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A Functional Analysis of Recorded Pre-Contact Archaeological Sites on Lopez Island, Washington

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A FUNCTIONAL ANALYSIS OF RECORDED PRE-CONTACT ARCHAEOLOGICAL SITES ON LOPEZ ISLAND, WASHINGTON

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by

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ABSTRACT

A FUNCTIONAL ANALYSIS OF RECORDED PRE-CONTACT

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Lopez Island, Washington has been the subject of archaeological study for over a century. Through an evolutionary archaeology framework, this thesis uses a functional analysis of recorded precontact sites on Lopez Island to determine how previous sampling and research strategies have influenced what is known about the island's archaeology. Knowing what is currently known about the island's archaeology shows how recorded sites can be further investigated to address regional Salish Sea research questions. I developed and applied a paradigmatic classification to 54 sampled sites from the Washington DAHP's WISAARD database by their level of previous research, microenvironment, and archaeology. This analysis showed that there has been little subsurface investigation on Lopez Island. The majority of archaeological sites and surveys have been concentrated on the coast of Lopez Island. Microenvironmental analysis showed that sites closer to the shoreline had greater variability in archaeology than further sites, and sites closer to freshwater also displayed greater variability. Sites containing shell (e.g., midden, artifacts, etc.) were most common in the archaeological classification; sites with rock cairns were the second most frequent filled class. The

results of the analysis identified sites on Lopez Island that could be further studied to address regional research questions of chronology, settlement and subsistence, and ideology. I also identified data gaps in the island's archaeological record including lack of data on the island's interior and a low frequency of subsurface excavation across the island. Lopez Island's archaeological record will remain an isolated piece of culture history until the data gaps identified in this thesis are addressed so that its historic context can be better integrated into the culture history of the Salish Sea.

ACKNOWLEDGEMENTS

This thesis is the result of shifting research plans that eventually resulted in this analysis of recorded Lopez Island archaeology. Initially this thesis was going to be covering a planned Central Washington University field school on Iceberg Point on Lopez Island, so I would first like to thank the Bureau of Land Management since I would not have settled on Lopez Island as my research area otherwise. Secondly, I want to thank the Washington Department of Archaeology and Historic Preservation for allowing me access to the WISAARD database which was one of the key sources of data for this thesis. A portion of my education and research was funded by the Wilson Archaeology Scholarship, so I would like to thank the Wilson Family for supporting my graduate education. I would also like to extend my thanks to Genavie Thomas, Gary Wessen, David Munsell, and Bob Kopperl who were all kind enough to share their knowledge of Lopez Island archaeology, and as well as influencing the development of this thesis through their past research on Lopez Island.

Special thanks also goes to my committee Dr. Patrick T. McCutcheon, Dr. Steven Hackenberger, and Dr. Patrick Lubinski as well as the other professors at Central Washington University who helped me throughout my graduate career by helping me to develop my analytical and research skills, and to become a better archaeologist. Finally, I would like to thank my friends and family for their endless support and encouragement throughout this journey.

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CHAPTER I

INTRODUCTION

The Salish Sea region encompasses a significant portion of the Northwest Coast culture area and includes the San Juan Islands, Washington. Archaeological investigations throughout the Salish Sea have been carried out since the late 1800s, beginning with early studies of rock cairns and petroglyphs in the San Juan Islands (Hill-Tout 1895; Smith 1907). Hundreds of sites have been recorded on the islands since then, due primarily to cultural resource surveys and academic research. Although Lopez Island has been the subject of archaeological investigations for over 100 years, there is no comprehensive summary using modern research contexts for the precontact archaeological record on Lopez Island, San Juan County, Washington.

In a previous inventory and historic context statement for San Juan County, Wessen (1988) provided three recommendations for future work in the San Juan Islands, including Lopez Island. His first recommendation notes that there are many sites that are still undiscovered and there needs to be continuous research and inventory to locate and protect sites. Wessen's (1988) second recommendation is based on an observed bias in the sampling strategies employed by archaeologists investigating throughout the region, which focused more on representative sampling within a handful of certain previously recorded sites rather than across different kinds of sites in the county. Finally, Wessen's (1988) third recommendation pointed to a need to incorporate the available natural resources such as floral and faunal materials around sites to understand the sites' past environmental context(s) and potential use(s). A site's natural characteristics and resources can provide further information about human behavior beyond what can be gleaned from studying artifacts collected from the site (Wessen 1988). These recommendations are not only important for looking at archaeology at the regional scale of the Salish Sea and San Juan Islands, but also at the smaller scale of individual islands like Lopez Island.

Wessen's (1988) historic context statement for San Juan County is now over 30 years old and unfortunately his recommendations have not been implemented on Lopez Island. Since Wessen's (1988) county-wide report, there have been 19 additional precontact sites recorded on Lopez Island. Work on these sites varied from some that were only identified in cultural resource surveys to others that were further investigated through formal excavations. More recent research on Lopez Island sites conducted by researchers such as Bovy (2005), Thomas (2006), and Taylor et al. (2011), make the island ideal for applying Wessen's (1988) recommendations and exploring how an individual island can provide further information on precontact human land use in the San Juan Islands. In order to reliably observe changes in site function and human activity over time on Lopez Island, a functional classification and analysis must be used to look at the relationship between sites' cultural materials and microenvironments (Thompson 1978). The functional analysis of recorded sites on Lopez Island carried out in this thesis shows where data gaps exist in the knowledge of Lopez Island archaeology, where the archaeology on the island fits in the greater regional context of Salish Sea culture history, and where future research could be targeted to fill in data gaps on precontact human activity on the island.

Problem

The recorded precontact sites on Lopez Island have never been studied as a whole and thus there is no modern summary of the island's archaeological record. The sites recorded and updated since 1988 may have the potential to address Wessen's (1988) recommendations for future research. Furthermore, modern research questions could potentially be addressed with this larger sample size of 54 precontact sites recorded on the island.

This thesis investigates whether the recommendations raised by Wessen (1988) were addressed through 31 years of additional cultural resource management surveys and research by using a functional analysis to assess the entire recorded archaeological record on Lopez Island. This approach allows for setting Lopez Island archaeology into a modern research context, with the outcome being a list of currently existing data gaps and recommendations for what steps should be taken to address those gaps. This thesis addresses whether the additional sites recorded since 1988 can be further investigated to address Wessen's (1988) recommendations for sampling and resource analysis in order to expand the knowledge of precontact human activity on Lopez Island and identify where gaps in the island's archaeological record exist despite the addition of new archaeological sites.

Purpose

The purpose of this thesis is to use a functional analysis of 54 precontact sites on Lopez Island to show what is currently known about precontact life on the island and to use this information to identify the historic and regional context of the island's cultural resources. Taking a functional approach is not uncommon in this region of the Pacific

Northwest Coast (Campbell 1981; Dunnell 1978b; Middleton 2017; Schalk and Nelson 2010; Rorabaugh 2015; Thompson 1978). In order to determine the kinds of human activities that occurred on the island during these time periods, defining the microenvironments that surround recorded sites provides information on the sites' function for the people who inhabited them and the kinds of human activity that led to their formation (Dunnell 1978b; Thompson 1978; Wessen 1988).

This thesis investigates the known archaeological record on Lopez Island through two analytical questions. The first question is: How have past sampling strategies influenced our understanding of the archaeological record on Lopez Island? For instance, is the archaeological record on the island a record of shell middens only? As is the case in most areas, not all the archaeological research done on Lopez Island has been conducted to recover data in a systematic manner. In many cases, archaeological sites on the island were recorded during cultural resource surveys and were not studied further through subsurface testing. This may have led to a bias in the recorded archaeology towards certain site types (such as shell middens) or geographic areas (Weiser and Lepofsky 2009, Stein 2000, Taylor et al. 2011). By looking at each site's microenvironment, archaeology, and previous research, this thesis attempts to determine what data the archaeological record can provide about the investigations conducted so far on Lopez Island and what we currently know about past life on the island.

The second analytical question asked in this thesis is: Are there adequately dated and recorded archaeological contexts on the island that can be used to address research questions about changes in settlement and subsistence patterns during the middle Holocene? Previous research in the Salish Sea region has noted a shift at about 5000 BP towards a more sedentary settlement and subsistence pattern that has been thought to be the result of resource intensification (Ames and Maschner 1999, Ames et al. 2010; Butler and Campbell 2004; Matson and Coupland 1994; Middleton 2017; Moss 2011; Schalk and Nelson 2010; Stein 2000). Lopez Island is situated in the middle of this regional shift, and its recorded sites may contain data that can be used to determine if and how the island fit into this greater regional change. Sites such as Watmough Bay (45SJ280) have been investigated multiple times in different studies (Bovy 2005; Bovy et al. 2007; Phillips et al. 2007; Taylor et al. 2011) and provide information on occupation dates and subsistence at the site. Other sites on Lopez Island have received less investigation even though they may also contain important information on precontact settlement and subsistence. By determining the extent of research conducted for each precontact site on Lopez Island and the kinds of archaeology recorded, this thesis shows whether the recorded archaeology on Lopez Island can provide further data on site age and function in order to address greater regional research questions such as changes in settlement and subsistence discussed by other researchers.

The following four objectives are used to address the stated analytical questions and achieve the purpose of this thesis.

Objective 1: Review previous research and historic context statements conducted in the Salish Sea region.

Reviewing Salish Sea archaeology literature allowed for setting a regional context for Lopez Island and its archaeological record. This aided in defining research questions that previously have been investigated throughout the region that may be further addressed through research on Lopez Island. There have been previous in-depth investigations and analyses carried out on Lopez Island (Bovy et al. 2007; Phillips et al. 2007; Taylor et al. 2011), however this thesis looks at the island's whole archaeological record and not at the individual site level. Furthermore, identifying the methods and techniques that past researchers used to address regional research questions aided in determining the kinds of environmental and archaeological variables that are used in this thesis's analysis to define dimensions for functional analysis. This review of research also made it possible to identify relevant research domains for Lopez Island's archaeological records and their associated data sets to determine their data potential.

Objective 2: Compile, identify, classify, and interpret all of the archaeological research done on Lopez Island, up to Spring, 2019.

Compiling all the documents associated with the 54 precontact sites on Lopez Island allowed for describing the extent of investigation done at each site as well as further information on sites' contents. WISAARD, the Washington Department of Archaeology and Historic Preservation's GIS database for recorded archaeological and historical sites, is the main source of information on the recorded sites on Lopez Island. As of May 2019, WISAARD had information on 64 individual sites for Lopez Island including site reports and cultural resource inventories. After initially sorting out duplicates, missing sites, and historic sites, there were 54 precontact sites remaining that comprise the sample for this thesis. Since WISAARD may not contain all documents for all the recorded sites on the island, this thesis also referred to sources such as grey literature, journal articles, academic theses and dissertations, and expert knowledge from archaeologists who have investigated in the area to gather further information about recorded sites and research conducted on Lopez Island.

Objective 3: Analyze the known sites by microenvironment, archaeology, and previous research.

This thesis analyzed Lopez Island site data by employing an approach used in previous studies to apply a functional classification model, such as those used by Dunnell (1978b), Dancey (1974), Thompson (1978), and more recent functional analyses (Middleton 2017; Rorabaugh 2015). Sites' microenvironment, archaeology, and previous research are the units of measurement used to classify sites and made it possible to look for trends, identify sites with data potential for addressing this thesis's specific research questions, and allowed for comparison between sites.

Objective 4: Develop recommendations and questions for further research and identify gaps in the current knowledge.

Given the results of the functional analysis, the final objective of this thesis is to make recommendations for future avenues of research on Lopez Island. Using the results of the functional analysis of recorded sites this study shows which site types can be used to further address research questions for the Salish Sea region, as well as data gaps where new sites may be needed to address these questions for Lopez Island. Given the results of this thesis, I identified Lopez Island microenvironments that may contain further undiscovered sites and known sites which could provide further data, and recommend further investigation into these identified regions and site types.

Significance

This thesis aims to provide an analysis that can be used to aid future research and management of cultural resources on Lopez Island. Through this compilation of the precontact archaeology that has already been recorded as well as data on the microenvironments of every site, researchers and resource managers will be better able to understand the diversity of archaeological remains on the island and where data gaps exist. By summarizing the locations and microenvironmental contexts of recorded sites, the results of this thesis's functional analysis may also aid in identifying microenvironments on Lopez Island that are informative for predictive modeling. This information will be useful for both research and protection of cultural resources. Furthermore, this thesis identifies sites that have been comparatively understudied and that may have great data potential to address regional research questions.

Lopez Island and the surrounding San Juan Islands are an environmentally rich area where people had access to a diverse variety of resources throughout all the seasons. This thesis shows how Lopez Island and its microenvironments fit into the greater historical and archaeological context of the region. Identifying how previously recorded sites can address ongoing research questions for the region shows how the current archaeological record of Lopez Island can be used to further investigate these questions. Using the microenvironmental information for each site also shows how resource areas around an archaeological site can provide further information about the site's function in the past (Dancey 1973). By defining microenvironments by characteristics such as topography, water, and soil it is possible to determine what the site's microenvironment may have been like during occupation (Dancey 1973).

The following chapters describe and discuss the research for this thesis. Chapter 2 describes the overall physical setting of Lopez Island, its biota, and its cultural history. Chapter 3 is a literature review organized by the five objectives stated for the study in the purpose section above. Chapter 4 describes the theory, method, and technique used for this study. Chapter 5 is a journal article that will be submitted for publication and it describes the results of the research, conclusions, and recommendations for future research.

CHAPTER II

STUDY AREA

This chapter describes the microenvironmental context of Lopez Island to provide context for the microenvironmental dimensions used in this thesis's functional analysis, starting with the geographical and geological elements and then reviewing terrestrial and marine biota. It also provides the cultural background extracted from ethnographies on the people of Lopez Island and the Salish Sea, referred to as the Straits Salish (Suttles 1990).

The first section below describes the physical setting of Lopez Island including a description of the island's geological origins, climate, and soil characteristics. The biota section outlines characteristic terrestrial and marine flora and fauna of Lopez Island which often served as resources for precontact peoples. The culture sections describe a brief culture history of the San Juan Islands and Lopez Island, and describes the island's modern cultural context.

Physical Setting

Lopez Island is part of the San Juan Archipelago, which consists of over 400 islands and reefs. The San Juan Islands are in the central region of the Salish Sea, which includes regions from the Puget Sound of Washington north to British Columbia (Figure 1).

Figure 1. Map of Salish Sea with San Juan Islands circled in red. Modified from Symer (2016).

Lopez Island has an area of approximately 29.5 square miles and is the third largest of the San Juan Islands, located on the southern end of the archipelago (University of Washington Publications in Geology 2006). The island is bordered by the Strait of Juan de Fuca on its south end, and Rosario Strait to the east. The closest major islands are San Juan Island to the south and west, Decatur Island to the east, Blakely Island to the northeast, and Shaw Island to the northwest (Figure 2).

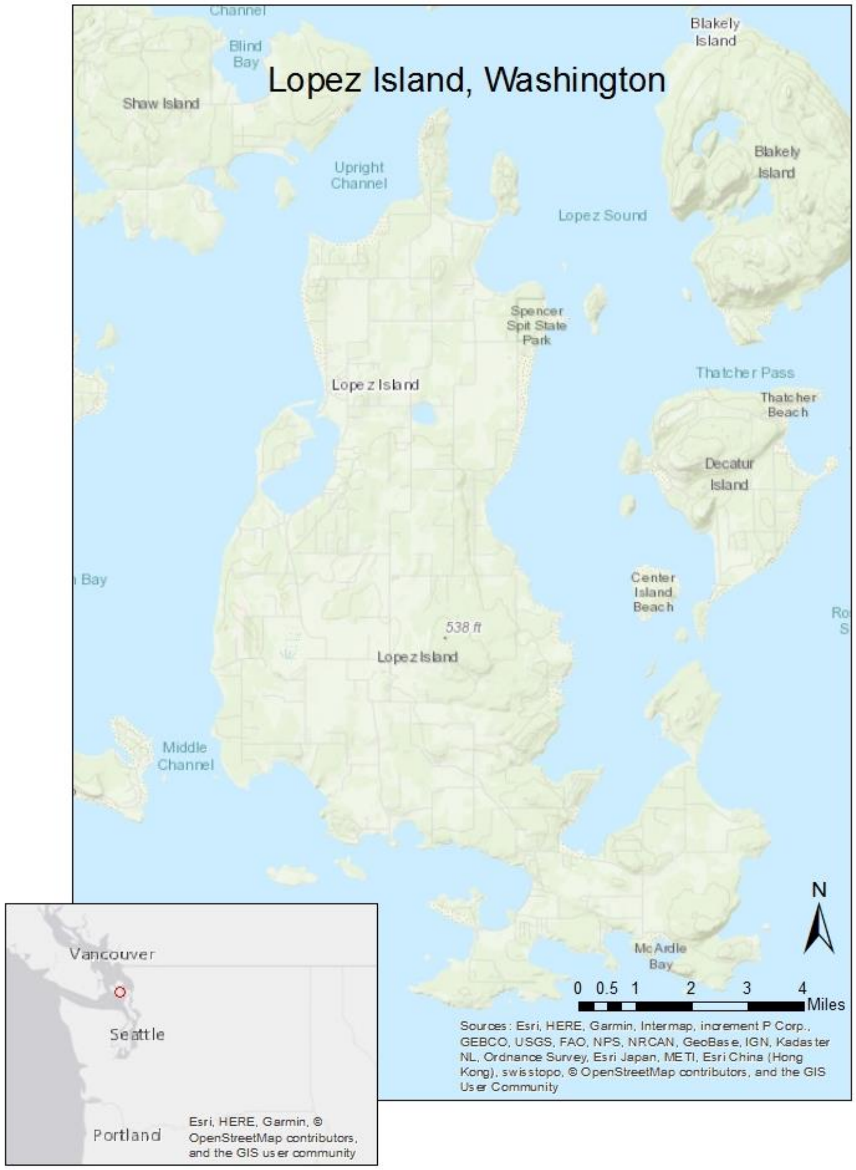

Figure 2. Map of Lopez Island and the Surrounding Islands. This map was created using ArcGIS® software by Esri. ArcGIS® and ArcMap™ are the intellectual property of Esri and are used herein under license. Copyright © Esri. All rights reserved. For more information about Esri® software, please visit www.esri.com.

Geology

The San Juan Islands were initially formed through the collision of tectonic plates in the San Juan Thrust System, and were further shaped by movement of the Juan de Fuca lobe of the Cordilleran ice sheet (Graham 2014; Porter and Swanson 1998). Lopez

Island was shaped through this glaciation action. The bedrock of Lopez Island is primarily made up of metamorphic deposits formed by plate movement (National Park Service 2015). Due to glacial movement, rock outcrops with small beaches underneath make up much of the island's coastline (Bureau of Land Management 1990). There is still evidence of glacial striations on the exposed bedrock in areas such as Iceberg Point (Figure 3) which are the result of glacial movement (University of Washington Publications in Geology 2006).

Figure 3. Glacial Striations Visible on Iceberg Point, Lopez Island. Photo credit: Patrick T. McCutcheon.

Soils

Glacial sediments, quaternary alluvium, and colluvium mantle the bedrock of Lopez Island (Regan 2009). The island's soils have formed through the weathering of these sediments. Lopez Island soils are dominated by inceptisols and alfisols, although there are also mollisols, entisols, and histosols present throughout the island (Regan

2009). According to the soil survey of San Juan County, Lopez Island is made up of five major soil units, each unit associated with a specific soil series. The most common soil units present on Lopez Island are those on glacial drift plains and in valleys of glacial drift plains (Regan 2009). The soils made up of glacial outwash (such as San Juan or Hoypus soils) tend to have higher organic matter presence and some volcanic ash, which increases the available water for vegetation (Regan 2009). Soils made up of colluvium with some glacial drift (such as Cady and Haro soils) appear in areas with thinner or eroded sediment deposits over bedrock, so the root zone is in contact with the bedrock (Regan 2009). These conditions impact the kinds of vegetation that can grow there–plants that require less water and space for their roots thrive better in colluvial sediments than the glacial outwash soils on Lopez Island. Lopez Island soils are also impacted by topography. Soils in north-facing slopes such as Everett and Hoypus soils get more protection from the sun and winds, so they have more forest vegetation than south-facing slopes (Regan 2009). Soils in lower areas and drainages such as Semiahmoo soils have a higher concentration of organic matter, which can result in the grown of more lush vegetation that requires more water (Regan 2009). The soils across Lopez Island impact the available nutrients and water for plants, leading to its varied microenvironments. Table 8 in Chapter 3 lists all the soil series present on Lopez Island by their respective soil orders and depicts the array of different soils present on the island.

Climate

The paleoclimate of the Pacific Northwest region experienced several changes throughout the late Pleistocene and Holocene periods. The late Pleistocene and early Holocene was characterized by a cool climate, caused by the late presence of glaciers

(Walker and Pellatt 2008; Walsh et al. 2010). From 10,500-8000 before present (BP) the climate shifted towards a warmer, drought trend with longer summers (Walker and Pellatt 2008, Walsh et al. 2010). The climate became cooler and moister again from 8000-4000 BP, and stabilized to be cooler but drier from 4000 BP until European contact (Walker and Pellatt 2008; Walsh et al. 2010). The retreat of glaciers from the region at the end of the Pleistocene is hypothesized to be a major cause of change in paleoclimate in the Pacific Northwest (Walker and Pellatt 2008:129). These changes in climate throughout the Holocene led to significant impacts on the biota and overall environment of the Pacific Northwest.

Because of Lopez Island's location in the rain shadow of the Olympic Mountains, its climate tends to be drier and sunnier than much of western Washington (Siler et al. 2012). The modern climate at Lopez Island is mild with the average high being 67.6° F and an average low of 36°, and the average annual precipitation is around 40.6-43.2 centimeters (Bureau of Land Management 1990). Most of this precipitation comes in the form of rain throughout the winter months, as the area gets little snow during the winter (Phillips 1960). The study area's climate is characterized by mild summers and cool winters with some rain and little snow (Suttles 1990).

Fire History

Throughout the middle to late Holocene there was an observed increase in fire activity throughout the Pacific Northwest, potentially due to changes in climate and/or an increase in anthropogenic burning (Walsh et al. 2015). Analysis of charcoal records from the Pacific Northwest show that prior to 10,000 BP, the region had a frequent fire regime that declined until about 8000 BP (Walsh et al. 2015). During the middle to late Holocene fire frequency increased again, which Walsh et al. (2015) interpreted as either a response to increasing climate variability or the increase of anthropogenic burning. After 900 BP the frequency of burning decreased, potentially due to climate and population changes in the Pacific Northwest (Campbell and Butler 2010; Prentiss et al. 2005, Walsh et al. 2015). Evidence of anthropogenic burning is visible in the fire record on Lopez Island. Spurbeck and Keenum's (2003) analysis of fire scars at Iceberg Point and Point Colville shows that there was a regular and frequent fire regime prior to about a century ago. The authors estimate that the fire regime prior to a century ago occurred at an interval of 11 to 15 years, which may be due to natural causes as well as changes in human prescribed burns (Spurbeck and Keenum 2003). Another fire study conducted on Lopez Island and San Juan Island indicated fire intervals of 120 to 170 years (Coffey et al. 2019). Fire suppression techniques starting in the nineteenth century leading up to today have resulted in a large decline in fire frequency (Marlon et al. 2012; Walsh et al. 2015).

