological complexities. *Quaternary International*, 466, 284-298.

Y

- Yansa, C. H. (2006). The timing and nature of Late Quaternary vegetation changes in the northern Great Plains, USA and Canada: a re-assessment of the spruce phase. *Quaternary Science Reviews*, 25(3-4), 263-281.
- Yansa, C.H., 1998. Holocene paleovegetation and paleohydrology of a prairie pothole in southern Saskatchewan, Canada. *Journal of Paleolimnology* 19, 429–441.

- Yi, S., Clark, G., Aigner, J. S., Bhaskar, S., Dolitsky, A. B., Pei, G., ... & Stamps, R. B. (1985). The "Dyuktai Culture" and New World Origins [and Comments and Reply]. *Current Anthropology*, 26(1), 1-20.
- Yi, M., Gao, X., Li, F., & Chen, F. (2016). Rethinking the origin of microblade technology: A chronological and ecological perspective. *Quaternary International*, 400, 130-139.
- Younie, A. M., Le Blanc, R. J., & Woywitka, R. J. (2010). Little Pond: A microblade and burin site in northeastern Alberta. *Arctic Anthropology*, 47(1), 71-92.
- Yu, Z. (2003). Late Quaternary dynamics of tundra and forest vegetation in the southern Niagara Escarpment, Canada. *New Phytologist*, 157(2), 365-390.

Z

- Zhao, C., Wang, Y., & Walden, J. P. (2023). Regional variation in the shift towards microlithization: The development of early microblade technology in North China. *Archaeological Research in Asia*, 34, 100441.
- Zong, C. (2015). *Late Pleistocene sea levels and resulting changes in global land distributions* (Doctoral dissertation, University of Kansas).