Biota

The flora of Lopez Island is varied, both on the island and in the waters surrounding it. The marine and coastal environments of Lopez Island contain plants such as rockweed (*Fucus distichus*), sea lettuce *(Ulva spp.*), and false Irish moss (*Mastocarpus stellatus*), which are abundant in the waters around the island (Puget Sound Institute 2018). Seaweeds such as sea lettuce were used by Native people as a food source and a replacement for salt, as well as an addition to foods cooked in steaming pits to add flavor and moisture to the food (Turner and Bell 1971). The forested area in the interior of Lopez Island includes trees and shrubs such as Douglas-fir (*Pseudotsuga menziesii*), alder (*Alnus rhombifolia*), wild rose (*Rosa pisocarpa*), and salmonberry (*Rubus spectabilis*)

(Bureau of Land Management 1990). The meadows provide habitat for forbs such as great camas (*Camassia leichtlinii*), chocolate lily (*Fritillaria lanceolata*), and sheep sorrel (*Rumex acetosella*) (Atkinson and Sharpe 1993). Past studies showed that natural factors such as fire and wind act as selective agents on the plant life throughout Lopez Island, resulting in the distinct plant regions on the land (Rust 1992).

The diverse inland terrain on Lopez Island is also home to a variety of animal species available to people on Lopez Island. Black-tailed deer (*Odocoileus hemionus columbianus*) and other smaller land mammals inhabit the forested region which provides plenty of cover (Bureau of Land Management 1990). The region is also used by birds such as different waterfowl which were a valuable food resource, as well as bald eagles (*Haliaeetus leucocephalus*) due to its ideal location next to the water and tree shelter (Bureau of Land Management 1990).

Marine mammals such as orcas (*Orcinius orca*), harbor seals (*Phoca vitulina*), and Stellar sea lions (*Eumetopias jubatus*) are commonly seen in the waters and near the reefs off Lopez Island (National Park Service 2015). Other marine mammals that are often seen in the Salish Sea around Lopez Island include sea otters (*Enhydra lutris*), harbor porpoises (*Phocoena phocoena*), and Dall's porpoises (*Phocoenoides dalli*) (MacDuffee et al. 2016). Mollusks including the Pacific littleneck clam (*Leukoma staminea*), bay mussel (*Mytilus trossulus*), and butter clam (*Saxidomus gigantea*) were another source of food for people (Dall 1921; Stein 1992).

Over 200 different species of fish have been recorded in the waters off the San Juan Islands, with some notable species being the Chinook/King salmon (*Oncorhynchus tshawytscha)*, Coho salmon (*Oncorhynchus kisutch)*, Pink salmon (*Oncorhynchus* *gorbuscha*), Sockeye salmon (*Oncorhynchus nerka*), and Steelhead (*Oncorhynchus mykiss*), as well as bottom fish such as flounder varieties (Pleuronectidae) and cods (Gadiformes) (Pietsch and Orr 2015). Pacific herring (*Clupea pallasii*) are another significant fish species in the Salish Sea. Herring spawning stocks have been recorded throughout the interior of the San Juan Islands, including off the southeast coast of Lopez Island (The Salish Sea Pacific Herring Assessment and Management Strategy Team 2018). The abundance of marine plants and animals around Lopez Island provided important resources for Native people who occupied the island. The species diversity both on Lopez Island and in the waters around it created a natural environment rich in available resources for precontact peoples.

Cultural Setting

The San Juan Islands are home to the Native American people collectively known as the Straits Salish, as shown in Figure 4 (Suttles 1990). The Lummi, Samish, Sooke, Songhees, and Semiahmoo tribes as well as the Saanich First Nations are all affiliated with the island and the surrounding areas and are collectively referred to as the Straits Salish due to their shared linguistic and cultural traditions (Suttles 1990). Suttles (1951) also considered the individual Straits Salish groups to have a similar culture due to commonalities in their adaptation to life in marine areas and their focus on reef-netting salmon for subsistence.

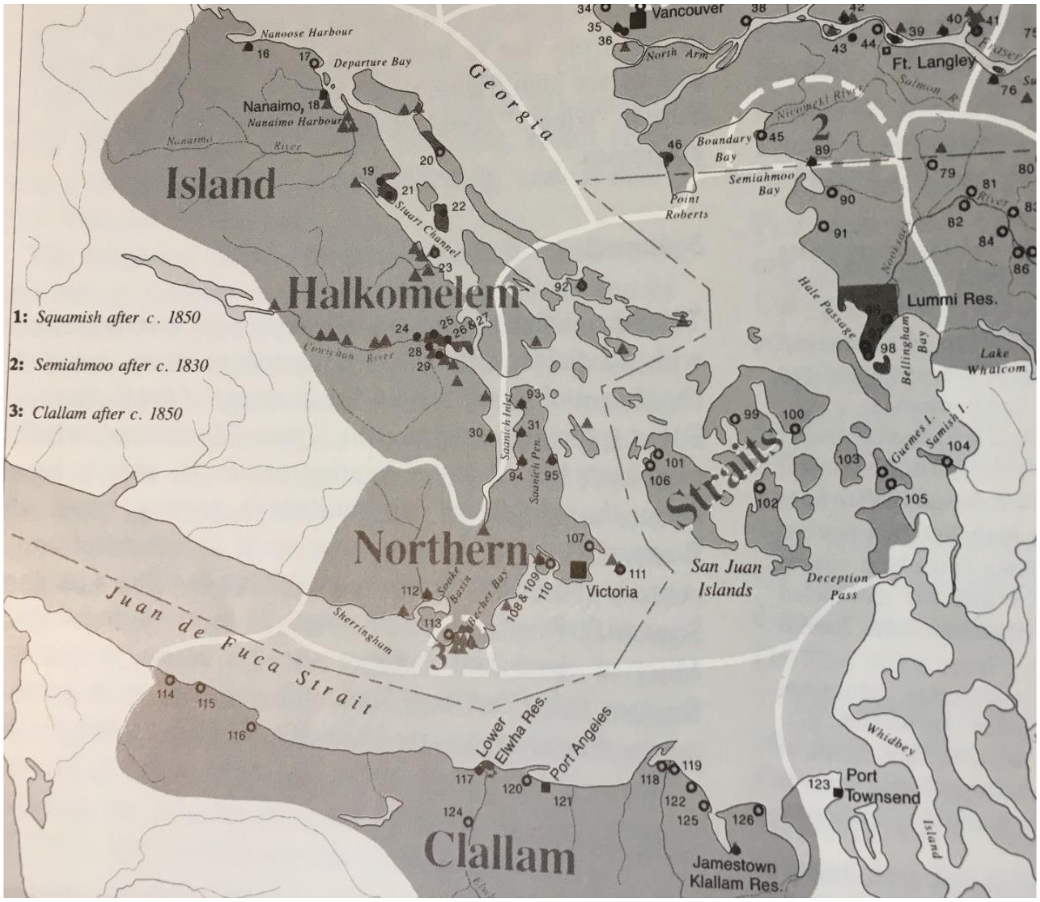

Figure 4. Territories and Principal Villages of the Central Coast Salish in the early 19th Century (Suttles 1990:454).

Because of its large fish population and plant resources, the San Juan Island region was an ideal place for humans to live. Acquisition of food resources was based on a seasonal schedule in which people would travel to different locations to gather the appropriate resources (Burley 1980; Stein 2000; Suttles 1990). Salmon was a major source of food, and teams of men would use reef nets to catch thousands of fish in a day (Suttles 1990). Zooarchaeological studies have shown that this use of salmon by humans in the Pacific Northwest remained constant for the last 7,500 years, indicating that people continued sustainable harvesting of the fish despite varying environments (Campbell and Butler 2010). Pacific herring were just as important of a resource and appear to be as widely used as salmon by people in the Salish Sea (McKechnie and Moss 2016). Migratory birds were another food resource, and Bovy's (2005) study of Watmough Bay (45SJ280) on Lopez Island showed that from AD 300 to 700 there was a shift in abundance from double-crested cormorant (*Phalacrocorax auratus*) to diving ducks (Aythyinae) in the archaeological record, and indicated the use of these waterfowl as a food resource.

Edible plants were another major food resource, with plants such as camas being a major source of starch and nutrients (Kramer 2000; Suttles 2005; Thoms 1989). In order to continue a supply of camas bulbs every year, people would use cultivation techniques to ensure the health of the plants and soil (Stein 2000; Suttles 1990). Large Straits Coast Salish families would often own resource areas such as camas prairies and reef net fishing spots, and could allow others to have access to them if they wanted (Suttles 2005). Ownership of these resource areas may have contributed to the social inequality and hierarchies that are also part of many Northwest Coast cultures (Ames 1994).

Europeans came to the San Juan Islands when Juan de Fuca, a Spanish explorer, arrived in 1543 and traveled throughout the Puget Sound region (Camfield 2000). Years later, Charles Barkley came to the region in 1787 to further the fur trade on the American West Coast (Suttles 1990). This led to an influx of Euro-Americans into the region, which only increased when mining took off in the 1850s (Suttles 1990). Some Native American groups participated in the fur trade and interacted with the Europeans but the influx of settlers led to the Native American population shrinking due to diseases, falling to about 7,000 people during the late 19th century (Fisher 1992; Suttles 1990). Today the population has slightly increased, but Native Americans only account for 1.3% of the total population in the state of Washington (United States Census Bureau 2015). As of 2015, San Juan County had an overall population of 16,252 people, and Lopez Island had a year-round population of 2,177 people (United States Census Bureau 2015). Today, the San Juan Islands region is known for being a large tourism area, so many people only live there seasonally.

CHAPTER III

LITERATURE REVIEW

The structure of this literature review is divided into four sections, in order of the objectives listed in Chapter 1. The first section reviews literature on Salish Sea archaeology, which sets the research context for the region. The second section outlines the history of archaeological research conducted on Lopez Island to show the extent of investigation that has been conducted on the island. Section three describes methods of functional analysis that provide the basis for the functional analysis of sites used in this thesis. Finally, the fourth section reviews literature on the theory of selective conditions and resource intensification which provides the foundation for the theoretical basis of this thesis's analysis. The sections in this literature review aid in developing a foundation to illustrate how known Lopez Island archaeology can be used to address research questions about potential bias in site sampling, how Lopez Island archaeology can be used to address data gaps, and determine possible locations of unknown sites.

Salish Sea Archaeology

Understanding common archaeological remains found throughout the Salish Sea region is crucial to pinpoint research questions that can be applied when investigating Lopez Island archaeology, and this section provides the greater regional context for the Lopez Island sites investigated in this thesis.

The archaeological chronology of the Northwest Coast is summarized into five general phases by archaeologists (Table 1): Paleo-Indian, Olcott-Cascade, Locarno Beach/Mayne/St. Mungo, Marpole, and San Juan Phases (Boxberger 1989; Burley 1980;

Moss and Erlandson 1995; Stein 2000; Thomas 2006). These phases characterize the archaeology of the region from 11,000 BP up until European contact.

Table 1. Precontact Regional/Local Chronology of the Salish Sea (Boxberger 1989; Burley 1980; Moss and Erlandson 1995; Stein 2000; Thomas 2006).

Time Period (BP)	Common Name	Description
11,000-9000	Paleo-Indian	Fluted Clovis points in lower Puget region, end of Pleistocene glaciation, increase in lodgepole pine and grasslands, hunting of megafauna and marine mammals.
9000-4500	Ollcott-Cascade	Little to no use of marine resources, stabilized climate, Douglas fir replacing lodgepole pine forests, rising sea levels impacting shoreline regions until 5000 BP.
4500-2500	Locarno Beach/Mayne/St. Mungo	Intensification of marine resources, increase in human populations, shellfish and faunal remains common, presence of stemmed, bone, and woodworking tools, cedar and hemlock forests develop.
2500-1500	Marpole	Carvings, basketry, and ground stone tools common, sedentary strategy with seasonal rounds for gathering resources, more focus on marine resources, greater use of shellfish based on middens, more year-round activity on islands.
1500-1800s CE	San Juan	Shoreline similar to modern conditions, more focus on wooden tools, semisedentary rounds focusing on camas, clam harvests, and fishing, stratified society based off resource area ownership.

The archaeology of the Paleo-Indian Phase (11,000-9000 BP) is characterized by the presence of Clovis points (Stein 2000). There have not been any Clovis points found in the San Juan Islands, however Clovis points have been found in the south Puget Sound and on Whidbey Island (Stein 2000). This phase is used to describe the earliest known presence of humans in the Pacific Northwest and North America, since Paleo-Indian sites are associated with the late Pleistocene to early Holocene periods. Although no Paleo-Indian sites have been identified on Lopez Island, on neighboring Orcas Island faunal remains from a *Bison antiquus* with signs of butchering was dated to 11,760 ±70 to 11,990 ±25 ^{14}C BP (Kenady et al. 2011). The presence of late Pleistocene human activity on a neighboring island means that there may have also been human activity on Lopez Island during the same period.

The Olcott-Cascade Phase (9000-4500 BP) is characterized by a predominant use of terrestrial animals as a resource, although fish and marine mammals are also represented in sites from this period (Matson and Coupland 1994). Faunal remains from this phase were found at nearby Cattle Point on San Juan Island, indicating human use of terrestrial mammals (Stein 2000). Despite their proximitiy to an abundance of marine resources, humans in this time period relied on terrestrial animals such as deer and elk as well as plant resources for their main source of food. Although first believed to be a spot for monitoring marine mammals, the DeSteffany Site (45SJ414) on San Juan Island was reinterpreted as a potential site for hunting terrestrial mammals, due to its early Holocene location in "parkland/grassland" and the presence of many chipped stone tools (Kenady et al. 2008:107). Cascade-style lithic tools, which are typically formed in a leaf shape, are also characteristic of the Ollcott-Cascade phase and were also found in excavations of Cattle Point (Stein 2000). This phase is also associated with a shift in settlement and subsistence patterns at approximately 5000 BP (Ames and Maschner 1999). Intensification of resources in the region during this period is believed to be a cause for more sedentary settlement patterns in the Salish Sea, which are observed in the Mayne/St. Mungo and Locarno Beach phases.

The Mayne/St. Mungo and Locarno Beach phases collectively range from approximately 4500-2500 BP. The major marker of this time period is the presence of shell and shell middens in the archaeological record (Burley 1980). The increase in shell middens allowed for better preservation of bone at sites from this period, providing more data for archaeologists. The Mayne/St. Mungo and Locarno Beach phases are also characterized by an increase in various lithic technologies such as microblades, ground stone tools, and stemmed chipped stone points, although chipped stone technology began to gradually decrease in frequency in favor of ground stone technology (Ames et al. 2010; Matson and Coupland 1994). The increase in adzes and other woodworking tools during this period is hypothesized to be a result of an increase in populations of western red cedar throughout the region (Stein 2000). Sites from this timespan also contain other artifact types such as basketry and bone tools (Matson and Coupland 1994).

The Marpole Phase (2500-1500 BP) continues the earlier trend of ground stone tools such as adzes being prevalent in the archaeological record (Matson and Coupland 1994). Antler harpoons are also more prevalent in Marpole sites than older sites, and copper body-adornment and “abstract non-utilitarian” artifacts have also been discovered in burial contexts as well (Hunt 2015:2; Matson and Coupland 1994). Based on the large increase in shell midden sites dating to this period, populations in the San Juan Islands appeared to have expanded (Stein 2000). This may be due to environmental changes throughout the region which allowed for greater resource availability to sustain larger populations. The Marpole Phase is also notable due to an increase in artifacts such as weavings and carved tools that contine as traditions for the Native people of the Northwest Coast today (Stein 2000).

The San Juan Phase (1500 BP-contact) is characterized by the further decrease of chipped stone tools in favor of bone and antler tools as well as ground stone artifacts

(Ames et al. 2010; Matson and Coupland 1994). Wood was also a common tool material throughout this period (Stein 2000). Defensive trenches, or trench embankment sites, have been dated to the San Juan Phase and may be indicative of warfare between communities (Matson and Coupland 1994). The archaeological remains of these defensive trenches appear across the San Juan Islands, including 45SJ288 on Lopez Island (David Munsell, personal communication 2017; Wessen 1986c).

In the past, there has been a focus on marine-adjacent sites over terrestrial archaeology, indicating a bias in the research towards coastal sites which can also lead to "midden-centrism" (Weiser and Lepofsky 2009). Shell middens, comprised of shell and other cultural materials, are common site types throughout the Northwest Coast which can contain valuable data since their alkaline conditions preserve organic material well in otherwise acidic soils (Álvarez et al. 2010; Stein 1992).

Researchers also use radiocarbon dating on cultural materials from middens such as charcoal and bone to determine site age, as Taylor et al. (2011) did with 41 shell-midden sites throughout the San Juan Islands including 8 sites on Lopez Island to investigate site settlement patterns and occupation. They radiocarbon dated auger samples from each of the sampled sites, observing a peak in dates from 650-300 BP (Taylor et al. 2011:308). Seven sites from Lopez Island were dated to this range. They compared the data to studies in the Fraser Valley in British Columbia which also sampled from middens, and noted that their higher frequency of dates during this period was potentially indicative of a climactic shift which may have impacted the San Juan Islands before other regions and resulted in more access freshwater and other resources (Taylor et al. 2011). They also observed an increase in midden accumulation rates after 650 BP, which they hypothesized was due to population increase and longer use of the sites throughout the year (Taylor et al. 2011). Due to a paleoclimatic shift towards more precipitation in the San Juan Islands after 600 BP, the authors hypothesized that the sampled midden sites would be closer to freshwater resources before 600 BP and have more variability in distribution after that time. They found that there was no correlation between shell midden site locations and freshwater stream access at their sampled sites over time, although factors such as how people actually traveled to access water may have been different than the distance to freshwater they measured (Taylor et al. 2011). Midden sites in the Salish Sea can provide information for comparison to other regions due to their wealth of preserved material and being studied consistently throughout coastal regions.

The presence of lithic artifacts in Salish Sea sites provides data on precontact activity at the sites where they occur. Analysis of lithic tools from Northwest Coast sites has been used to infer the extent that cultural transmission of tool technology can be connected to changes in social organization that emerged by the Marpole phase (1100-2400 BP) (Rorabaugh 2014). The changes in lithic artifact morphology over time can provide further data that can help archaeologists attempt to understand changes in social organization and access to restricted knowledge in creating tools that occurred throughout the Salish Sea (Rorabaugh 2015).

Microblade technology is another characteristic of Salish Sea lithic tools, and is associated with the Locarno Beach Phase (4500-2500 BP) (Mitchell 1968; Matson and Coupland 1995). A study by Kannegaard (2015) investigated the function of quartz crystal microblades throughout the Salish Sea and concluded that the tools had multiple uses in both processing and potentially ceremonial activities. Ground stone adze technology is also common in Salish Sea archaeological sites (Mackie 1995; Stein 2000). Sites at Ebey's Prairie on Whidbey Island contained lithic assemblages of chipped stone flakes, ground stone, and cores that were interpreted as evidence of hunting, manufacturing stone tools, cooking, and processing food (Weiser 2006; Weiser and Lepofsky 2009). Research like that conducted at the Ebey's Prairie site shows how lithic tools can provide further information on human activity that occurred at Salish Sea sites.

Other artifacts such as faunal, textile, and wood remains are also part of the Northwest Coast archaeological record and are sometimes well preserved due to their presence in shell middens and wet sites. The Marpole Phase (2500-1500 BP) is marked by an increase in antler tools such as harpoons, and the San Juan Phase (1500 BP-contact) is characterized by a large increase in worked bone and antler tools, pointing towards an increasing use of faunal remains as tool materials over time (Matson and Coupland 1994). Zooarchaeological remains may indicate people's interaction with animals in the area, especially fish. Butler and Campbell (2004) analyzed animal remains from sites on the Northwest Coast and the Columbia Plateau, noting the abundance of fish remains at sites located on the coast, as well as deer and elk remains found at almost all coastal sites studied. Bovy (2005) researched a collection of bird bones from the Watmough Bay site (45SJ280) and observed a change in frequency from double-crested cormorant (*Phalacrocorax auratus*) to diving ducks (Aythyinae) in the archaeological record between 1650 and 1250 BP. Although marine faunal remains are prevalent throughout Salish Sea sites, bird remains like those found at Watmough Bay can also show how people did not just rely on fish and mammals as food resources and possibly indicate changes in diet.

Basketry is another characteristic artifact type of Salish Sea archaeology. Moss (2011) details how archaeologists have discovered traces of wood and textile artifacts, technologies that are recorded in ethnographies and are still created by Native Americans throughout the region today. Croes's (2019) analysis of basket items from water-saturated sites on the Northwest Coast investigated a chronological continuity of basket styles determined the function of various areas at the sites based on the kinds of basketry found there. The variety of basketry found throughout sites on the Northwest Coast provides information about the kinds of human activity that occurred at sites and the sites' function, as well as the kinds of resources people were using and transporting.

Previous Lopez Island Research

Understanding the previous research conducted throughout Lopez Island aids in placing the island's archaeology into its regional context, as discussed in the previous section on Salish Sea archaeology. As of May 2019, there were 56 individual sites recorded on Lopez Island, each with varying levels of archaeological investigation. The majority of recorded sites were investigated as a result of compliance archaeology and cultural resource management, so there have not been many in-depth analyses of Lopez Island sites. This section provides an overview of the history of archaeological research conducted on Lopez Island, from the earliest expeditions to more recent academic studies. Reviewing the history and extent of archaeological investigations on Lopez Island provides this thesis with data to be used in developing the functional analysis, and shows the kinds of studies that support what we currently know of the archaeological record of the island.

The earliest recorded research conducted on Lopez Island dates to the early 1900s with Harlan I. Smith's (1907) research conducted during the Jesup North Pacific Expedition. Smith recorded cairns and rock art in the Strait of Georgia, and later conducted surveys along the coast and in the San Juan Islands, including Lopez Island (Suttles 1990). Smith's work on the San Juan Islands and was mainly descriptive since most of the archaeological research done at the time was exploratory (Matson and Coupland 1994; Suttles 1990). Further research emerged after World War II due to increases in funding and public interest (Matson and Coupland 1994). The earliest recorded sites on WISAARD are 45SJ185 and 45SJ186, which are noted as being tested by Liston and Forbes in 1949 (Wessen 1986a). Further investigation was carried out by University of Washington field schools in the 1960s. Robert Greengo conducted a field school that excavated at "several Lopez Island sites" in the early 1960s (Wessen 1988). Another University of Washington field school led by David Munsell in 1968 conducted data recovery excavations at multiple sites on Lopez Island including Watmough Bay (45SJ280) and at Iceberg Point (45SJ288), and collected artifact and sediment samples from sites 45SJ215, 45SJ254, 45SJ278, and 45SJ280 that are still housed in the Burke Museum at the University of Washington (David Munsell, personal communication 2017). These initial investigations provided early descriptions of the archaeological record on Lopez Island (and collections for study in the case of the 1968 field school).

Wessen (1988) surveyed San Juan County including Lopez Island during 1986 and 1987 to confirm and document the location of previously recorded sites and sample for new sites throughout the county for the Washington Department of Archaeology and Historic Preservation. The main goal of the study was to gather descriptive data for the sites and determine if there were any “empirical patterns” between the sites (Wessen 1988:25). During the study he visited the locations of previously recorded sites to inventory them and describe each site. The second aspect of the project was survey by sampling from previously understudied microenvironments in the county, primarily using plant communities as microenvironments due to their visibility (Wessen 1988). During the survey, 30 sites on Lopez Island were either updated or discovered. This survey resulted in a classification of the studied sites by six site types: shell midden sites, rock cairn sites, lithic sites, earthworks sites, rock art sites, and wet sites (Wessen 1988:40). The survey also allowed Wessen (1988) to evaluate the conditions and stability of each previously recorded site and note the kinds of changes that had occurred since initial recording. Given the findings of this project, Wessen made recommendations for future study that are the basis of this thesis. This report was one of the most comprehensive summaries of San Juan County archaeology at its publication and provided a basis for further research throughout the county and on individual islands.

Thomas’s (2006) thesis evaluated Iceberg Point, a BLM owned parcel on the southern end of Lopez Island, as an ethnographic landscape that may be eligible for the National Register of Historic Places. Using the National Park Service cultural landscape evaluation, Thomas described the cultural and natural history of Iceberg Point to provide the BLM with information that could be used to better manage the cultural resources on Iceberg Point. Ethnographically Iceberg Point was known to be a camas prairie where people cultivated the plant for food, but it was also reported to be adjacent to an important reef-netting site (Suttles 1951; Thomas 2006). Thomas's thesis provides context for human activity on camas prairies like that at Iceberg Point by illustrating the connection that may have existed between marine and terrestrial resource areas and their ownership by different familial groups. It also illuminates various issues with conducting fieldwork in areas on the island that have thick vegetation and sites that are not immediately visible, since much of Iceberg Point is currently thickly forested. There are three recorded sites on Iceberg Point, all of which are located on the water. One of the sites, 45SJ522, was interpreted as a potential precontact camp site with a debitage flake, shell, and charcoal (Sweeney 2010a). The adjacent site (45SJ523) is a shell midden with fragments of faunal remains (Sweeney 2010b). The third site located on the northwest edge of Iceberg Point (45SJ288) is a shell midden as well, but also contains a trench feature that runs north to south across the site (Wessen 1986c). The archaeological research conducted on Iceberg Point provides information on the resource use and potential defensive activity in the area, however Thomas's (2006) thesis suggests that more investigation inland on Iceberg Point may provide further information on the terrestrial resource use there.

Lopez Point on Fisherman Bay on Lopez Island is the location of seven recorded sites. The area is associated with traditional Lummi settlements close to reef-net fishing areas in the bay (Suttles 1951). A survey and site assessment of San Juan County Land Bank property on Lopez Point identified and assessed four sites in the area (Wessen 2003). A large shell midden site (45SJ254) contained shell, faunal remains, chipped stone debitage, charcoal, and fire modified rock (FMR) (Wessen 2003). A lithic scatter site with some midden deposits (45SJ440) north of 45SJ254 contained numerous flakes as well as some fragmented faunal remains and FMR (Wessen 2003). Two additional lithic scatter sites (45SJ441 and 45SJ442) were also recorded during the survey (Wessen 2003). An additional shell midden site (45SJ261) was also recorded on the southwest end of Lopez Point (Wessen 1986b). The archaeological record on Lopez Point shows that while there was use of resources like shell and fish at the settlement, there was also significant lithic processing throughout the area.

Watmough Bay (45SJ280) on the southeast part of Lopez Island is a shell midden site that has been the subject of multiple excavations and studies. The site was traditionally a camp for Straits Salish peoples who stayed there while reef-net fishing off nearby Watmough Head and Point Colville (Suttles 1951). The University of Washington 1968 field school conducted by David Munsell first excavated at the site, and Wessen later surveyed the site for his 1988 report. Bovy (2005) analyzed bird remains collected from the site during the 1968 field school to determine the species of birds consumed at the site, and whether the frequency of those species changed over time. She also radiocarbon dated charcoal from the excavation, providing dates for many of the bird remains which showed that there were probably two short but intensive human occupations at the site around CE 300-700 (Bovy 2005).

The Watmough Bay shell midden was investigated further during the Watmough Bay Site Stabilization Project in 2004, which included data recovery from the original excavation done in 1968 and for an erosion stabilization project that was planned for the area (Bovy et al. 2007). The authors of this project confirmed stratigraphy of the site from the 1968 records, radiocarbon dated charcoal from the site, analyzed faunal remains, and documented new features. They found that charcoal samples ranged in uncalibrated age from 2480-2870 BP inside the hearth feature to 780-850 BP at the top of the sampled unit, showing the range of occupation dates for the site (Bovy et al. 2007). New features recorded included a hearth feature containing lithics and faunal remains, and charcoal sampled from throughout the site was DNA tested to identify the kinds of wood used there including Douglas fir (*Pseudotsuga menziesii*), red cedar (*Thuja plicata*), and alder (*Alnus* sp.) (Bovy et al. 2007). These dated samples were also compared to charcoal, shell, and bone dates done between 1998 and 2004 from the 1968 Watmough Bay excavation collections, showing two major clusters in samples dating to 2850-2550 BP and 1650-1250 BP (Bovy et al. 2007).

The faunal remains collected during the site stabilization project also provided further insight into the human activity at the site. The faunal analysis showed that the site was likely used year-round, and more intensely used during the salmon run periods (Phillips et al. 2007). Juvenile deer, elk, harbor seal, and birds were noted as common in the assemblage, which the authors interpreted as a higher level of procurement during the summer season (Phillips et al. 2007). The authors also observed evidence of heat treatment and potential cooking on the faunal remains at Watmough Bay, especially among salmon bones from one of the excavation units (Phillips et al. 2007). The extensive investigations done for the Watmough Bay site show how much data can be gleaned from one site on Lopez Island as well as methods that could be applied to less studied sites throughout the island. However, there are many other sites on Lopez Island that have not been the subject of such in-depth research, and the main source of information on those sites is typically site forms.

The majority of research carried out on Lopez Island has been compliance archaeology. The Washington Department of Archaeology and Historic Preservation's WISAARD (Washington Information System for Architectural and Archaeological Records Data) database contains the majority of site reports and forms completed for compliance archaeology. These forms and reports tend to have less intensive analysis of cultural materials at the sites than the previously discussed studies, and tend to focus on the cultural materials present and site location. Shell midden sites such as 45SJ371 contain a variety of cultural materials such as burned mammal bone, flakes, bifaces, and fire modified rock (Thomas and Muschal 2016). With more intensive investigation, sites like 45SJ371 might provide extensive information on precontact activity on Lopez Island due to midden preservation. Lopez Island also has several recorded rock cairn sites, which can often be an indicator of burials. These sites were initially observed by Smith (1907) and are usually described as piles or stacks of larger rocks that are typically locally available (Kenady 1998; Wessen 1999). Other cultural materials recorded at Lopez Island sites are lithics, faunal remains, and ground stone. The constraints of compliance archaeology mean that much of the recorded archaeology on the island is only at the level of materials observed, and most of the island's sites have not been the subject of interpretation or studies like those done at Watmough Bay. The extent of archaeological research on Lopez Island can provide information on precontact human activity that will be synthesized through developing a functional analysis, such as those reviewed in the following section.

Functional Methods of Classifying and Analyzing Sites

This section examines the development and use of functional analyses for archaeological sites and assemblages to develop the functional analysis model described and used in the Methods chapter. Dunnell (1978b:51) laid out a framework for analyzing function in the archaeological record scientifically where he defines prehistoric function (referred to in this thesis as precontact function) as "the artificial relationship that obtains between an object at whatever scale conceived and its environment both natural and artificial." In the slightly larger context of archaeological sites, this can include the defined natural environment of and around a site, as well as whatever human activity occurred at the site or any cultural meaning given to the site that is understood through the artifacts and cultural materials found there (Dancey 1973). In functional analyses that look at the microenvironments of different sites such as performed by Dancey (1973) and Thompson (1978), analyzing sites by their microenvironmental characteristics allows for further comparison of function between different sites.

Inter-site functional analyses provide further examples of how this method can be used to look at archaeology on a larger scale than artifacts. Thompson (1978) developed a functional analysis to compare sites throughout the Salish Sea and their microenvironments in order to understand the impact that microenvironments may have on the function of sites. Cluster analysis sorted sites into settlement types based on different microenvironmental factors such as geomorphology, locations of freshwater and saltwater, and plant environments (Thompson 1978). By sorting sites based on the different microenvironmental factors that may have impacted human activity, Thompson (1978) showed how trends in site and settlement function can reveal biases towards specific microenvironment types. She then used cluster analysis to test the usefulness of the functional microenvironment types and to see if certain assemblage clusters were associated with specific microenvironments. The cluster analysis showed that multiple clusters showed up in the same environment, indicating that influences beyond function such as environmental change or functional change over time may have influenced the distribution (Thompson 1978). Thompson also proposed that the cluster analysis results show that the microenvironmental definitions used may have been too broad or developed incorrectly. The incorporation of microenvironments in functional analyses shows how sites' environmental contexts can be used to further understand the function of the sites during their use, and how the analysis results can be tested to determine whether they accurately reflect the function of sites.

Campbell's (1981) analysis of the Duwamish No. 1 shell midden site used a functional analysis to classify artifacts from the site by dimensions such as use wear, shape, and technology type (Campbell 1981:255). The analysis of the artifacts found at the site were used to infer the function of different areas within the site, as well as to build a site chronology that would allow for comparisons to other sites in the region. Campbell's analysis showed how intra-site functional analysis can be used to develop inter-site comparisons in order to better understand trends on the regional scale. Similarly to Thompson's (1978) study, Campbell's (1981) study provides an example of how a functional analysis within a site might be applied to cross-site comparisons.

Functional analysis can be used at the artifact level to understand the impact that function has on tool morphology. Rorabaugh (2015) used a functional analysis to understand the impact that cultural transmission had on the variation of lithic technologies among the Coast Salish people. Using the cultural transmission assumption that restricted access to certain technological knowledge would reduce variation in style over time, Rorabaugh (2015) used a discriminant function analysis to separate unstemmed arrows and darts from the sample of stone tools. After cross-referencing the analyzed artifacts with dating information from their respective sites, Rorabaugh pointed out that the changes in point technologies from darts to arrows can be linked to increased diversity of land mammal resources throughout the Salish Sea. Artifacts dated to the Marpole period also displayed a decrease in stylistic variation when compared to older sites and artifacts, which Rorabaugh (2015) interpreted as being a result of increasing restricted access to technological knowledge.

Middleton's (2017) thesis used a functional analysis to compare plow-zone and excavated artifact assemblages within one Skagit Valley site and to compare that site's assemblages with similar sites in the region. Middleton used a paradigmatic classification system to sort artifacts from the studied assemblages into functional classes used to interpret the excavated collection. This classification was followed by a statistical analysis to compare within and between site assemblages (Middleton 2017). This functional analysis showed how artifact assemblages can be compared to understand the data potential for future study, and provides further background for developing a functional classification that allows for comparing between sites.

Resource Intensification on the Pacific Northwest Coast

This section reviews literature on resource intensification, which as used in this thesis is an evolutionary archaeology explanation for human adaptation to changing selective conditions in the Salish Sea. This theoretical framework was developed for the functional analysis, which is detailed in the following Methods chapter. In evolutionary archaeology, the selective conditions (or microenvironment) of an artifact or site can be identified once sorting via post-depositional processes have been accounted for (O'Brien and Lyman 2000). In much of the research done in the San Juan Islands and throughout the Northwest Coast, resource intensification is used to explain the observed change in settlement and subsistence strategy that is believed to have occurred approximately 5000 BP (Butler and Campbell 2004; Derr 2014; Middleton 2017; Weiser and Lepofsky 2009). Resource intensification attempts to explain how and why people moved from a hunting-gathering strategy to "increasing specialized resource use" (Butler and Campbell 2004:337), which may have led to more annual cycle resource use and sedentary settlement patterns. There are several theories for how the phenomenon of resource intensification occurs that are relevant to this research.

Flannery's (1969) Broad Spectrum Revolution (BSR) model suggested that as populations grow in areas with better access to resources, people are forced to move to places with less favorable resources due to competition. In these less favorable areas, humans make up for missing resources by focusing their efforts on acquiring what resources are available. The success of focusing on a particular resource would lead to people using the same techniques in more favorable areas in order to increase their resource yield. Zeder (2012) built off the BSR model with the Niche Construction theory, which asserts that instead of the BSR phenomenon and resource intensification occurring in places where there are less favored resources, it would instead happen in environments where resources were dense and easy to collect. The wider access to more resources would make it easier for people to become sedentary and have access to a wide variety of resources from one spot.

Bird et al.'s (2016) model for resource intensification accounts for human modification of the environment, and the effects that modification has on the entire ecosystem and social structure. For instance, burning and hunting can result in a change in resource species, leading to a shift in human social organization and even reduced mobility (Bird et al. 2016). This study's incorporation of human-environment modification may apply to Lopez Island and its past consistent fire regime which was identified in previous studies (Spurbek and Keenum 2003). Thoms's (1989) model of geophyte resource intensification focuses on the significance of floral and terrestrial resources in the Pacific Northwest and posits that people's increasing reliance on plants such as camas depends on the distance and size of camas stands in the area. He notes that that there is a positive correlation between camas use and bulk processing and between population density and the intensity of management techniques like burning. Thoms's (1989) model focuses on the evolutionary impact of intensifying use of plant resources, which can lead to humans becoming more sedentary in their settlement patterns.

The intensification on salmon as a resource on the Northwest Coast is viewed as vital to the shift towards sedentism, however there is some discussion over whether salmon was the driving resource in this shift or if it was just one of a variety of resources that made up the subsistence patterns of people on the coast (Ames 1994). In their analysis of salmon remains from sites throughout the Pacific Northwest spanning a 7500 year period, Butler and Campbell (2010) observed that changes in environment and social structures that occurred throughout that period did not appear to impact the consistency in using salmon as a resource. They suggest that this sustainability may point towards generalized use of more resources by precontact peoples. Intensification on salmon is also hypothesized to be linked to an increase in storage and processing technologies in the Marpole phase that may have allowed for increased salmon storage and consumption throughout the year (Croes and Hackenberger 1988; Matson and Pratt 2008). Salmon was undoubtedly an important resource for peoples on the Northwest Coast, but the variability in salmon yields from year to year indicates that people may have also had to use other resources for subsistence (Ames 1994). Storage technology and mass harvesting techniques that are often linked to intensification of faunal resources are also theorized to be indicative of social organization and complexity on the Northwest Coast (Monks 2019). The development of these storage technologies and intensive use of secondary resources are potential drivers towards people moving towards sedentism in the region, and social and political developments such as the emergence of an elite class and the use of slaves may have been a result of having greater access to these resources (Ames 1994). Explanations for resource intensification not only provide possible explanations for the causes of settlement and subsistence changes, but also for human adaptations to varying microenvironments and selective conditions in the Salish Sea and on Lopez Island.

The literature review in this chapter provides the academic background and framework for the functional analysis of recorded Lopez Island archaeology. Chapter 4 details the theory, methods, and techniques used to address the research questions of this thesis.

CHAPTER IV

THEORY, METHOD, AND TECHNIQUE

This chapter outlines the analytical framework employed to address the following analytical questions:

1. How have past sampling strategies influenced our understanding of the archaeological record on Lopez Island?

2. Are there adequately dated and recorded archaeological contexts on the island that can be used to address changes in settlement and subsistence patterns during the middle Holocene (approximately 5000 BP)? Such changes have been identified elsewhere in the Salish Sea region (Ames and Maschner 1999; Ames et al. 2010; Butler and Campbell 2004; Matson and Coupland 1994; Middleton 2017; Moss 2011; Schalk and Nelson 2010; Stein 2000).

Each of the following sections identifies the relevant information necessary to address each of these questions. This chapter outlines and describes the data collection and functional analysis of Lopez Island sites used in the following Chapter 5 where results, discussion, and historic context synthesis are located.

Theoretical Approach

The theoretical framework for this thesis draws from evolutionary archaeology theory first developed by Dunnell (1978a, 1978b). Evolutionary archaeology explains the changes in human activity recorded in the archaeological record through the influence of natural selection, which is the mechanism that drives changes in technology and function (while cultural transmission accounts for variation in stylistic features) (Dunnell 1978a). Natural selection, as a mechanism, constrains past human activity and favors adaptation to selective conditions if populations are to persist using certain cultural traits in any particular area. Shifts in these traits detected in the archaeological record over time or across space may indicate changes in adaptations to differing microenvironments. This is visible in the non-random sorting of functional and technological traits in the archaeological record. Past human populations are free to adapt in any number of ways to changes in environmental constraints, and that is why identifying variability in the material culture of past societies is the subject of study in an evolutionary archaeology approach. Natural selection also acts upon the attributes of artifacts used over time, as those that lead to better fitness will be replicated differentially over time (O'Brien and Lyman 2000). Evolutionary archaeology holds that cultural ideas are transmitted just like physical traits, and that cultural ideas are "the product of the interaction between human genotypes and their environment" (O'Brien and Lyman 2000:386). Processes that influence biased sorting of the archaeological record such as post-depositional alterations, taphonomy and sampling differentials like screen size are well known to influence archaeological evidence. After accounting for these post-depositional sorting processes it is possible to interpret the distribution of cultural materials as influenced by the selective conditions and contexts (O'Brien and Lyman 2000).

The concept of selective conditions and resource intensification uses evolutionary archaeology to understand how humans interact and evolve in environments with varying resource diversity and availability, and is often applied in studies in regions with diverse resources like the Salish Sea (Butler and Campbell 2004; Derr 2014; Middleton 2017; Thomas 2006). Forces such as climate and population change impact the available resources for humans, and their material culture left behind can indicate the changes they used to adapt to these variable or changing selective conditions. By looking at the diversity of microevironmental characteristics present on Lopez Island such as freshwater proximity or vegetation, the environmental constraints that may have impacted precontact human activity can be identified. Through this framework, it is assumed that humans respond to their microenvironment in ways that improve their evolutionary fitness (Kopperl et al. 2011). The function of the sites sampled in this thesis are interpreted by looking at the microevironmental characteristics of each site that were acted upon by natural selection and contribute to overall fitness (Dunnell 1978a). Therefore, it is assumed that natural selection and the microenvironments of each site would have an impact on the fitness of the people there, and their adaptations to those places would be reflected in the sorting of the archaeological record. Archaeological site locations within these variable microenvironments will provide the first level of consideration and description of functional variation (Dancey 1973; Thompson 1978; Wessen 1988). This theoretical framework provides the terms used in the methods for this thesis to understand the relationship between site microenvironment and function in order to determine the extent of the current archaeological record on Lopez Island.

Methods

Using the theoretical framework of evolutionary archaeology (Dunnell 1971), the methods section defines the evolutionary archaeology variables that are used to address this thesis's research questions. The functional model developed for this thesis contains the framework to observe variation in the island's archaeological record across different microenvironmental selective conditions and to summarize and analyze the Lopez Island recorded archaeology sites' previous research, microenvironment, and archaeology, which are the main variables used in this thesis that will aid in showing how Lopez Island can address regional research questions.

Previous research addresses what is currently known about each site and allows for documenting the extent of research conducted, both at the individual level and on the island geographic scales. Previous research shows what we know about the sites recorded and sampled. The previous research variable acts as a "quality control" section in order to identify how much is currently known about each site, and how biased sorting through post-depositional processes may have influenced the Lopez Island archaeological record. As previously discussed in the literature review, much of the archaeological research and recorded sites on Lopez Island are a result of compliance archaeology, causing a bias in their location and level of research towards regions that are more likely to have development. The sites sampled for this thesis provide a biased analysis, and the variable of previous research is an attempt to determine the extent and kinds of research conducted on Lopez Island to show what is currently known and how that may impact the island's current archaeological record. Another outcome of analyzing the level of previous research done at each site will be the kind of information each site can provide for future research, such as having materials that can be radiometrically dated and whether dating research has actually been conducted.

Previous microenvironmental studies define site microenvironments through several dimensions such as vegetation, topography, and water access (Dancey 1973), and microenvironment reconstruction from historic sources (Thompson 1978). In this thesis, the variable of microenvironment defines the physical context of sites in order to address how these contexts contributed to the selective conditions and their impact on the kinds of human activity occurring there. Since the sites' microenvironments influenced the changes that people had to make in order to adapt to selective conditions, this variable contributes to the interpretation of the selective conditions that led to differential sorting of the material adaptations found in the site area (Kassa and McCutcheon 2016). For example, microenvironmental characteristics such as distance to freshwater may show variation in the material culture present at different sites, since distance to freshwater may have influenced the adaptations people had to make due to their closer or farther proximity to water.

In order to determine what is currently known about Lopez Island archaeology and the extent of evidence for precontact function at each site, the final variable of archaeology looks at the kinds of artifacts or features found at each site through the identified cultural material type. These three variables guide the definition of analytical dimensions (discussed in Techniques below), and aid in addressing the research questions. The results of the analysis derived from classifying Lopez Island sites provide an overview of the kinds of sites recorded on the island, their microenvironments, and what is already known about each site in order to address the specific research questions of this thesis.

Technique: Paradigmatic Classification and Functional Analysis

In order to address the research questions for this thesis, the functional analysis approach investigates the three dimensions for each Lopez Island site: archaeology, microenvironment, and previous research. The use of a paradigmatic classification for each variable and their respective dimensions resulted in three separate codes for each individual site per variable (microenvironment, archaeology, and previous research). Table 2 provides definitions of each paradigmatic classification and their dimensions; the following techniques section explains how the individual modes were chosen, the data used for classifying each site, and how it was compiled.

Table 2. Paradigmatic classification for the functional analysis of Lopez Island sites.[1]

Dimensions (Microenvironment)	Modes
Flora	1. Meadows, 2. Open rocky outcrops, 3. Open transitional woodland, 4. Dry coniferous woodland, 5. Moist mixed woodland, 6. Disturbed woodland, 7. Maritime, 8. Freshwater
Freshwater distance (in meters)	1. 0-483, 2. 484-967, 3. 968-1451, 4. 1452-1935, 5. 1936-2419, 6. 2420-2903, 7. 2904-3387
Shoreline distance (in meters)	1. 0-15 (shoreline), 2. 15.1-50 (near shoreline), 3. 50.1-352 (off shoreline)
2+ soil orders	0. absent (only 1 order), 1. present
Geomorphology	1. Protected shoreline, 2. Exposed shoreline, 3. Bedrock, 4. Glacial terrace, 5. Lowland slope

Dimensions (Archaeology)	Modes
Faunal remains/bone	0. absent, 1. present
Chipped stone	0. absent, 1. present
Ground stone	0. absent, 1. present
Shell midden	0. absent, 1. present
Shell	0. absent, 1. present
Fire modified rock	0. absent, 1. present
Human remains	0. absent, 1. present
Anthropogenic soils/charcoal	0. absent, 1. present
Rock cairns/miscellaneous	0. absent, 1. present

Dimensions (Previous research)	Modes
Radiometric dates	0. absent, 1. present
Shovel probes excavated	0. absent, 1. present
Data recovery/major excavation	0. absent, 1. present
Collections	0. absent, 1. present

[1] Details on these categories are described in the following text.

The variables of archaeology and microenvironment can be interrelated based on the theoretical assumption that each influences the sorting of the other and the evidence of such sorting can be found at a site. The microenvironment at and around sites impact the kinds of adaptations people made at those sites, which are expected to be reflected in the cultural materials left behind that survived. For example, previous research showed a relationship between shell midden sites and shoreline locations throughout the Salish Sea and on Lopez Island (Bovy et al. 2007; Taylor et al. 2011). Since shell middens usually have large quantities of shell remains, it would be expected that there would be a relationship between these kinds of sites and proximity to the coastline. Furthermore, it would be expected that proximity to shoreline would have greater number of archaeology classes (Table 2) filled due to access to multiple, rich resource zones and better preservation conditions. The relationship between previous research and archaeology is similar–the more intensive the previous research conducted at a site (e.g., data recovery), the more filled archaeology dimensions since it is expected that more intensive investigation would detect a greater diversity in cultural materials.

Through the analysis of previous research, microenvironment, and archaeology of 54 precontact sites on Lopez Island this thesis aims to identify the information already recorded that can be used to address established research questions, as well as what research needs to be carried out to address current gaps in the archaeological record on Lopez Island. The expectation for variability after conducting the initial classification and analysis is that there will not be much variability in microenvironment across sites.

Compiling Data for Classification and Analysis

The main source of archaeological site information used for this thesis was the WISAARD database. The database serves as a "digital repository" for the cultural resources of Washington state (Washington Department of Archaeology and Historic

Preservation 2019). WISAARD contains GIS data, site forms and reports, and Native American Graves Protection and Repatriation Act (NAGPRA) information on all sites recorded in Washington. Additional sources of site data came from academic articles, doctoral dissertations, and masters theses, many of which provided detailed information on more intensively investigated sites.

The site information for Lopez Island was compiled into a spreadsheet using the following fields (columns) for each site (rows): Smithsonian number, site form date(s), reports referring to the site, any additional forms (such as radiocarbon dating reports), academic articles, theses or dissertations, whether the site is precontact or historic, and WISAARD comments. This provided an overview of all the information currently available for each site. These documents were the primary source of information for the sites and were used to classify each site by archaeological contents as recorded in the documents. A separate spreadsheet was compiled for the site classifications (Appendices A and B).

The archaeological record information provided on WISAARD is limited to some GIS information and site documents, so outside sources had to be used to gather some of the environmental information used in this study. Information on the flora surrounding each site was primarily drawn from site forms and then cross-referenced with Atkinson and Sharpe's (1993) descriptions of plants in the San Juan Islands so that sites' plant life could be classified and used for comparison in the functional analysis. While historic land use has undoubtedly changed the plant communities from what they were at contact, recent and current plant communities are used as a proxy for potential precontact plant diversity. This likely underestimates the diversity present at European contact, however modern vegetation can still provide information on other microenvironmental factors such as soil, geomorphology, and access to freshwater. For this reason, the flora recorded at each site is still included as a microenvironmental dimension.

Distance to freshwater resources was the second microenvironmental attribute measured for each site, since a site's proximity to water resources may provide information on the functional use of that site and because it can be measured and compared between sites. When the site forms included distance information about a nearby freshwater source that distance in meters was used. However, for most sites there was no recorded information on freshwater in the provided field in the site form. The Department of Ecology (1975) map of freshwater resources on San Juan County was used to measure distances from sites to the closest water source in meters. A more updated GIS database of water resources was also consulted to ensure that there were no recorded sources missing (U.S. Geological Survey 2019). However, this study is limited since these sources are modern studies of freshwater locations and they may not account for all the water sources that existed during site occupation. The data used in this study shows site distance to modern freshwater sources, but precontact sources that later dried up may have been available as well.

Site distance to the shoreline was measured using WISAARD's built-in measuring tool, which allowed for measurements up to one-tenth of a meter. The distance was measured from the site location on the water side boundary to the nearest locatable shoreline point.

Soil orders for each site were also recorded using WISAARD's overlay of the USDA Soil Survey and were cross-referenced using Regan's (2009) soil survey for San

Juan County (Figure 5). Since the USDA Soil Survey provides individual soil series throughout the island that varied due to specific factors such as elevation and slope, I recorded the different soil series for each site as well as their corresponding soil orders. For the purposes of this study, the data on just the broader soil orders was deemed a sufficient level of data for comparison between sites on Lopez Island. Because some sites have up to three different soil series (and soil orders) represented at their location because of differences in slope, keeping the level of analysis to presence/absence of two or more orders reduced the amount of arbitrary differences in slope that would have been resulted in almost 100 unique soil series if they were used as the level of analysis for this study.

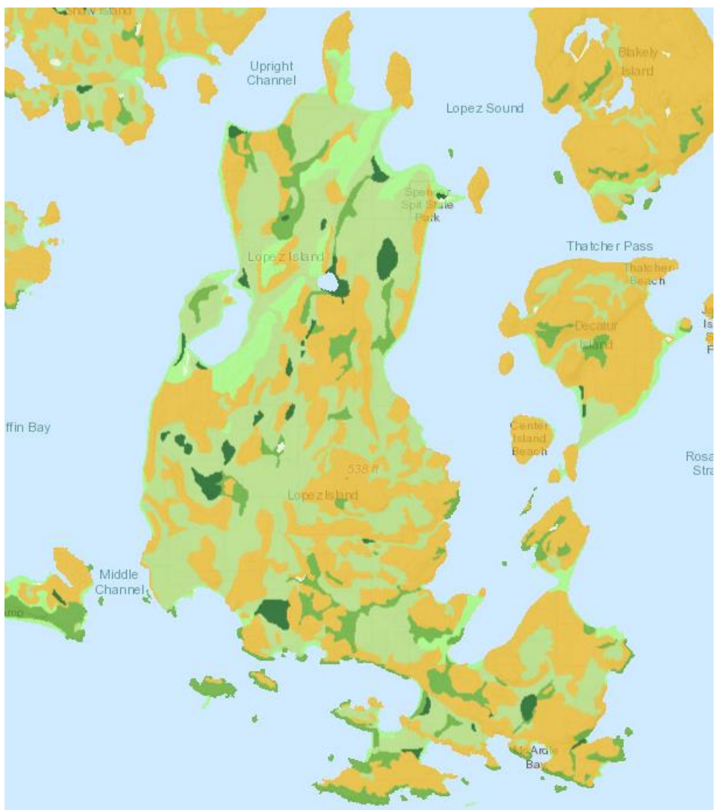

Figure 5. Screenshot of Lopez Island in WISAARD with USDA soil survey layer displaying majority presence of inceptisols (yellow), alfisols (light green), mollisols (medium green), and histosols (dark green) (Washington Department of Archaeology and Historic Preservation, accessed April 17, 2019).

Some site forms contain archaeologists' observations on the geomorphology and landforms for those sites, while others were not as complete. When site forms did not provide enough information to determine the geomorphology for a site, San Juan County LIDAR and satellite maps of Lopez Island were referenced to determine an appropriate summary of the site's landforms, location near the coast or freshwater, and other geomorphological characteristics. The information gathered for each of these microenvironmental factors allowed for creating classes for each category which were developed during Objective 3.

After collecting information for all the recorded sites on the island, I sorted through the data and removed all historic sites (n = 6) and sites that were reported to be destroyed or unlocatable (n = 2), since this thesis focuses on precontact sites that should be able to be resampled and restudied. The destroyed or unlocatable sites on Lopez Island may not contain enough data to be further investigated, so they were left out of the sample for this thesis. This left the final sample size for this study at 54 precontact archaeological sites (n = 54).

Previous Research Classification

In order to identify the level of previous archaeological investigations for each site, this thesis uses a four-part classification consisting of the presence or absence of: radiocarbon dating, sub-surface survey, data recovery, and artifacts or samples from that site in collections. Identifying the level of previous research makes it possible to identify variation in archaeology recorded across the different levels of archaeological investigation. Classifying the level of previous archaeological research at each site shows the extent of research already conducted at each individual site as well as across the island (Table 3). There may be areas of the island that have had less levels of work or research done, making them spatial data gaps. By determining the extent of research conducted on Lopez Island, it is possible to identify any potential gaps in the current knowledge of recorded sites. Information on previous research was gathered from the documents compiled in Objective 2.

Table 3. Examples for Previous Research Classification.

Carbon dates	STPs excavated	Data recovery	Collections	Previous research code
0	0	0	0	0000
0	0	0	0	0000
1	1	0	1	1101

Archaeology Paradigmatic Classification

The archaeology dimension of the analysis addressed the presence or absence of nine artifact materials present on Lopez Island. If the artifact mode was present, it was recorded as a 1. If it was absent, then it was recorded as a 0. The presence/absence modes can be used to identify diversity in artifact types within sites-the more 1s that are present in a site code, the more diverse artifact types exist at the site. Across site records, some archaeologists noted the presence of worked tools such bifaces or carved bone tools and provided in depth artifact descriptions. However, since many site forms did not provide any further information than the presence of artifact material types like chipped stone or shell, cultural material was used for the dimensions since it allows for comparison between all sites.

The artifact types recorded in order are: faunal remains, chipped stone, ground stone, midden, shell, fire-cracked rock, human remains, anthropogenic soils/charcoal, and cairns (Table 4). The more artifact types present at a site the more ones (1) in the artifact class code. The cairn dimension was initially labeled as miscellaneous to account for materials such as wood or basketry, but after sorting through the archaeology recorded on Lopez Island it became used for rock cairn sites that are explicitly described as such by the recording archaeologist (wood and basketry were not recorded in any of the sites sampled).

Table 4. Example Classifications for Archaeology.

Faunal remains	Chipped stone	Ground Stone	Shell Midden	Shell	FCR	Human remains	Anthro soils/charcoal	Rock Cairns	Artifact Class Code
0	0	0	1	1	0	0	0	0	000110000
0	0	0	1	1	0	0	0	0	000110000
1	1	0	1	1	1	1	0	0	110111100

These artifact types were selected for this thesis due to their presence in regional literature. Each of these types also occur at least once in a recorded Lopez Island site. The presence and absence of artifact types were all based on the site documents from WISAARD and academic literature, so the number of and variety in filled classes is limited to the information provided in site forms and other academic sources. In most cases the artifact types were easily classified, however a distinction was made for shell versus shell midden. For this study shell middens were defined as a matrix of broken shell, soil, and stone (Álvarez et al. 2010, Stein 1992). In most cases the distinction between shell and shell midden was determined by how the site was recorded–if the archaeologist only described a midden with no distinct individual shell presence (e.g., only recording it as “midden” instead of “shell midden”), then it was classified as only having midden present. If the site was recorded as a shell midden with additional shell mentioned as a separate component or with shellfish species accounted for, then shell was classified as present. Middens on the Northwest Coast almost always include shell as a main component, however to remain faithful to the way each site was recorded this distinction was made.

Microenvironment Paradigmatic Classification

Microenvironmental variation was measured with a multi-dimensional classification using five dimensions: flora, distance to freshwater, distance to shoreline, presence of two or more soil classes, and geomorphology. These dimensions define the selective conditions that impacted the human activity on Lopez Island. Looking at the characteristics that make up the microenvironments of each site aids in understanding more about the biological and cultural aspects of the site represented through material culture. The material culture of the sites is addressed through the archaeology codes in this study and understanding the relationships between these two larger variables and their dimensions is influenced by previous functional analyses such as Dancey (1973) and Thompson (1978). Since the flora and geomorphology could be classified beyond presence or absence of certain qualitative characteristics, this analysis used a qualitative scale as well as presence or absence of two or more classes for the analysis, which is discussed more below and in the following chapter.

The flora class (also referred to as plant class) was adapted from Atkinson and Sharpe's (1993) description of the different plant life on the San Juan Islands (Table 5). Due to constantly changing environments, plant life at a site cannot be assumed to be the same as it was at precontact because of historic land use practices like grazing. Including flora as a dimension causes a modern bias because it is not always reflective of precontact conditions. However, the kinds of flora at a site can still provide information about the climate, geology, and soil nutrients at the site. The decision to include it is attenuated by doing so using only coarse-grained descriptions.

Table 5. Lopez Island Plant Environment Classes (taken from Atkinson and Sharpe 1993).

Class Number	Name	Description
1	Meadows	South facing slopes, less precipitation, grass/herb vegetation, low soil water and nutrients
2	Open Rocky Outcrops	Common throughout islands, lichens/grasses/herbs/occasional shrubs, low soil nutrients and high sun exposure
3	Open transitional woodland	SE or SW facing, high winds and summer temps, moderate/steep slopes near saltwater, low soil nutrients, good drainage, mix of forest and forest edge species
4	Dry coniferous woodland	Gradual slopes, wind and sun protected, more moist than open transitional, more duff but well drained soils, Douglas fir/shrubs/herbs present
5	Moist Mixed woodland	North facing slopes, poorly draining soils with rich organics, moist, cooler temperatures, more diverse tree species/ferns/herbs
6	Disturbed woodland	Woodlands that have been recently disturbed, some trees/invasive European weeds, some succesional species
7	Maritime	High salinity and sunlight, dry soils, low growing plants with extensive root systems and other adaptations, includes rocky headlands, sandy coves, and salt marshes
8	Freshwater	Areas surrounding lakes and permanent streams, steep sided deep lake environment or shallow boggy lakes, Pacific willow/diverse shrubs and forbs

Initially, sites that fell into more than one plant class were given as many classes as necessary in order to account for all represented coarse-grained plant classes at the site. In order to analyze the sites using Microsoft Excel another dataset was created with duplicates of the sites with more than one plant class (n = 81). This allowed for generating frequency data for flora class, although this analysis led to the number of filled classes exceeding the number of sites in the sample since some sites displayed more than one flora class. This duplicate data is biased since it is based on the qualitative observations of the recording archaeologists and this thesis's interpretation of the site forms, however this technique made it possible to measure the representation of different plant classes across the recorded sites.

Freshwater distance classes were determined using the statistical "rule-of-thumb" class interval equation: $k = 1+3.3(\log_{10}N)$, where k = the number of classes (Burt et al. 2009:49). This resulted in seven comparable, mutually exclusive distance classes for distance to freshwater (Table 6). The ratio-level measurements of freshwater distance were put into these ordinal-scale classes in order to compare across sites, and because it allowed for using the distance in the same classification as more nominal data such as the plant classification.

Table 6. Freshwater Distance Classes.

Class number	Distance from freshwater (meters)
1	0-483
2	484-967
3	968-1451
4	1452-1935
5	1936-2419
6	2420-2903
7	2904-3387

The distribution of Lopez Island sites in relation to the island's shoreline led to a change in class distribution from equal intervals to using natural breaks in the data to define intervals in order to maximize variation. Since the majority of sites on the island are located close to or on the shoreline, it left many classes unfilled when using the "rule-of-thumb" equation to determine classes for distance to the shoreline (Burt et al. 2009). Since the "rule-of-thumb" equation resulted in sites 0 meters from the shoreline being grouped in a class 0-50.5 meters (Figure 6), variation closer to the shoreline was not visible so the classes were changed to better reflect how shorelines can change over time due to natural processes such as water levels rising and erosion as well as through anthropogenic impacts.

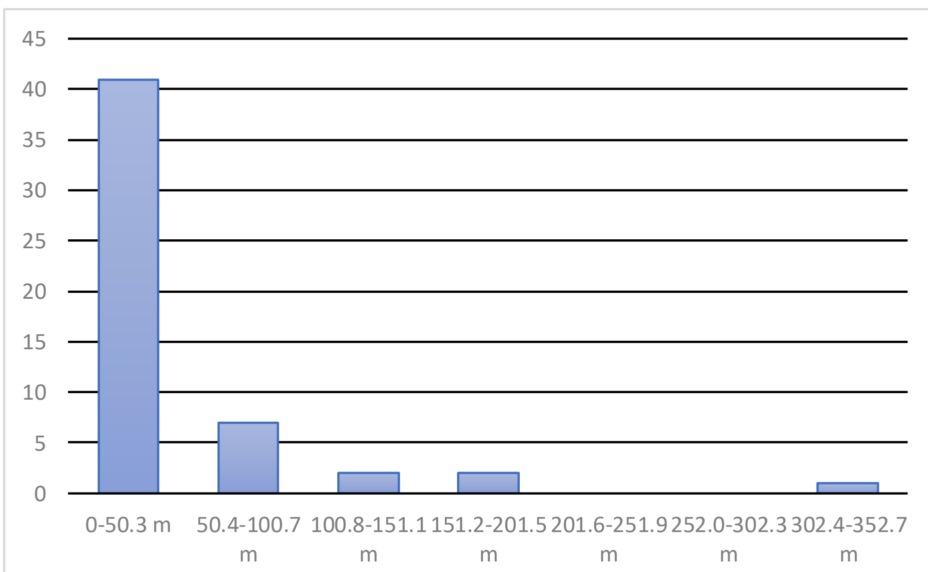

Figure 6. Shoreline distance data with equal class intervals.

This resulted in three shoreline distance classes which were defined as shoreline, near shoreline, and off shoreline (Table 7).

Table 7. Shoreline Distance Classes.

Class number	Distance from shoreline (meters)
1 (shoreline)	0-15
2 (near shoreline)	15.1-50
3 (off shoreline)	50.1-352

Due to the complexity of soil series across Lopez Island, most sites had at least two soil series present and multiple soil orders. In order to keep the soil information at the same nominal level as the rest of the data and minimize the arbitrary impact of soil classes using slope categories, the presence of more than one soil order at sites was used for this microenvironmental analysis, for example if a site had both mollisols and inceptisols present. Table 8 shows the soil series represented in the sampled sites for this study, sorted by their soil order. This data was used to determine the number of soil orders represented at each site. Similarly to the archaeology classifications, if a site had more than one soil order, it was given a value of 1. If not, it was given a value of 0.

Table 8. Lopez Island Soil Series by Order (Regan 2009). Note: series from multiple orders are represented in all applicable orders.

Inceptisols	Entisols	Mollisols	Histosols	Alfisols
Sholander-Speiden	Beaches-Endoaquents, tidal-Xerothents	Sholander-Speiden	Shalcar muck	Coveland loam
Sholander gravelly loam	Whidbey-Hoyus	Coupeville loam	Semiahoo muck	Coveland-Mitchellbay
Limepoint-Sholander	Keystone sandy loam	Limepoint-Sholander	Orcas Peat	Deadmanbay-Moran Creek
Deadmanbay-Morancreek	Xerothents-endoaquents, tidal association	Bazal-Mitchellbay	Dugualla muck	Bazal-Mitchellbay
Deadmanbay-Bazal-Cady	Hoypus sandy loam	Deadmanbay-Bazal-Cady		Deadmanbay-Bazal-Cady
Whidbey gravelly loam	Hoypus-Whidbey	Mitchellbay-Sholander-Bazal		Mitchellbay gravelly sandy loam
Alderwood-Everett		Limepoint-Alderwood, warm Sholander		Suica loamy sand
Mitchellbay-Sholander-Bazal		Pilepoint loam		Mitchellbay -Sholander-Bazal
Limepoint-Alderwood, warm Sholander		Rock outcrop-Haro		Limepoint-Alderwood, warm sholander
Whidbey-Hoyus		Haro-Hiddenridge-Rock outcrop		Roche-Killebrew
Roche-Killebrew				Suica-Sholander
Everett sandy loam				Roche-Killebrew rock outcrop
Suica-Sholander				Roche-Mitchellbay
Roche-Killebrew rock outcrop				Mitchellbay-Rock Outcrop-Killebrew
Laconner gravelly sandy loam				
Hoypus-Whidbey				
Roche-Mitchellbay				
Cady-Rock outcrop				
Doebay, moist-Cady-Doebay				
Cady-Doebay-Rock outcrop				
Haro-Hiddenridge-Rock outcrop				
Doebay-Cady-Rock outcrop				

Finally, the geomorphology of sites was the final dimension for the microenvironment classification. The initial geomorphology classes were created by looking at the general geomorphic features present on Lopez Island and how they were described in an archaeological context in the site forms. In many cases site geomorphology was simply listed as “shoreline” or “protected forest” with little additional detail. From this general information geomorphology was narrowed down into five separate classes: protected shoreline, exposed shoreline, bedrock, glacial terrace, and lowland slope (Table 9). These classes were developed from the kinds of geomorphology that was listed in recorded site forms and refined from sources such as Atkinson and Sharpe (1993) and studies of the geology of the San Juan Islands (Russell 1975), as well as definitions from geomorphological reports (National Soil Survey Center 2017; Shipman 2008). Like the flora classification, some sites had more than one geomorphology class recorded on their site form. This was accounted for by first classifying each site by the presence or absence of more than one geomorphology class (with 0 meaning only one class present and 1 representing two or more classes present) regardless of what the classes were.

Another separate classification was created to determine the overall frequency of individual geomorphology classes, in which the sample size increased above the total number of sites due to duplicates (n = 61). Each site with more than one geomorphology class was listed multiple times for each separate class it fell into, so a site with two geomorphology classes would be listed twice. This resulted in a separate but non-representative duplicate dataset for geomorphology classification, and counting each instance of geomorphology class as separate instead of just by site made it possible to determine the individual frequency of each geomorphology class.

Table 9. Geomorphology Classes (Atkinson and Sharpe 1993; National Soil Survey Center 2017; Shipman 2008).

Class number	Geomorphology class	Description
1	Protected shoreline	Also known as small embayments. Are less impacted by wave action and more by tidal action (Shipman 2008)
2	Exposed shoreline	Also known as barrier beach, spit, or tombolo, vulnerable to erosion, often form where sediment converges from multiple directions and in "bends in shoreline" (Shipman 2008:17)
3	Bedrock	Areas where bedrock is exposed. Usually not significantly impacted by erosion when present on shoreline, but may have some sediment deposited on top of bedrock (Shipman 2008)
4	Glacial terrace	Stepped slope that was formed by glacial action, indicating previous shorelines (National Soil Survey Center 2017).
5	Lowland slope	Low-lying sloped area usually at or near sea level, sometimes located in a valley (National Soil Survey Center 2017)

The functional analysis of microenvironments resulted in a 5-digit code for each site that allowed for summarizing the kinds of microenvironments represented at Lopez Island archaeological sites. Table 10 shows an example layout of the classifications and the final microenvironment code for three different sites.

Table 10. Example Microenvironmental Class Codes.

2+ plant. classes present	Freshwater distance class	Shoreline distance class	2+ soil classes present	2+ geomorph. classes present	Microenvironment class code
1	3	1	0	0	13100
0	2	1	1	1	02111
0	4	2	1	1	04211

Classification Analysis

Appendix A shows the layout of classification codes for the sampled sites. This classification resulted in a set of three codes per site, with one code for archaeology, microenvironment, and previous research. After entering the codes into Microsoft Excel, I used the Pivot Table tool to generate the frequencies of different site codes for the three different variables of archaeology, microenvironment, and previous research. Having the individual number entries for each dimension as well as the full codes for each site made it possible to compare individual dimensions within the multi-dimensional classifications, for example comparing freshwater distance with ground stone and major excavations to observe their relationships. The data from this thesis makes it possible to look at the relationships between the individual elements and sites in order to address this thesis's research questions.

Out of a potential 168 microenvironment classes, 31 were filled. For the archaeology class, there were a total of 28 filled classes out of a potential 512 classes, and for the previous research class 10 were filled out of a potential 16 classes. In depth results and discussion of the filled and unfilled classes are in the following chapter. Figure 7 shows the general locations of all of the sites used in this analysis, as well as the location of cultural resource surveys conducted on Lopez Island. Given the general locations of the recorded sites shown in Figure 7, almost all the sites appear on the coastline of the island which leads to the expectation that most of the sites would be in marine, shoreline microenvironments. Since most of these sites are close to marine resources, the expectation for archaeological site types was that there would also be a higher frequency of midden sites on Lopez Island. Furthermore, Figure 7 shows that not only are most of the recorded sites near the shoreline, many of the survey areas are concentrated on the shoreline region as well. This also contributed to the expectation that there would be a bias in the recorded archaeology towards shoreline sites, since most of the survey activity appears to be in that region.

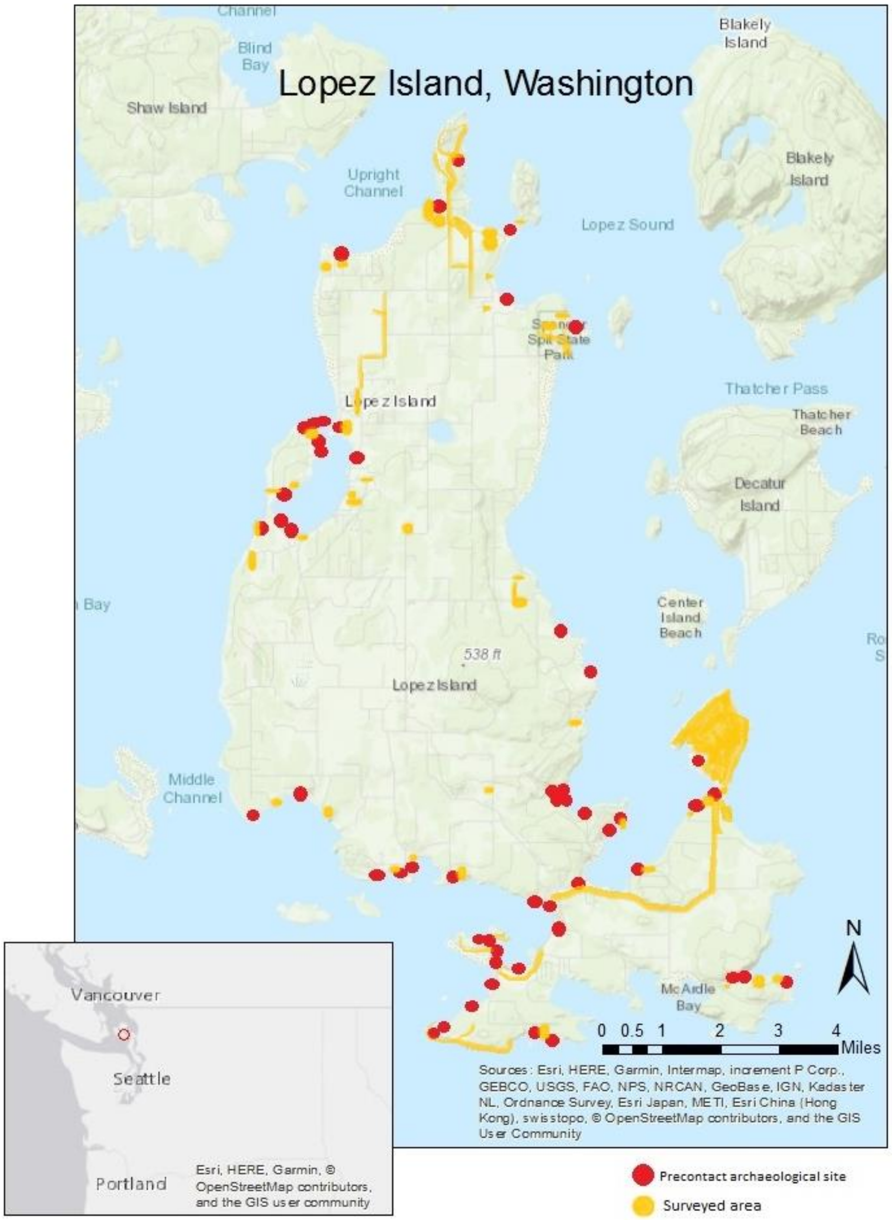

Figure 7. Map of Lopez Island with General Site Locations and Survey Locations.

These relationships between site archaeology and microenvironments and other results will be explored in the following chapter, along with the discussion of results and conclusions. The final chapter is also the draft for the journal article version of this thesis which will be submitted to the journal *Archaeology in Washington*.

CHAPTER V

A FUNCTIONAL ANALYSIS OF RECORDED PRE-CONTACT ARCHAEOLOGICAL SITES ON LOPEZ ISLAND, WASHINGTON

The student coauthored this manuscript with the committee chair, and it will be submitted to *Archaeology in Washington* journal. The manuscript begins on the next page and will be the version submitted; the final manuscript (if accepted) may result in differences based on the results of editorial and blind peer review.

A Functional Analysis of Recorded Pre-Contact Archaeological Sites on Lopez Island, Washington

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Abstract

Through an evolutionary archaeology framework, this study uses a functional analysis of recorded precontact archaeological sites on Lopez Island, Washington to determine how sampling and research strategies have influenced what is currently known about the island's archaeology. We developed and applied a paradigmatic classification to 54 sites by their level of previous research, microenvironment, and recorded archaeological remains. This analysis showed that there has been little subsurface investigation on Lopez Island, and most sites and surveys are concentrated on the shoreline. Microenvironmental analysis showed that sites closer to the shoreline had greater archaeological variability, as well as sites closer to freshwater. Sites containing shell were most common in the archaeological classification; sites with cairns were the second most common. We identified sites on Lopez Island that could be further studied to address research questions of chronology, settlement and subsistence, and ideology. We also identified data gaps in Lopez Island's archaeological record including lack of data on the island's interior and subsurface excavation. Lopez Island's archaeological record will remain an isolated piece of culture history until the data gaps identified in this study are addressed so that it can be better integrated into the cultural context of the Salish Sea.
(199 words)

Keywords: Archaeology, Salish Sea, Lopez Island, functional analysis

Introduction

Archaeological investigations in the Salish Sea region have led to persistent research questions that often lack the appropriate data for synthesis. The San Juan Islands in the Salish Sea have a human history dating back to at least 9,000 years before present (BP) (Stein 2000). The archaeological record in the Salish Sea points towards a shift in settlement and subsistence patters approximately 5000 BP, with humans shifting from a mobile to a more sedentary settlement pattern (Boxberger 1989; Burley 1980; Moss and Erlandson 1995; Stein 2000). The cause of this settlement shift is believed to be resource intensification throughout the region (Butler and Campbell 2004; Derr 2014; Thomas 2006). One key to this shift is increased predation pressures due to human population increases, and the development of storage technologies such as basketry that allowed for intensified marine and terrestrial resource use (Ames 1994; Croes 2019; Croes and Hackenberger 1988). Lopez Island, Washington is the third largest of the San Juan Islands and contains a variety of microenvironments harboring a variety of marine and terrestrial resources important to past people. An understanding of the relationship between archaeological sites on Lopez Island and their microenvironments can provide further information on how Lopez Island fits into the greater regional shift in settlement and subsistence throughout the Salish Sea.

For over a century Lopez Island, Washington has been the subject of archaeological investigations, yet the most recent summary of this work is over 30 years old. The island was investigated in the archaeological inventory of San Juan County, Washington compiled by Wessen (1988) which updated information on previously discovered sites and surveyed for new ones. Since then, there has been extensive fieldwork conducted on the island and the count of precontact archaeology sites on Lopez Island has grown, but lacks an updated summary that places the sites in a historic context. A synthesis would permit an assessment of what is known, and more importantly, what is not known. Knowing where data gaps exist in prehistory is vital to future identification and significance evaluations of archaeological resources (Little et al. 2000) on Lopez Island, as others have done elsewhere in the Pacific Northwest (Hackenberger 2009; Kopperl et al. 2011). An outcome of such studies here is setting Lopez Island's archaeological record into a regional context of the Salish Sea. Once set, we can determine how Lopez Island archaeology is unique and/or is similar and how the island's archaeology may be used to address regional research questions.

This study uses a coarse-grained functional analysis approach similar to other work in the region (Dancey 1974; Dunnell 1978b; Thompson 1978). We use evolutionary archaeology theory (Dunnell 1978a) to select our variables and define our units of analysis. Here our approach first measures how previous archaeological sites were recorded and analyzed. Then, we measure variation in each archaeological properties' microenvironmental character and situation. Finally, we measure each properties' variation in artifact content. Three mutually exclusive, multidimensional paradigmatic classifications of previous research, microenvironment, and archaeology permit comparison of sites across the island's known precontact archaeological record. By systematically classifying each archaeological site, a contemporary research framework can be applied to determine what is known and where the data gaps exist. To do this, the following analytical questions for this study aid in developing our approach:

1. How have past sampling strategies influenced our understanding of the archaeological record on Lopez Island?
2. Are there adequately dated and recorded archaeological contexts on the island that can be used to address changes in settlement and subsistence patterns during the middle Holocene? Such changes have been identified elsewhere in the Salish Sea region (Ames and Maschner 1999; Ames et al. 2010; Butler and Campbell 2004; Matson and Coupland 1994; Middleton 2017; Moss 2011; Schalk and Nelson 2010; Stein 2000).

Through a functional analysis of precontact sites, this study aims to put the archaeology on Lopez Island, Washington into its microenvironmental and greater regional context to understand how precontact people used the island and how recorded archaeology can be used to address data gaps in Salish Sea research in the region. By showing what is currently known about the archaeological record on Lopez Island and where there may be gaps in the current knowledge, this study will aid future research and cultural resource management on Lopez Island and throughout the San Juan Islands. Further development and application of this approach to islands elsewhere in the archipelago would create a systematic understanding of what is and is not known about Straits Salish land use.

Study Area

In order to describe variation in microenvironmental character of each archaeological site's location, we first review the various elements that contribute to those microenvironments and consider the changing conditions in the past that influenced their formation and evolutionary history.

Physical Setting

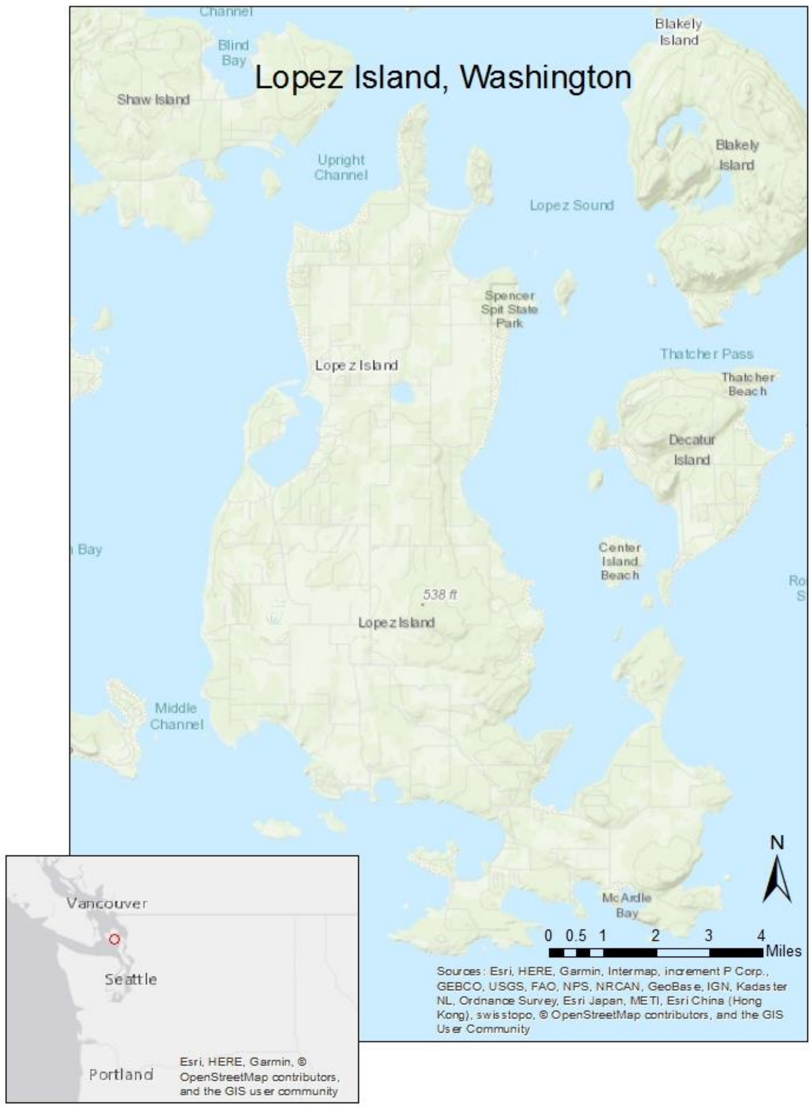

Figure 1. Map of Lopez Island and the Surrounding Islands. This map was created using ArcGIS® software by Esri. ArcGIS® and ArcMap™ are the intellectual property of Esri and are used herein under license. Copyright © Esri. All rights reserved. For more information about Esri® software, please visit www.esri.com.

Lopez Island is the third largest island in the San Juan Archipelago in the Salish Sea (Figure 1). Located towards the southern end of the San Juan Islands, Lopez Island and its neighboring islands were formed through glacial movement of the Juan de Fuca lobe of the Cordilleran Ice Sheet (Porter and Swanson 1998). This movement led to the glacial striations that can be seen on exposed bedrock on the island today. At the end the Pleistocene, glacial melt resulted in the deposition of the glacial sediments, in which soils formed during the Holocene Epoch (Bureau of Land Management 1990).

Paleoclimate

Unfortunately, the resolution of past climate on Lopez Island and the San Juan Islands area is limited to generalizations from adjacent regional studies. The Pacific Northwest paleoclimate record derived from glacial history, lake salinity, and palynological and dendrochronological data is characterized by several shifts in moisture and temperature throughout the late Pleistocene and Holocene. These changes are recorded as moving from a cooler climate due to glacial presence to a dryer, warmer period from 10,500-8000 YBP (Walker and Pellatt 2008; Walsh et al. 2010). Around 8,000 YBP the climate cooled again and became moister, stabilizing around 4,000 YBP until contact (Walker and Pellatt 2008:129). Other paleoecological reconstructions in the Pacific Northwest use lake cores to determine the climate and fire history of sampled sites (Walsh et al. 2010). In those studies, the authors describe that changes in climate led to an increase in pollen and charcoal content, and point to drier and hotter conditions in the region around 1100-700 YBP, but that cooler climactic conditions and more precipitation around 500 YBP may be the reason for less frequent and lower intensity fire episodes (Walsh et al. 2010).

Fire History

Throughout the middle to late Holocene there was an observed increase in fire activity throughout the Pacific Northwest, potentially due to changes in climate or an increase in anthropogenic burning (Walsh et al. 2015). Analysis of charcoal records from the Pacific Northwest show that prior to 10,000 YBP the region had a frequent fire regime that declined until about 8,000 YBP (Walsh et al. 2015). During the middle to late Holocene fire frequency increased again, which Walsh et al. (2015) interpreted as either a response to increasing climate variability or the increase of anthropogenic burning. After 900 YBP the frequency of burning decreased, potentially due to climate and population changes in the Pacific Northwest (Campbell and Butler 2010; Prentiss et al. 2005, Walsh et al. 2015). Evidence of anthropogenic burning is visible in the fire record on Lopez Island. Spurbeck and Keenum's (2003) analysis of fire scars at Iceberg Point and Point Colville on Lopez Island shows that there was a regular and frequent fire regime prior to about a century ago. The authors estimate that the fire regime on Lopez Island prior to a century ago occurred at an interval of 11 to 15 years, which may be due to natural causes as well as changes in human prescribed burns (Spurbeck and Keenum 2003). Another fire study conducted on Lopez Island and San Juan Island indicated fire return intervals of 120 to 170 years; however, the authors do not distinguish charcoal sources and thus it is unclear whether the fires represented natural stand-clearing events or cultural burning of grassy meadows meant to stimulate plant resources (Coffey et al. 2019). The frequency of fires throughout the Pacific Northwest and on Lopez Island appear to have decreased after European-American contact, and fire suppression techniques starting in the nineteenth century leading up to today have resulted in a large decline in fire frequency (Marlon et al. 2012; Walsh et al. 2015).

Biota

The varied microenvironments across Lopez Island provided people with differential access to a wide variety of resources. Shoreline and marine environments provided access to a host of plants and animals, making up a highly variable island environment. For instance, shoreline and adjacent intertidal zones contain marine plants like sea lettuce (*Ulva lactuca*) and rockweed (*Fucus vesiculosus*), while the interior of the island has forests of Douglas fir (*Pseudotsuga menziesii*) and alder (*Alnus sp*.) as well as meadows with Great camas (*Camassia leichtlinii*), sheep sorrel (*Rumex acetosella*), and other forbs (Atkinson and Sharpe 1993; Turner and Bell 1971; Bureau of Land Management 1990). The diversity of plant life on Lopez Island is similarly reflected in the range of fauna native to the island and its surrounding waters.

Terrestrial animals such as mink (*Neovison vison*), river otter (*Lontra canadensis*), beaver (*Castor sp*.), and black-tailed deer (*Odocoileus hemionus*) were faunal resources found throughout the San Juan Islands (National Park Service 2015; Suttles 1990; Bureau of Land Management 1990). Waterfowl were more utilized than other birds as a source of meat and eggs for people including species like the double-crested cormorant (*Phalacrocorax auritus*), great blue heron (*Ardea herodias*), as well as a variety of over 26 duck species (Suttles 1990). Lopez Island's location in the Salish Sea also gave people access to a wide variety of marine resources. Marine mammals like humpback whales (*Megaptera novaeangliae*), Steller sea lions (*Eumetopias jubatus*) and harbor seals (*Phoca vitulina*) were another food resource for the people in the Salish Sea (National Park Service 2015; Suttles 1990). The fishes throughout the Salish Sea including Pacific herring (*Clupea harengus*), rockfish varieties (*Sebastes* sp.), and six different salmon species provided a significant seasonal food resource for humans (Matson and Copeland 1994; Pietsch and Orr 2015; Suttles 1990). Marine invertabrates such as butter clam (*Saxidomus giganteus*), littleneck clam (*Protothaca staminea*), and razor clam (*Siliqua patula*) were an additional food resource for precontact peoples (Dall 1921; Stein 1992; Suttles 1990). The diverse microenvironments throughout the Salish Sea and on Lopez Island provided precontact people with a variety of biotic resources to exploit, which influenced their annual resource acquisition practices and settlement patterns over time.

Culture

Lopez Island and the San Juan Islands are the ancestral home of the people collectively known as the Straits Salish. Anthropologists consider the Lummi, Samish, Sooke, Songhees, Semiahmoo, and Saanich First Nations people as members of the Straits Salish people due to their linguistic commonalities and similar cultural traditions (Suttles 1990). The varied microenvironments throughout the Salish Sea and on Lopez Island provided the Straits Salish people with diverse access to resources. Exploitation of marine invertebrates and discarding the shells in their middens led to large deposits of shell middens usually on the shorelines, which preserve organic materials and artifacts that people threw away (Álvarez et al. 2010; Stein 1992). Salmon remained an important resource for the Straits Salish and people throughout the Pacific Northwest since approximately 7500 BP, despite changes in the climate and the environment (Campbell and Butler 2010). Resource acquisition areas such as reef netting sites off the coast of Lopez Island as well as camas prairies such as Iceberg Point on the south end of the island were owned by different Straits Salish families who managed the areas and controlled who had access to the resources (Boxberger 1989; Monks 2019; Suttles 2005; Thomas 2006). The social stratification reflected in access to resource areas has also been hypothesized to be reflected in other practices, such as access to stylistic lithic knowledge (Rorabaugh 2015) and in burial practices, including the use of rock cairns as graves (Thom 1995). The arrival of Europeans in the Pacific Northwest began in the 1500s, but increased during the mining boom in the 1850s (Camfield 2000; Suttles 1990). This was followed by a decrease in Native American populations throughout the region due largely to disease, shrinking to approximately 7,000 people during the late 1800s (Suttles 1990). Further displacement during settlement and treaty making resulted in many of the Straits Salish to be marginalized (Harmon 1998).

Theoretical Framework

The evolutionary archaeology theoretical framework used for this study to analyze Lopez Island archaeology was first developed in the Pacific Northwest region with the objective to identify variation in human land use of different microenvironments over time (Dunnell 1978a, 1978b). Evolutionary archaeology is an ideal theoretical framework for this study because the subject matter is variability in the archaeological record that can be placed in the context of space and time (Dunnell 1978a, 1978b; Kassa and McCutcheon 2016; O'Brien and Lyman 2000; Parfitt and McCutcheon 2017). Evolutionary archaeology frameworks aim to explain changes in material culture in the archaeological record horizontally (spatially) and vertically (temporally) through the influence of natural selection. Natural selection, or the selective conditions, influence functional characteristics and cultural transmission influences stylistic characteristics

(Dunnell 1978a, 1978b; O'Brien and Lyman 2000). Based on the selective conditions of a site, it is expected that the recorded archaeology would reflect the artifact traits favored by natural selection through sorting caused by natural selection (Dunnell 1978a; O'Brien and Lyman 2000; Parfitt and McCutcheon 2017).

The effects of selective conditions and human adaptations such as resource intensification have been considered in many other studies conducted in the region (Butler and Campbell 2004; Derr 2014; Middleton 2017; Thomas 2006). An evolutionary archaeology approach to assessing recorded archaeology is valuable because it allows for identifying sorting caused by natural selection and post-depositional sorting processes that are a biased result of how the archaeology was investigated, not from past peoples responding to selective conditions (O'Brien and Lyman 2000). This allows for identifying the data gaps that are a result of this sorting and impact what we currently know about the island's past. An analysis of sites on Lopez Island that looks at the functional impact that microenvironment has on human activity at archaeological sites allows for an evolutionary archaeology approach to interpret how selective conditions such as access to freshwater or particular geomorphologies impacted human activity and the material culture people left behind. The theory of evolutionary archaeology shapes the methods and techniques in which we investigated what is currently known about Lopez Island archaeology and its functional context.

Methods and Technique

The methods section defines the variables that are used to address this project's analytical questions (Dunnell 1971). The methods define the variables that are used in this study, which allows for a summary and analysis of recorded precontact archaeological sites on Lopez Island. From these variables, dimensions of variability are defined so that an analytical framework can determine the quality of the archaeological record and how much past recording practices may have biased what we know or do not know about the islands culture history. Once that is accomplished, we can use the representative data to evaluate modern research questions developed in the Salish Sea.

The first variable is ‘previous research’ which addresses what is currently known about each site, and allows for documenting the extent of research conducted both at the individual level and on the island geographic scales. Using previous research as a variable allows for identifying what we know about the sites recorded and how they were sampled, which then allows for evaluating each site for its representativeness based on the level of investigation carried out there. Sorting caused by post-depositional processes and kinds of archaeological investigation techniques like screen size and volume of excavation impact what the archaeological record in addition to the cultural patterns look like (O’Brien and Lyman 2000). This variable acts as a quality control in order to identify how much is currently known about each site, and how post-depositional sorting may have influenced the current Lopez Island archaeological record.

‘Microenvironment’ as a variable defines the physical context of these sites in order to understand how the selective conditions may have had an evolutionary impact on the function of the cultural materials found at the site (Dunnell 1978b). Previous analyses define site microenvironments through several analytical dimensions such as vegetation, geomorphology, and water access (Dancey 1973), and microenvironment reconstruction from historic sources (Thompson 1978). This variable contributes to the description and interpretation of the selective conditions that led to differential sorting of the material culture found in the site area, which humans used to adapt to selective conditions (Kassa and McCutcheon 2016). For example, microenvironmental characteristics such as distance to freshwater may show differences in the selective conditions at sites or limits in the material culture present at different sites, since freshwater access would limit the kinds of activity people could carry out in an area (Taylor et al. 2011).

To determine what is currently known about Lopez Island archaeology and understand the selective conditions of each site, the final variable of 'archaeology' looks at the kinds of artifacts or features found at each site through the identified cultural material type. These three variables in the functional analysis show how different sites on Lopez Island can aid in addressing this study's analytical questions and what kinds of information each site can provide, such as having materials that can be dated and whether dating research has actually been conducted. The outcome of this functional analysis provides a synthesis of the archaeology recorded on Lopez Island, their microenvironments, and what is already known about each site in order to address the main research questions of this study (Figure 2).

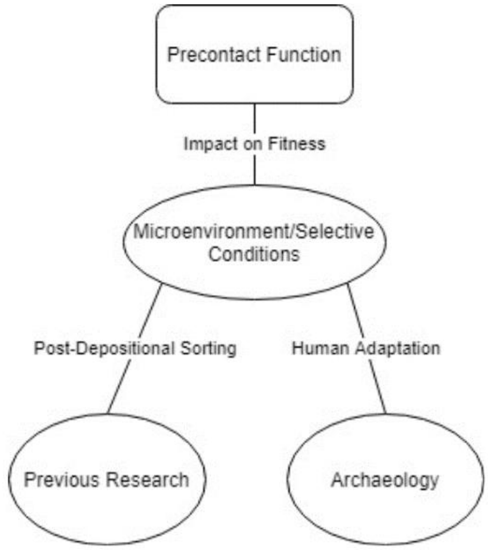

Figure 2. Diagram of Relationships between Precontact Function and Microenvironment, Previous Research, and Archaeology.

In order to address the analytic questions for this study, the data gathered on Lopez Island sites (n = 54) was compiled into the three previously discussed variables of microenvironment, archaeology, and previous research. The majority of data on the sites were gathered from the Washington DAHP WISAARD database, which contains site forms and other documents on recorded archaeology within the state. This provided a general overview of the microenvironment for each site, as well as data on the cultural materials discovered and the kinds of investigations conducted at the site. Further data on site microenvironment was gathered from the Washington Department of Ecology and U.S. Department of Agriculture in order to provide an environmental context for each of the sites.

This study uses a paradigmatic classification as the technique for the functional analysis of Lopez Island sites. The paradigmatic classification system used to classify the 54 sites on Lopez Island resulted in 3 separate classificatory codes, per site for each variable. Each classification generated numerous possible classes, but only a small portion of those classes were actually filled by the sites sampled. Table 1 outlines the paradigmatic classification system with all the components for the three codes. The previous research code describes the extent of investigation conducted at each site, as well as the kinds of data that was collected from the site (such as carbon dates or artifacts in collections) that may be used in future research. The microenvironmental code addresses dimensions that shape the environmental context or potential selective conditions for each site. The archaeological code addresses the presence or absence of nine different types of artifacts or material culture that are common to archaeology in the Salish Sea. The archaeology code allows for identifying and comparing the cultural materials present at each site and how sites with these cultural materials can be further investigated to address regional research questions. The further investigation of these sites is explored in the results and discussion section of this article.

The variables of microenvironment and archaeology are interrelated because the evolutionary archaeology framework assumes that environmental factors can influence the kinds of archaeology found at a site-for example, shoreline and shell middens (Bovy et al. 2007; Taylor et al. 2011). Previous research and archaeology are related because the level of previous research influences how much is known about the archaeology at a site. Sites that were investigated through data recovery are more likely to have more filled archaeology dimensions than those investigated through pedestrian survey.

After classifying each site and entering the data into Microsoft Excel, the Pivot Table tool was used to determine the frequency of site classes for each of the three major variables. This also allowed for observing trends between specific factors, such as individual artifact types and microenvironmental variables.

Table 1. Paradigmatic classification for the functional analysis of Lopez Island sites.

Previous research	Microenvironment	Archaeology
Carbon dates: Chronological data from cultural materials (0-absent, 1-present).	**Flora**: Plant life present at and adjacent to site.	**Faunal remains**: Animal bone and teeth.
STPs excavated: Shovel probes up to 1 meter deep, 35-50 cm wide (0-absent, 1-present).	**Freshwater distance**: Distance to closest freshwater source in meters.	**Chipped stone**: Lithic artifact with evidence of percussive reduction.
Data recovery: Excavation greater than 50 cm in width, usually 1 x 1 meter units (0-absent, 1-present).	**Shoreline distance**: Distance to closest shoreline in meters.	**Ground stone**: Lithic artifact with evidence of grinding or pecking reduction.
Collections: Museum or repository collections present or repatriated (0-absent, 1-present).	**2+ soil orders present**: Presence of more than one soil order.	**Shell midden**: Cultural deposit of shell, soil, and stone.
	Geomorphology: Geomorphological features/context at and around site.	**Shell**: Bivalve remains.
		FMR: Fire modified reock with evidence of heating such as discoloration.
		Human remains
		Anthropogenic soils/charcoal: Soils with organic cultural layer or deposited charcoal.
		Cairns: Stacked or piled rocks, usually indicative of burial.

Results

The results are described by each individual dimension for the main variables of previous research, microenvironment, and archaeology. For each variable, we describe the expectations for results for each dimension, the observed results, and an interpretation or possible explanation for each result and whether our expectations were met. When discussing results for previous research and microenvironment, we first discuss the results in terms of class distribution and then in terms of archaeological class richness based on the expectations of results. The distributions across the filled archaeology class codes are used to display the class richness, or number of filled archaeology classes, for the individual previous research and microenvironment dimensions.

Previous Research Analysis

Classifying recorded sites on Lopez Island by the extent of previous research done reveals the level of investigation at each site and across the island to show what is currently known about the island during precontact period. The expectation for levels of previous research for Lopez Island is that there will be more filled artifact classes and greater class richness for sites that have had more intensive research conducted at them, including subsurface investigations using shovel testing (STP) and data recovery techniques (Lyman 1991). Shovel testing has been conducted on 22 (41%) of the 54 sampled sites on Lopez Island. The extent of shovel testing for each site varies due to the differences in investigations and cultural resource surveys carried out throughout the island. Only five sites on Lopez Island (9%) have had one or more formed excavation units (e.g., 1 x 1 meter units). The sites that have been excavated for data recovery are 45SJ215, 45SJ254, 45SJ278, 45SJ280, and 45SJ288. Thirteen (24%) sites on Lopez Island had C14 dates associated with them (Table 2). Sites 45SJ255, 274, 278, and 280 have radiometric dates with a median value of 2500 BP or greater, but not all of those dates have been uploaded into WISAARD or published (Gary Wessen, personal communication 2020). A total of 16 (30%) sites on Lopez Island have or have had museum or repository collections associated with them. Some of these collections have been repatriated and have associated NAGPRA repatriation forms for the sites on WISAARD.

Table 2. List of Lopez Island sites with radiometric dates associated with them (from WISAARD or associated publications).

Site Smithsonian Number	Radiometric date (BP)
45SJ185	2545
45SJ186	820
45SJ200	1390, 1540
45SJ252	605-145, 535-430, 375-325, 740-645, 870-530 (all cal BP)
45SJ274	1470, 1330, 1140
45SJ277	540
45SJ279	700, 960, 1700, 700, 1340, 770
45SJ280	2850-2550, 2870-2480, 1650-1250, 850-780 (all cal BP)
45SJ281	1240
45SJ453	760
45SJ459	1110

As shown in Figure 3, the expectation that subsurface investigations such as those with STPs and data recovery would have more filled archaeology classes and greater class richness is true for sites with STPs excavated, but not for data recovery. Since many of the records and site forms do not provide further information on the volume and extent of subsurface investigation, it is difficult to determine if the current research done on Lopez Island accurately reflects the variability relationship whereas volume excavated increases, so will the expected artifact class richness (Lyman 1991).

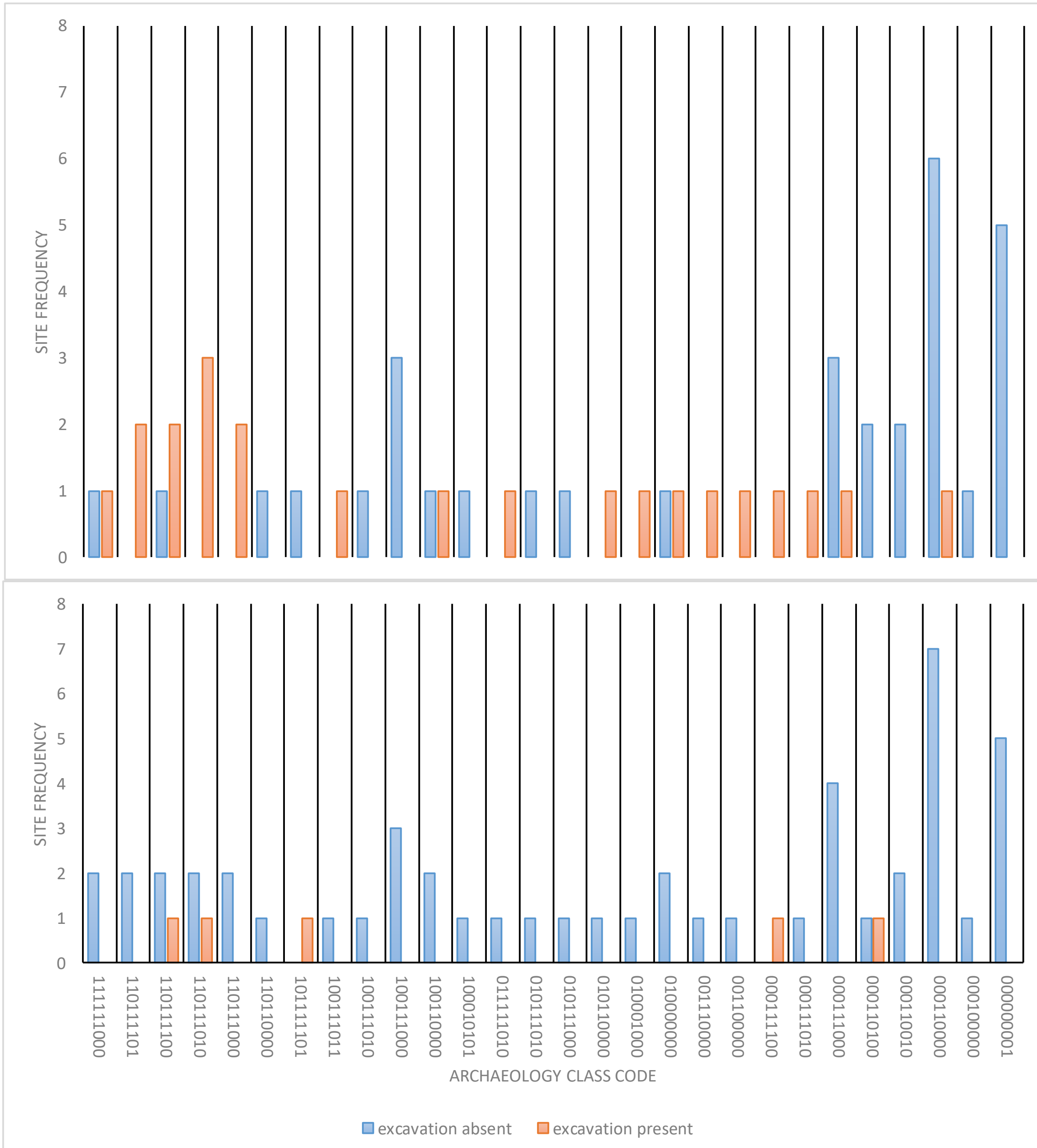

Figure 3. Frequency of site classes with STPs present and absent (top) and frequency of site classes with major excavations present and absent (bottom) (n = 54) The X-axis depicts archaeology classes in approximate order of greater to lesser class richness.

Another expectation of this study is that the microenvironments of sites may impact the level of research conducted at the site because of differences in access and visibility in different microenvironments throughout the island. The variability of artifact richness across excavated sites may not be only the result of how the archaeological record was investigated, but also the influence of differential selective conditions at each site. Figure 4 shows that the majority of sites and archaeological surveys on Lopez Island are located on the island's coast. Sites closer to the shoreline had a higher level of previous research conducted across all previous research classes. All 10 of the sites with radiometric dates were located on the shoreline. Out of the 16 sites with museum collections, 15 were on the shoreline and one was in the off-shoreline distance class. Out of the sites that had been shovel tested, 19 (35%) were located between 0 and 15 meters from the shoreline.

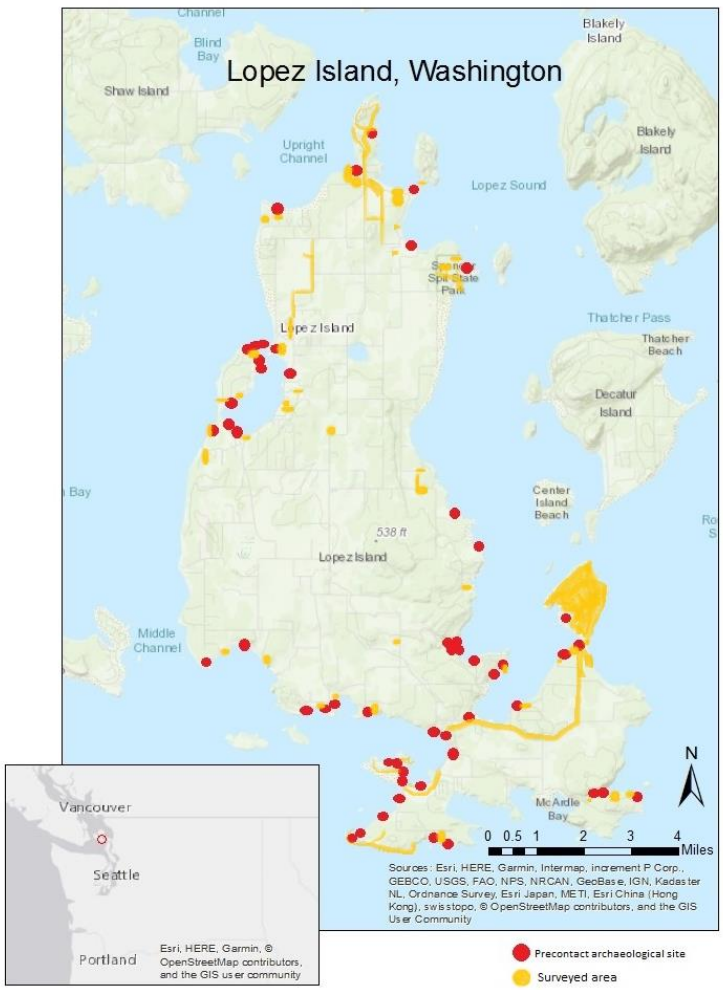

Figure 4. Map of Approximate Archaeological Site and Survey Locations on Lopez Island.

Figure 4 shows that when compared to work done on the coast of Lopez Island, the interior has barely been investigated, with the exception of interior road surveys. Without looking at the previous research done on Lopez Island, the recorded sites on the island gives the impression that there are no sites in the island's interior. The lack of investigation in the interior was a major data gap noted by Wessen (1988) and remains so today. The high number of recorded shoreline sites may be indicative of a higher frequency of sites on the shoreline of the island, or that there is a bias towards investigation of shoreline sites. Shoreline sites are also more likely to contain shell middens that can preserve organic materials, so these sites may contain more dateable materials, although recent advances in dating method and technique suggest alternatives to a reliance on charcoal dating (Brown et al. 2018). Regardless of the reason for the distribution of recorded archaeology on Lopez Island, the current archaeological record appears to be biased towards shoreline sites, with less than half of those sites investigated with any subsurface excavation.

Since all of the data used in this study was taken from sources such as site forms and other previous studies, the analysis used in this study is a biased interpretation of a biased sample of sites on Lopez Island. Not only are sites' data influenced by the various archaeologists and researchers who previously investigated them, they are also influenced by where things may be better preserved, and therefore more likely to be observed. This is noticeable through the concentration of recorded sites on the shoreline of the island, which is associated with shell middens which can better preserve organic materials (Stein 1992). Analysis of the microenvironments and archaeological characteristics at the sites provides further information about what is currently known about the recorded sites on Lopez Island that was not influenced by this sorting.

Microenvironment Analysis

In the case of plant and geomorphology classes, many sites had more than one recorded classification that is based on the recording archaeologists' observations. For initial classification purposes, we recorded presence or absence of more than one flora and geomorphology class. To ensure that all microenvironments were represented and to view the site distribution across the individual flora and geomorphology classes, we created two separate data sets for flora and geomorphology. In each dataset we duplicated each site that had more than one class, so that the frequency of specific flora and geomorphology classes could be observed. For example, a site that had both disturbed woodland and marine flora classes represented would be represented twice, once for each different class. This resulted in an inflated and unrepresentative sample for the flora (n = 81) and geomorphology class frequencies (n = 61). We discuss the impact to our analysis below.

The expectation for the flora microenvironments was that there would be more sites located in environments with access to more plant resources, as plants were a major source of food and medicine for Northwest Coast people (Suttles 1990). We found that in the sampled 54 sites, 28 sites had one flora class, and 26 had more than one flora class recorded. When observing the impact of multiple flora classes on archaeology class richness, we found that the class richness of sites with only one plant class versus 2+ plant classes was similar. This indicates that the number of flora classes did not impact the variation observed in archaeology class richness across the sites.

When including duplicated classes (n = 81) to account for sites that had multiple flora classes represented, maritime was the highest filled class with 29 sites (Figure 5). 15 of those sites were duplicates from a site with more than one flora classification. Freshwater flora was the only flora class with no sites represented. Given these results the sampled sites overrepresent maritime sites, however the open rocky outcrops, open transitional woodland, and dry coniferous woodland all have similar levels of frequencies across classes. Disturbed woodland was recorded in 16 sites, which may be due to the disturbing of flora happening after site occupation. This could be due to all of these classes being woodland variations, as well as differences in how the recording archaeologists defined and interpreted site environment. Noticeable gaps in the data are sites associated with freshwater plant microenvironments since that class was unfilled, as well as the meadow class, which had only 4 recorded sites associated with it. Given that Lopez Island has large areas of meadow land such as Iceberg Point, the lack of meadow sites shows another gap in the data. The expectations for flora classification were generally met, since almost half of the sites had more than one plant class represented and maritime plant microenvironment was the class with the highest frequency. However, more than one plant class recorded per site may be subjective biased by our analysis or as a result of different levels of expertise across different archaeologists recording the sites, both of which are limitations of this study. Although it provides an overestimation of flora class frequencies, the presence of duplicates does not change the overall pattern and distribution of sites across flora classifications.

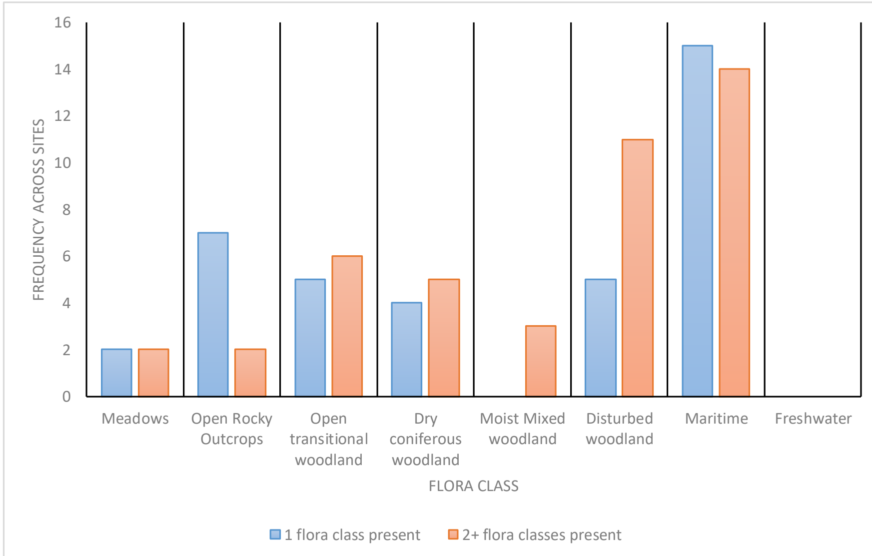

Figure 5. Frequencies of precontact sites in flora classes with either 1 or 2+ flora classes present (n = 81).

The expectation for the distribution of the archaeological record across geomorphic classes on Lopez Island is that there would be more sites with shoreline geomorphology due to the observed bias in previous research towards the island's shoreline. Furthermore, we expected to see greater archaeological variation in sites with two or more geomorphology classes, since access to more varied microenvironments with different resources would allow for more variation in human activity. The geomorphology of the sampled sites (Figure 6) shows that only 7 out of the 54 sites are in areas with more than one geomorphic class. When looking at the artifact class richness of sites with one geomorphic class versus 2 or more classes, sites with one geomorphology classification had more sites present in less rich artifact classes, however the 7 sites with 2 or more classification were distributed relatively evenly across the spectrum of class richness.

With the duplicate geomorphology dataset (n = 61) that has 7 sites with 2 or more geomorphology classes, 36 of the sites were recorded as being in a protected shoreline environment (Figure 6). Five of the protected shoreline sites were duplicates. There were no unfilled classes for geomorphology, however the class with the fewest sites was lowland slope with 4 sites. Despite the exposed shoreline class being in a marine environment, only 6 sites had exposed shoreline geomorphology. This may point towards a preference for protected shoreline areas, or that natural processes may have deteriorated sites on the exposed shoreline faster. Sites on exposed shorelines may also leave less of a trace than those on protected shorelines, especially considering that much of the exposed shorelines on Lopez Island today are steep, rocky cliffs. The exposed shoreline, bedrock, and glacial terrace classes have very similar frequencies. Overall, the recorded geomorphology at the sampled sites is biased towards protected shorelines, although when looking at non-protected shoreline classes the distribution has evenness across the other four classes, with each of those classes filled by less than 10 sites (Figure 6). Since this study is based off of the recording archaeologists' observations of the site, the detail in recorded microenvironment geomorphology will vary. This is observable in the differences in number of geomorphology descriptions (interpreted as multiple classes) between different sites. Furthermore, a bias in survey and fieldwork toward geomorphology classes associated with the coast of Lopez Island will obviously lead to more sites recorded on shoreline landforms. The higher frequency of protected shoreline sites is also related to the trend we see in the flora classification, where maritime flora had the highest number of sites represented. Due to all of these factors the Lopez Island sites sampled in this study display a high frequency of maritime environments.

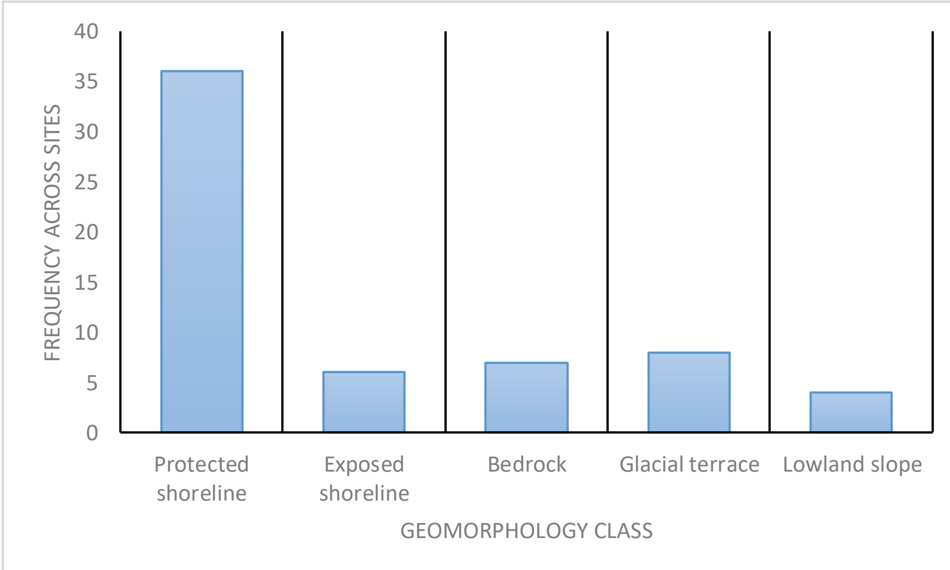

Figure 6. Frequency of geomorphology classes with duplicates represented (n = 61).

The third microenvironmental dimension used for this classification is distance to shoreline. The expectation for site distance to shoreline is that there would be more sites closer to the shoreline because of the large amount of compliance archaeology conducted on the island's coast. Shoreline properties are valuable today because of their view, however they may have been valuable during precontact because they can provide access to a wider variety of resources. Therefore, another expectation is that the closer to the shoreline a site is, the more filled artifact types since there would be a wider variety of precontact activity. All of the shoreline distance classes were filled, although the distribution is biased towards sites 0-15 meters from the shoreline.

The shoreline class (0-15 m) was the class with the highest frequency of sites (37). This is in line with the results from the geomorphology and flora analysis of majority marine shoreline microenvironments. However, the class with the second highest frequency is off shoreline (50.1-352 m), not near shoreline. This class encompasses a very large distance interval which may account for it having the second highest frequency, however it still shows that there is some variability in the recorded sites on Lopez Island and that not all of the sites are on or near the shoreline. Near shoreline sites is the lowest frequency class, with only 5 sites. Figure 7 shows that not only does the shoreline class have a higher frequency of filled classes, it also has more classes with filled artifact dimensions. This shows that the expectation of more artifact variation closer to the shoreline is supported.

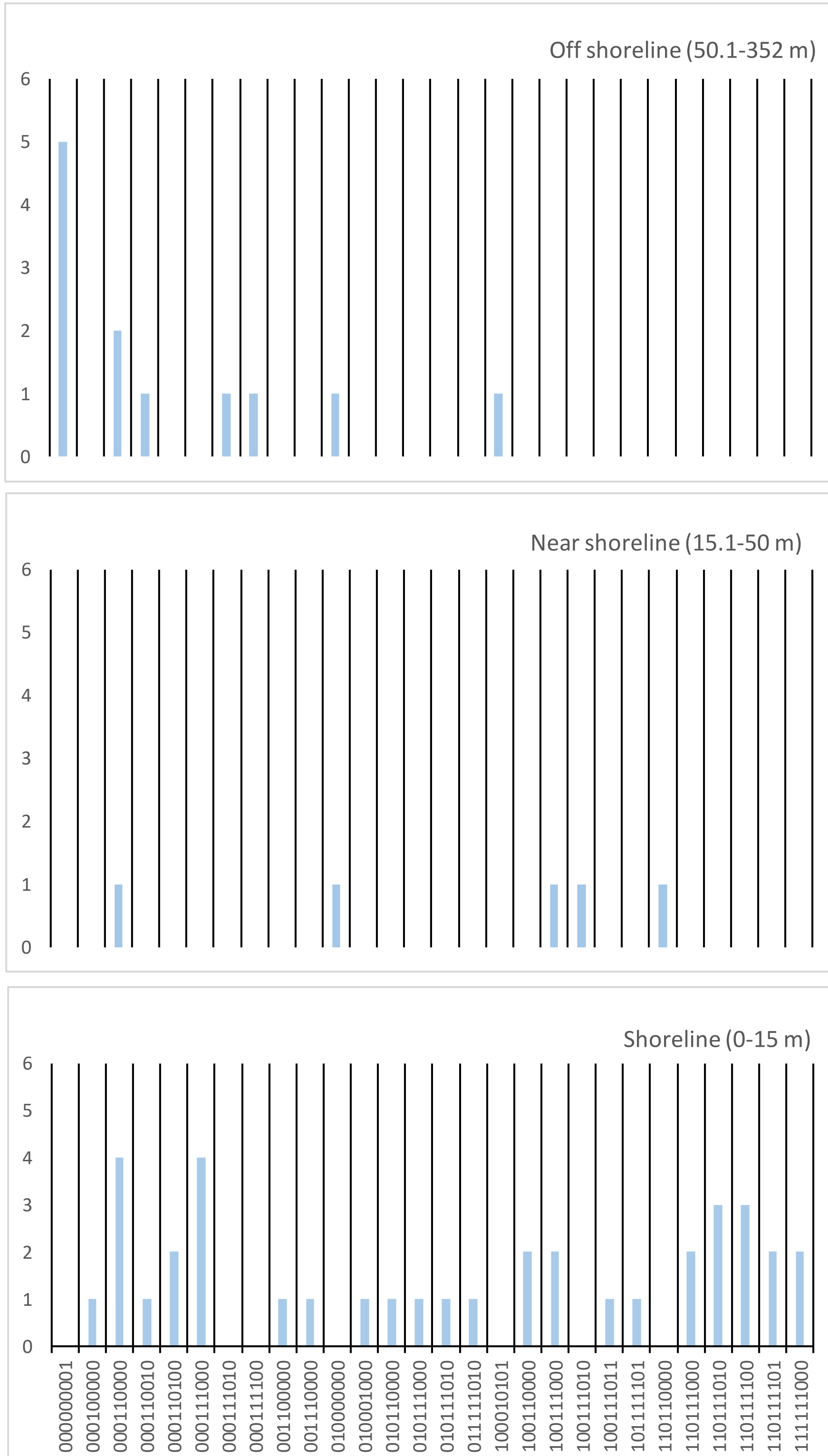

Figure 7. Frequency of filled artifact classes by shoreline distance classification, X-axis is the same for all three graphs and shows artifact classes in order from greater to lesser class richness (n = 54).

Analysis of site distance to freshwater sources may provide further information on the resource access available at each site. Distance from freshwater sources to midden sites was investigated by Taylor et al. (2011) by measuring the distance from 50 sites in the San Juan Islands and the first and second most close water source to determine if there were changes in water resource use over time. Our assumption for freshwater distance for Lopez Island sites was that closer proximity to water allowed people to carry out a wider variety of activities because it would reduce the effort to transport water to other areas. Therefore, the expectation for distance to freshwater is that there would be richer artifact class frequency closer to freshwater because better access to water would make it easier to carry out a wider variety of activities, including activities that would require a large amount of water. Frequency of archaeological sites and freshwater distance classification (Figure 8) showed that the class with the highest frequency of sites was Class 2 (484-967 meters), followed by Class 3 (968-1451 meters). The distribution of sites decreases in each following freshwater distance classes after Class 2.

The frequency of sites and distance to freshwater decreases from Class 2 to the last class. Despite the expectation that there would be more sites close to freshwater sources, there are only 9 sites in Class 1 within 483 meters of known freshwater sources. There were no unfilled classes for this dimension. This information was gathered from modern sources on freshwater on Lopez Island (Russell 1975, U.S. Geological Survey 2019). There may be changes in freshwater availability since site occupation leading to a bias as noted in Taylor et al. (2011). Taylor et al. (2011) looked at midden site distance to freshwater and found no significant change in distance to freshwater over time, and concluded that the shortest distance to freshwater may not reflect the actual routes people may have taken to get to these sources based on the changing marine environments surrounding middens. The expectation of there being richer artifact class frequencies closer to freshwater was also met. This supports the expectation that the closer a site is to a freshwater source, the more varied activities would occur there and reflected as more variation in the archaeological record. One exception to this is the site class code 000000001, which are rock cairn sites. Since these sites do not have great class richness it was expected that they would not be located near freshwater sources, however that site class has the greatest frequency of 3 sites in freshwater distance class 2, which is 484-967 meters away.

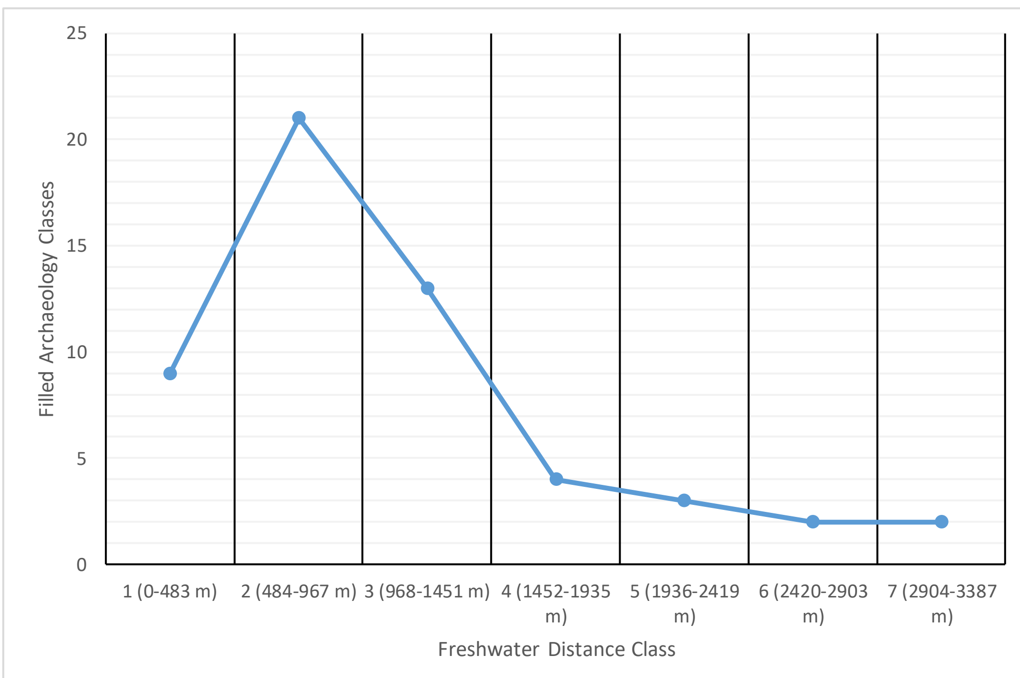

Figure 8. Artifact site class frequency by freshwater distance class (n = 54).

Soils were included in the microenvironment classification and analysis because soils at a site can impact the kinds of resources and landforms accessible at a site. For this study we classified soils by the presence or absence of more than one soil order at each site. The amount of available data for soil orders and series at each site includes more detailed information than the amount of soil orders present such as soil series and slope, however for the purposes of this thesis measuring the variability of soil orders by the number of orders present shows the diversity of soils within sites' microenvironments. The expectation for the soil dimension is that since we expected more sites closer to the shoreline, soil variability would be lower and would have more sites with only one soil order represented. Out of the 54 sites sampled in this thesis, 26 only had one soil order while 28 had two or more soil orders represented.

Both classes were filled because it was a presence/absence classification. The slightly higher frequency of 2+ soil orders per site indicates that there is considerable variability in the soils within individual sites, as well as across the island. The expectation of less variability in soil orders was not met, since the number of sites with more than one soil order is almost equal to those with only one order represented. Furthermore, there were more filled artifact classes and more artifact material types present in the sites with 2 or more soil orders than in those with only one soil order represented (Figure 9). This may be due to more soil variety resulting in more varied resources available, and therefore more variation in the material culture observed.

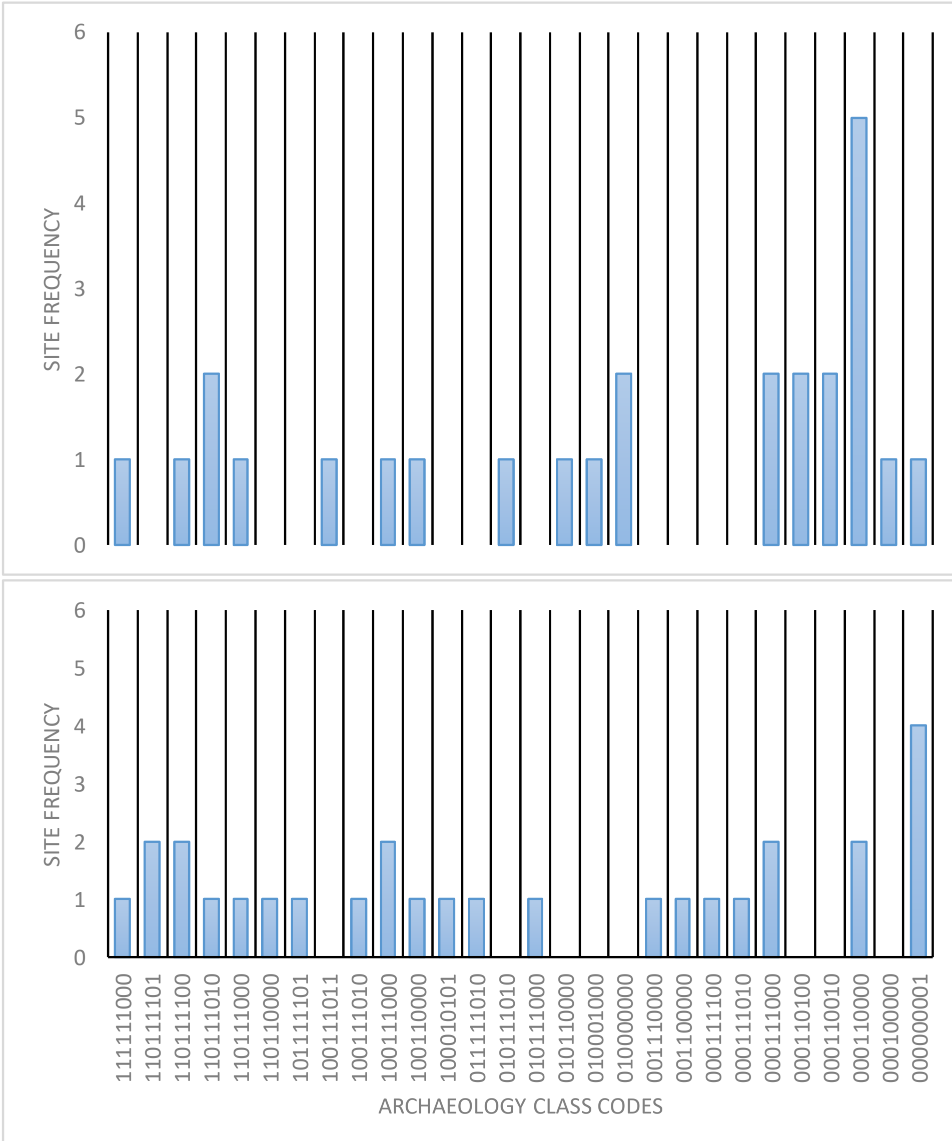

Figure 9. Frequency of Archaeology Classes with One Soil Order (top) and 2+ Soil Orders (bottom). The archaeology classes are in approximate order of greater to lesser class richness (n = 54).

The results of the microenvironment classification and analysis is summarized first by individual microenvironment attribute similarities and differences and secondly by archaeological class richness. The outcomes of our expectations for microenvironments of recorded sites on Lopez Island were different between different dimensions. For the flora classification, the expectation that there would be more sites in resource rich areas such as marine zones was met, and there was an almost equal amount of sites with and without more than one plant class, showing that there is a high amount of sites with access to a variety of plant resources. For geomorphology, the expectation that there would be more sites with access to 2 or more geomorphology classes was not met, although there was a high frequency of sites in protected shorelines, indicating that these areas with access to both marine and littoral resources are still well represented (Dancey 1973, Thompson 1978). Overall, the similarities among these microenvironmental dimensions towards a marine shoreline environment reflect what the previous research analysis showed, that there is a sorting bias towards these shoreline sites on Lopez Island. However, the expectation that there would be more sites with only one soil order represented was not met despite the bias towards shoreline sites, indicating that almost half of the sites had access to selective conditions with more diverse soils and potentially more resources.

Artifact variability and class richness was also investigated across microenvironmental dimensions. The expectation that the closer to the shoreline, the more variability in artifact types was met, showing that there is more variability within sites the closer they are to the island's coast. This may also be due to more intensive investigations on the shoreline, which would provide more data on sites. For distance to freshwater the expectation that there would be more artifact variability closer to freshwater was also confirmed. Furthermore, sites with 2+ soil orders displayed more variability and greater class richness than sites with only one soil order represented. These results show that sites in microenvironments associated with access to resources display greater variation in their cultural materials. Therefore, our expectation that sites in microenvironments with greater resource access would have greater variation in human activity was met.

The analysis of microenvironments for recorded sites on Lopez Island shows that there is a high frequency of protected shoreline sites in marine flora environments, with freshwater access not close to the sites. However, the observed archaeological variation within the individual microenvironmental classifications shows that overall our expectations of areas with access to a greater variety of resources would have greater archaeological variation were met. This diversity of microenvironments represented in the recorded archaeological sites on Lopez Island shows that these different microenvironments can be used to understand the selective conditions of sites, and therefore the precontact function of the cultural materials at each site that increased people's fitness (Dunnell 1978b). However, due to the bias in this sample towards marine shoreline environments the evidence of post-depositional sorting and sampling is evident and must be taken into account when interpreting the selective conditions of the recorded archaeology on Lopez Island. Just because there are more sites in shoreline microenvironments does not mean that the shoreline provided more ideal selective conditions for precontact peoples, but that there is more information on these sites due to sorting. The following section describes the results of the archaeology analysis, which is interpreted as the adaptations to the microenvironments' selective conditions.

Archaeology Analysis

Due to the low sample size in this study, we focus more on the frequency distribution across the modes for each archaeological dimension instead of the filled class distributions. In order to identify variation in site archaeology on Lopez Island, the archaeology classification for this study uses nine different dimensions based on the material culture identified from a site. Material type was used as the level of analysis for this study because most of the archaeological data was gathered from site forms and reports, many of which vary in the level of material culture descriptions. The expectation for archaeology represented in the recorded sites on Lopez Island is that there would be a higher frequency of shell and shell midden represented, due to recorded sites' proximity to the shoreline and the preservative chemical qualities of shell midden sites (Stein 1992). The analysis of archaeology for Lopez Island's sites resulted in 28 filled material type classes out of a potential 512 classes (Figure 10). In general, the more 1s in a class code means more rich in material types present.

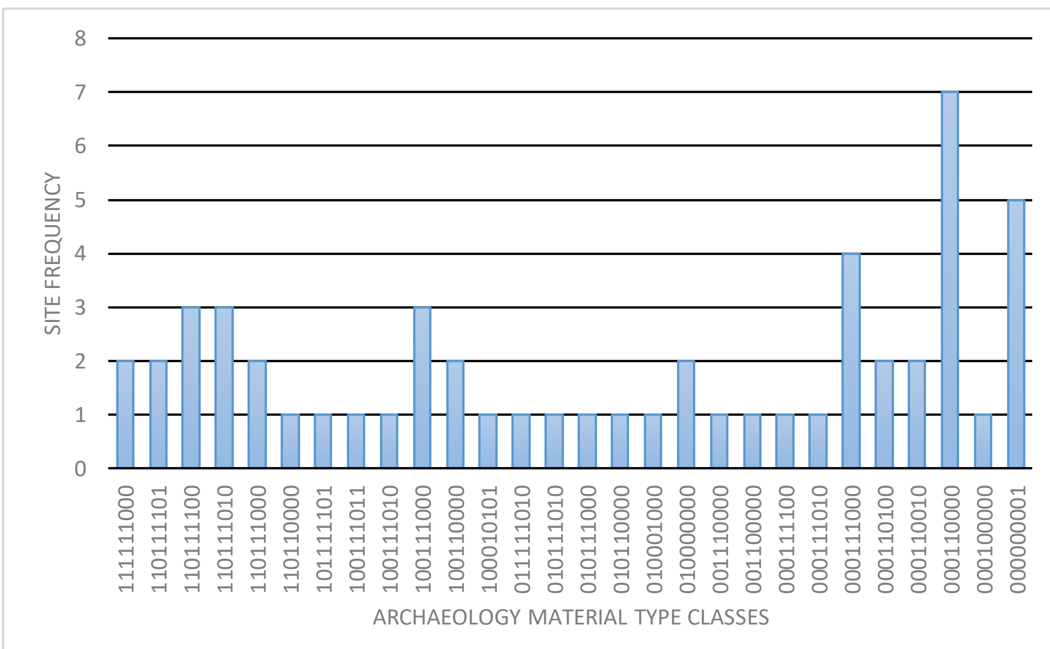

Figure 10. Frequency of sites by archaeology material type class (n = 54).

The class with the highest frequency of seven sites was 000110000, which are sites with only shell and shell midden present. Midden without the adjective shell was written on a number of site forms. The class with the second highest frequency of five sites was 000000001, which are rock cairn only sites. The sites under this class were described explicitly as rock cairns in their site forms with no other artifact material types, and they tended to be further away from the shoreline than other filled classes (Kenady 1998, Wessen 1999).

Figure 11 shows the frequency of artifact material types across all of the 54 sampled sites. Shell had one of the highest present frequencies of the archaeology dimensions. It is present in 44 of the sites, or 82% of the total sampled sites. Similarly, shell midden was recorded at 45 of the sites, or 83% of the sample. Only one of the sites without shell midden contained shell, while 43 of the midden-present sites also contained shell. This overlap is probably due to the presence of shell as a major component of archaeological middens throughout the region. Inconsistencies with middens without shell may be a result of how the site was recorded. Bone faunal remains were present in 22 sites (41%). Faunal remains were recorded as present in 21 midden sites, and only one site had faunal remains without midden. This relationship may be due to the preservative qualities of middens leading to better identification of faunal remains (Stein 1992).

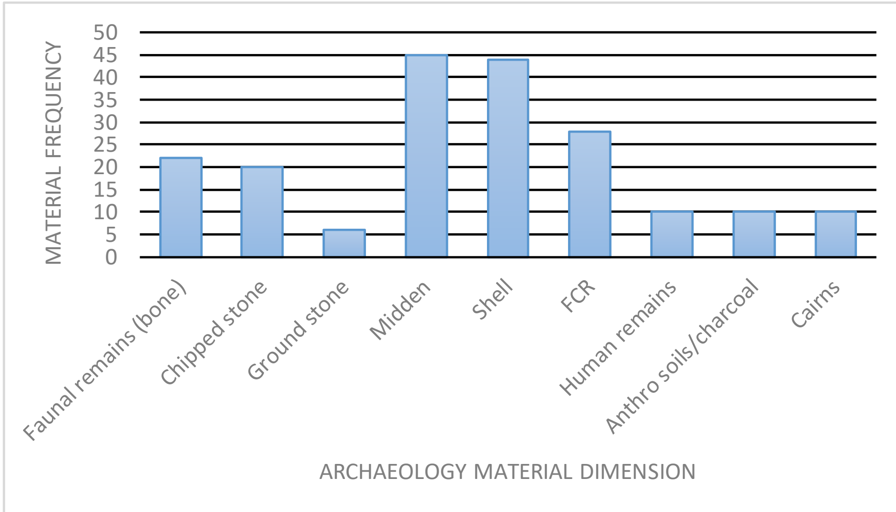

Figure 11. Frequency of observations of each present artifact dimension across all sites. Each artifact type is independently reported.

Chipped stone material was present in 20 of the sites, or 37% of the sample. Ground stone was less frequent, present in 6 (11%) sites. Fire modified rock (FMR) is present in 28 of the sites (52%). Charcoal/anthropogenic soils were present in 10 sites (19%). Cairns were present in 10 sites (19%). Human remains were also present in 10 sites (19%). There are four sites with both cairns and human remains present. The variability across artifact classes indicates a wide variety of precontact activity, however as shown in the most frequent archeology code of 000110000, sites with just shell and midden are predominant in recorded sites on Lopez Island. This shows that the expectation that shell and shell midden would be heavily represented is met, however the result of rock cairns being the second most frequent class was not expected and shows that these sites are also prevalent in the recorded archaeology of Lopez Island.

The following section discusses interrelationships between individual artifact material and microenvironment dimensions that may provide further information on site precontact function. The microenvironmental dimensions of geomorphology, distance to freshwater, and distance to shoreline are the most stable over the last 3,000 years and provide information about distance and access to resource areas.

Archaeology and Microenvironment Interrelationships

Relationships between the microenvironment and archaeology dimensions provide information on potential function of the sites in this sample. The first interrelationship we discuss is with distance to freshwater. In general, artifact materials tended to be in freshwater distance class 2 (484-967 meters) with the exceptions of human remains and faunal remains. Human remains had two sites in freshwater class 2 and three sites in class 3. Faunal remains were consistent across the first three freshwater distance classes and were skewed away from freshwater sources (Figure 12). After 1451 meters the frequency of faunal remains decreases. Although there was an initial expectation of there being a greater frequency of faunal remains closer to freshwater since we assumed that water access while processing and consuming food would be at a premium, the relationship between freshwater distance and faunal remains shows that faunal remains were not significantly more frequent closer to freshwater, remaining consistent from 0 to 1451 meters. The frequency of faunal remains did drop off after almost 1500 meters.

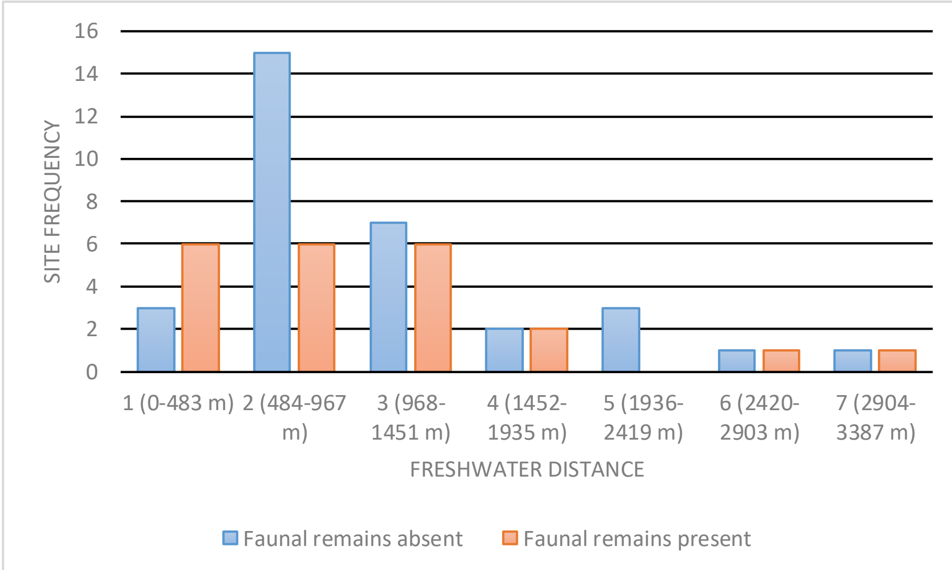

Figure 12. Faunal remains frequency, presence and absence, and distance to freshwater.

The presence of faunal remains in the sample is probably also influenced by the presence of shell middens, since they provide a preservative environment. Out of the 22 sites containing faunal remains, 21 are also shell midden sites. Therefore, the presence of faunal remains is also most likely biased towards these sites that provide more preservation and microenvironmental characteristics like freshwater distance may have less impact on the distribution of faunal remains.

Another notable correlation we observed was with freshwater and FMR. Our expectation was that there would be FMR closer to freshwater, and that expectation was met, with FMR being most frequent in freshwater Class 2 (Figure 13). The relationship between FMR and freshwater distance may be due to use of rocks for heating water or other resource processing activities. The initial expectation for this study was that sites involving resource use and processing like shell middens would have closer proximity to freshwater, but the results show that sites were often not right near water sources like we expected. Other material adaptations such as basketry may have allowed people to adapt to the selective condition of freshwater access and made further distance to freshwater less of a constraint (Croes 2019; Suttles 1990). Furthermore, sources of freshwater could have dried up since site occupation and may have been missed during the contemporary studies used for this thesis. Finally, we know that the interior areas of Lopez Island are not well surveyed and many of those areas are closer to fresh water so the results presented above may change with additional survey and site identification in the interior areas.

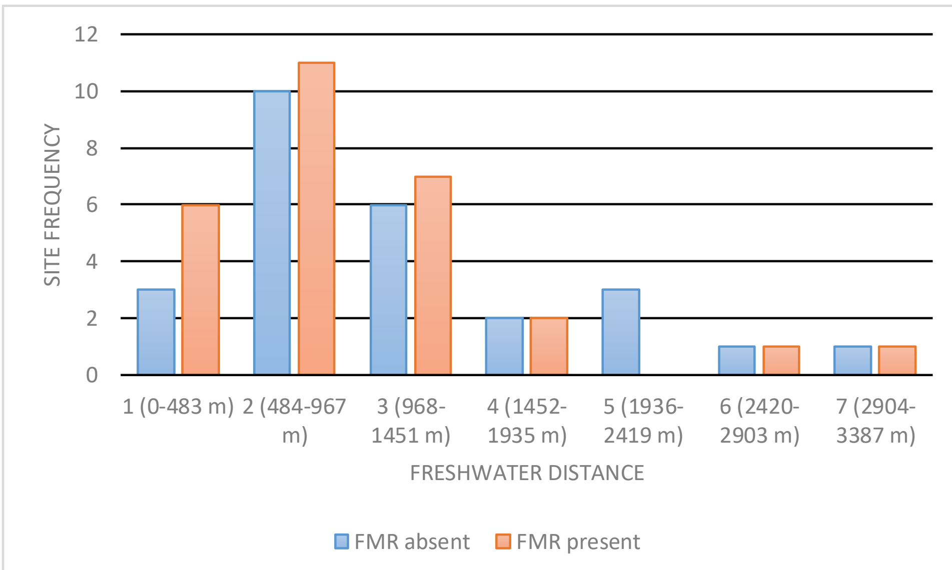

Figure 13. FMR frequency, presence and absence, and distance to freshwater.

The second microenvironment and artifact material interrelationship described is distance to shoreline. In general, shoreline distance and individual artifact material reveals the same microenvironmental trend displayed for all archaeological sites; most of the archaeological sites are located on the shoreline. All material type modes were recorded across all shoreline distance classes, while most filled classes were in each shoreline class groundstone artifacts only occurred in shoreline sites (Figure 14).

Although groundstone was relatively rare in the sample of sites, the sites that did have groundstone were all shoreline sites (0-15 meters). This may indicate that resource processing activity was occurring on the shoreline, potentially due to easier access to marine resources. Four out of the six sites with groundstone present had shovel testing done compared to one near shoreline and two off shoreline, so this more intensive sampling at sites with groundstone may have contributed to a greater class richness at these sites and a potential sampling bias.

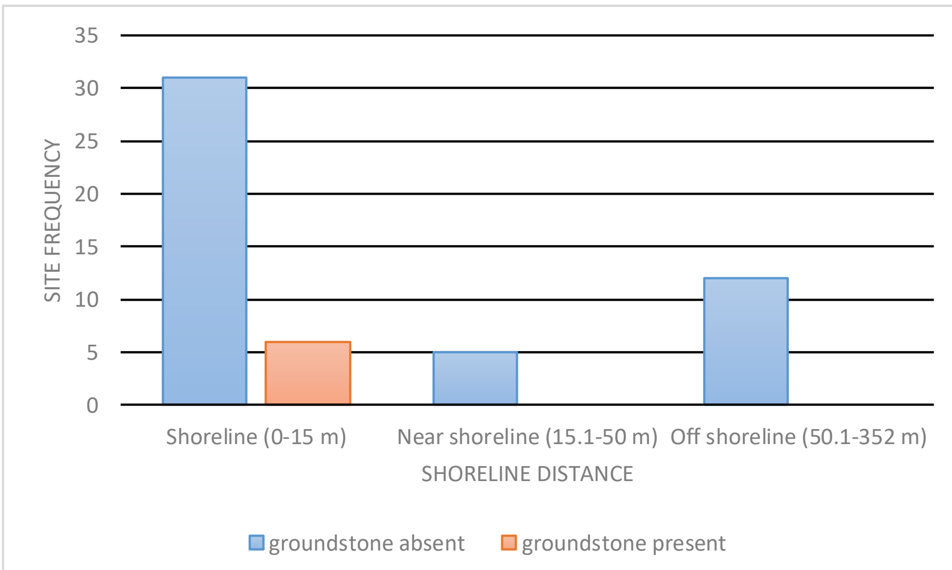

Figure 14. Frequency of sites with groundstone artifacts present and absent, and shoreline distance.

Midden sites are present in all three shoreline distance classes with on shoreline having the highest frequency, but the class with the second highest frequency of midden sites is shoreline distance class 3 with 5 midden sites present (Figure 15) (class 2 has 4 sites recorded). Our expectation was that the frequency of midden sites would decrease the further away from the shoreline. The frequency of these 5 midden sites at least 50.1 meters from the shoreline may indicate a bias in the class intervals since the off-shoreline class is still relatively close to the shoreline starting at 50.1 meters. However, it could also point towards midden and disposal activity occurring in areas besides the shoreline, where middens are typically observed. This result is also not surprising because past shorelines may have existed where these sites are located, and variable midden locations could be evidence of changing shorelines on Lopez Island.

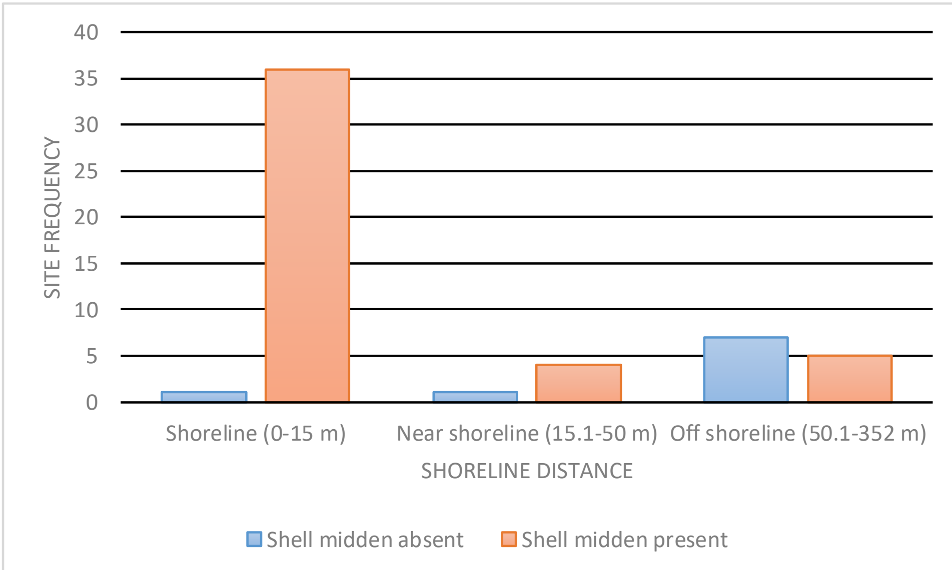

Figure 15. Frequency of sites with shell midden present and absent, and shoreline distance.

While we found above that the geomorphology of recorded sites on Lopez Island reveal that the majority of sites are located in a protected shoreline context, the distribution of artifact material types reveals some variation in the distribution across non-protected shoreline classes. FMR was present in six bedrock and glacial terrace geomorphological contexts. The presence of FMR in non-beach contexts shows that burning and potential resource processing activity was not limited to the beaches on Lopez Island. Cairn sites had the highest frequencies of four sites in both protected shoreline and lowland slope, indicating that these kinds of sites may vary in their function depending on geomorphology. The variation in geomorphology for cairn sites may indicate differing function of cairns based on other factors not investigated here, such as viewshed or elevation.

Discussion and Conclusions

This section discusses how recorded sites on Lopez Island could be further investigated to place the island into the greater regional and historic context of the Salish Sea. We then discuss various data gaps identified through the functional analysis in this study. Finally, we identify recommendations for future efforts based off the results of this research.

Historic Context

Previous studies used inventory and analysis of recorded archaeology to put the archaeology of defined areas into their greater historic and regional context (Bruce et al. 2001; Hackenberger 2009; Kopperl et al. 2011; Miss 1999). This study similarly analyzed sites through a functional analysis and created a site classification through the microenvironment, archaeology, and previous research codes. Through the previous research classification, this approach allowed us to identify sites and areas that may be biased due to variation in recording and restrict the analysis to areas that may not be biased because of that variation. This approach allows for identifying sources of sorting that may not be addressed in an exhaustive historic context, but the results of this study are also limited due to that non-random variation that is the result of post-depositional processes and fieldwork. Identifying which site classes can be applied to regional research questions shows how the recorded archaeology on Lopez Island may fit into the regional context of the Salish Sea.

Chronology is a research domain that has been explored through previous investigations on Lopez Island (Taylor et al. 2011). Site types that are positive for shell middens and charcoal/anthropogenic soils such as those at Mud Bay (45SJ279) on the southeast end of the island and Spencer Spit (45SJ274) on the northeast side would be ideal for continuing this research path because of their data potential and organic materials. Sites that tested positive for FMR could also be tested using thermoluminescence dating and provide more chronological data about those sites and the associated archaeology. Sampling from sites containing these kinds of cultural materials across the island could provide more data on the human chronology of Lopez Island, and would also be able to be compared to other dated sites across the San Juan Islands and throughout the Salish Sea.

Settlement and subsistence in the Salish Sea are another topic of research that have previously been investigated (Taylor et al. 2011; Thomas 2006; Weiser and Lepofsky 2009). Site classes on Lopez Island that may be used to further investigate precontact settlement and subsistence are again sites containing shell midden, but also sites such as 45SJ288, which is located near resource acquisition microenvironments like camas prairies. This kind of site could provide more information on the kinds of human activity occurring at different resource areas and how those resource areas may have been used during changes in settlement and subsistence strategies.

Finally, ideology is another domain that could be investigated through study of recorded Lopez Island sites. Rock cairn sites have been identified in previous research on the island (Smith 1907; Wessen 1988) and are identified as their own site class in this analysis (archaeology class 000000001). Although intensive fieldwork at these sites may not be possible or advisable due to their tendency to be burial markers, identifying the kinds of microenvironments they are found in may provide further information on the situational contexts for sites with potential burial functions for more informed site identification in the future. Furthermore, developing a better understanding of the microenvironmental contexts of cairn sites in conjunction with tribal collaboration on Lopez Island will aid in identifying areas with a higher probability of cairn sites so that they can be better protected.

Data Gaps

The final requirement for historic contexts is to “identify further information needs” for the study area (Little et al. 2000:15). For this study the information needs are the data gaps in the archaeological record of Lopez Island. This study reveals a trend in that the survey coverage and archaeological site locations on Lopez Island are biased towards marine shoreline sites. Other studies (Stein 2000; Thomas 2006; Weiser and Lepofsky 2009) have acknowledged the influence of midden-centrism throughout Northwest Coast research, and the prevalence of middens in this analysis points towards midden-centrism in Lopez Island research as well. Another potential reason for the bias towards shoreline sites on Lopez Island is that the interior of the island is primarily private farmland and forested, which may account for the fewer number of archaeological investigations carried out there (Wessen 1988). Ethnographic records point towards Straits Salish people using inland resources in addition to marine resources, so the presence of unrecorded archaeological sites in the island’s interior is likely (Suttles 1990). Wessen (1988) recommended further survey in the interior of the San Juan Islands, and that recommendation still holds today for Lopez Island.

Another result of this study is the finding that there have been few subsurface investigations carried out on Lopez Island. Many of the sites recorded on the island are exposed middens on the shoreline that were not surveyed to determine their extent. The lack of major excavations on the island means that very little data recovery has been carried out for more extensive studies (with the exception of projects like those carried out at Watmough Bay by Bovy et al. 2007, Phillips et al. 2007, and Taylor et al. 2011). This means that the current archaeological record on Lopez Island is likely only a partial picture of the island's cultural resources.

The second research question for this study was whether there were adequately dated and recorded contexts on Lopez Island to determine how the island may fit into the shift towards sedentism 5000 YBP. Out of the 54 sites sampled on Lopez Island, only 13 of them have radiometric dates associated with them and all of those dates were taken from sites on the shoreline. Faunal remains were present in 17 undated sites, shell in 34 undated sites, and midden in 35 undated sites. These sites contain organic materials that could be used to date and add to the knowledge of chronology on Lopez Island. There are four sites that have median dates of 2500 YBP or older, however not all of those dates are accessible on WISAARD (Gary Wessen, personal communication 2019). With only 24% of the sites dated and none of those dates taken from non-shoreline sites, it is clear that a final data gap is that there are not adequately dated sites on the island to address where it fits in the regional shift towards sedentism 5000 BP. With a larger sample size of 54 sites it may be possible to investigate this research question further, however the lack of in-depth archaeological investigations at most sites on the island shows that further research on Lopez Island is required.

Recommendations

Recommendations for future research to fill the data gaps in the archaeological record on Lopez Island address the previously discussed issues of biased sampling. The frequency of shell and midden sites that have potential for analysis such as radiometric dating certainly can provide further data on precontact occupation and are be worth investigating. However, there is little to no archaeology recorded for the interior of the island, which may contain more information on Holocene and potentially late Pleistocene occupation. These interior microenvironments would be worth surveying in order to determine how non-marine resource areas on Lopez Island may have been utilized during precontact.

Investigations in the interior of the island would provide a better picture of the kinds of human activity that occurred there. Consultations with private landowners who may have further knowledge about archaeology found on their property would also provide further information on potential inland archaeology on Lopez Island that has never been recorded.

The sites that have already been recorded on Lopez Island may also provide further data to investigate regional research questions. Using radiocarbon dating or other dating techniques on sites located near resource acquisition areas could provide data on the changes in resource and site use over time. Sites close to freshwater sources could be further sampled and analyzed to gauge changes in water resource use.

The bias towards surface observations and exposed middens could be addressed through further subsurface testing of recorded sites in order to understand more about the extent and content of known sites. Our analysis of previous research shows that shovel testing increases the archaeological class richness at sites, so using shovel testing as a minimum level of investigation would provide more data on Lopez Island archaeology. The use of geophysical survey methods such as ground-penetrating radar, magnetometry, and electronic resistivity would also be a less invasive way of investigating recorded sites and new sites that would address this data gap.

In addition to showing how currently recorded archaeology can be further investigated to address regional research questions, we also aim for this study to aid in the management of cultural resources on Lopez Island. This study of recorded archaeology on Lopez Island shows what we currently know about the location and distribution of sites on the island's coastline, especially sites containing shell midden. The distribution of these sites is mainly on protected shorelines. Little is known on inland sites and subsurface archaeology. A better understanding of what is known about the sites currently recorded on Lopez Island can help resource managers to identify areas that may have a higher probability of archaeology and what kinds of cultural materials may be present in different microenvironments on the island, allowing for better management and protection of these resources. Collaboration with the Native American tribes associated with Lopez Island will provide resource managers and researchers with further context for these sites and better understanding of the human history of Lopez Island.

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APPENDICES

Appendix A: Raw Data, No Duplicates

Site count	Smithsonian site #	2+ plant. Classes present	Freshwater distance class	Shoreline dist. Class	2+ soil classes present	2+ Geomorph classes present	Microenvironment class code
1	SJ176	0	2	3	1	0	02310
2	sj177	0	3	1	0	0	03100
3	sj185	1	3	1	1	0	13110
4	sj186	1	3	1	0	0	13100
5	Sj200	0	2	1	1	1	02111
6	sj205	0	4	2	1	1	04211
7	sj215	0	2	3	1	0	02310
8	sj252	1	1	1	1	0	11110
9	sj254	0	2	1	0	0	02100
10	sj255	1	2	1	1	0	12110
11	sj256	0	2	3	0	0	02300
12	sj257	1	1	1	1	0	11110
13	sj259	1	2	1	1	0	12210
14	sj260	0	1	1	0	0	01100
15	sj261	1	3	2	0	0	13200
16	sj263	1	1	1	1	0	11110
17	sj265	0	4	1	1	1	04111
18	sj266	0	2	3	1	0	02310
19	sj267	1	4	1	0	0	14100
20	sj268	0	5	1	0	0	05100
21	sj269	0	5	1	0	0	05100
22	sj270	1	6	1	0	0	16100
23	sj271	0	1	1	1	1	01111
24	sj272	0	2	1	0	0	02100
25	sj273	1	1	1	1	0	11110
26	sj274	0	3	1	1	0	03110
27	sj276	1	2	1	1	0	12110
28	sj277	1	3	1	0	0	13100
29	sj278	0	3	1	0	0	03100
30	sj279	1	2	1	1	0	12110
31	sj280	0	2	1	0	0	02100
32	sj281	1	3	1	1	0	13110
33	sj288	0	6	1	1	0	06110
34	sj368	0	2	3	1	0	02310
35	sj370	0	2	3	1	0	02310
36	sj371	1	3	1	0	0	13100
37	sj411	0	2	3	0	0	02300
38	sj418	1	5	3	1	0	15310
39	sj419	1	4	3	1	0	14310
40	sj420	0	1	2	1	0	01210
41	sj423	1	1	2	1	0	11210
42	sj440	0	2	1	0	0	02100
43	sj441	0	3	2	0	0	03200
44	sj442	0	2	1	0	0	02100
45	sj453	1	2	1	0	0	12100
46	sj458	0	2	1	1	1	02111
47	sj459	1	2	1	0	1	12101
48	sj463	1	2	3	1	0	12310
49	sj506	0	3	1	0	0	03100
50	sj522	1	7	1	0	0	17100
51	sj523	1	7	1	0	0	17100
52	sj534	1	1	3	1	0	11310
53	sj561	1	3	3	0	1	13301
54	sj569	0	3	1	0	0	03100

Smithsonian site #	Faunal remains	Chipped stone	Ground Stone	Shell Midden	Shell	FMR	Human remains	Anthro soils/charcoal	Rock Cairns	Artifact Class Code
SJ176	0	0	0	1	1	0	0	0	0	000110000
sj177	0	0	0	1	1	0	0	0	0	000110000
sj185	1	1	0	1	1	1	1	0	0	110111100
sj186	0	0	0	1	1	0	1	0	0	000110100
Sj200	1	1	0	1	1	1	1	0	0	110111100
sj205	1	0	0	1	1	1	0	0	0	100111000
sj215	0	0	0	1	1	1	1	0	0	000111100
sj252	1	1	0	1	1	1	0	1	0	110111010
sj254	1	1	0	1	1	1	0	1	0	110111010
sj255	1	1	1	1	1	1	0	0	0	111111000
sj256	0	0	0	1	1	0	0	1	0	000110010
sj257	1	0	0	1	1	0	0	0	0	100110000
sj259	0	0	0	1	1	1	0	0	0	000111000
sj260	0	0	0	1	1	1	0	0	0	000111000
sj261	0	0	0	1	1	0	0	0	0	000110000
sj263	1	1	0	1	1	1	1	0	0	110111100
sj265	0	0	1	1	0	0	0	0	0	001100000
sj266	0	0	0	1	1	0	0	0	0	000110000
sj267	1	1	0	1	1	1	0	0	0	110111000
sj268	0	0	0	1	1	0	0	0	0	000110000
sj269	0	0	0	1	1	0	0	1	0	000110010
sj270	0	0	0	1	0	0	0	0	0	000100000
sj271	0	1	1	1	1	1	0	1	0	011111010
sj272	1	0	0	1	1	1	0	0	0	100111000
sj273	0	1	0	1	1	1	0	0	0	010111000
sj274	1	1	0	1	1	1	1	0	0	110111100
sj276	0	0	0	1	1	1	0	0	0	000111000
sj277	0	0	0	1	1	1	0	0	0	000111000
sj278	1	1	0	1	1	1	1	0	0	110111100
sj279	0	0	1	1	1	0	0	0	0	001110000
sj280	0	0	0	1	1	0	1	0	0	000110100
sj281	1	0	0	1	1	1	0	0	0	100111000
sj288	1	0	1	1	1	1	1	0	0	101111100
sj368	0	0	0	0	0	0	0	0	1	000000001
sj370	0	0	0	0	0	0	0	0	1	000000001
sj371	1	1	1	1	1	1	0	0	0	111111000
sj411	0	0	0	0	0	0	0	0	1	000000001
sj418	0	0	0	0	0	0	0	0	1	000000001
sj419	0	0	0	0	0	0	0	0	1	000000001
sj420	1	0	0	1	1	1	0	1	0	100111010
sj423	1	1	0	1	1	0	0	0	0	110110000
sj440	1	1	0	1	1	1	0	1	0	110111010
sj441	0	1	0	0	0	0	0	0	0	010000000
sj442	0	1	0	0	0	1	0	0	0	010001000
sj453	0	1	0	1	1	0	0	0	0	010110000
sj458	1	1	0	1	1	1	0	0	0	110111000
sj459	0	0	0	1	1	0	0	0	0	000110000
sj463	0	0	0	1	1	1	0	1	0	000111010
sj506	1	0	0	1	1	1	0	1	1	100111011
sj522	0	1	0	1	1	1	0	1	0	010111010
sj523	1	0	0	1	1	0	0	0	0	100110000
sj534	1	0	0	0	1	0	1	0	1	100010101
sj561	0	1	0	0	0	0	0	0	0	010000000
sj569	0	0	0	1	1	0	0	0	0	000110000

Smithsonian site #	Radiometric dates	STPs excavated	Data Recovery	Collections	Previous research code
SJ176	0	0	0	0	0000
sj177	0	0	1	0	0000
sj185	1	1	1	1	1101
sj186	1	0	1	1	1001
Sj200	1	1	1	0	1100
sj205	0	0	1	0	0000
sj215	0	1	0	1	0111
sj252	1	1	0	0	1100
sj254	0	1	0	1	0111
sj255	0	0	0	1	0001
sj256	0	0	0	0	0000
sj257	0	1	0	0	0100
sj259	0	0	0	0	0000
sj260	0	0	0	0	0000
sj261	0	0	0	0	0000
sj263	0	1	0	0	0100
sj265	0	1	0	0	0100
sj266	0	0	0	0	0000
sj267	0	1	0	1	0101
sj268	0	0	0	1	0001
sj269	0	0	0	1	0001
sj270	0	0	0	1	0001
sj271	0	1	0	0	0100
sj272	0	0	0	0	0000
sj273	0	0	0	0	0000
sj274	1	1	0	1	1101
sj276	0	0	0	0	0000
sj277	1	1	0	1	1101
sj278	0	0	0	1	0011
sj279	1	1	0	0	1100
sj280	0	0	1	1	0011
sj281	1	0	0	0	1000
sj288	0	0	0	1	0011
sj368	0	0	0	0	0000
sj370	0	0	0	0	0000
sj371	0	1	0	0	0100
sj411	0	0	0	0	0000
sj418	0	0	0	0	0000
sj419	0	0	0	0	0000
sj420	0	0	0	0	0000
sj423	0	0	0	0	0000
sj440	0	1	0	0	0100
sj441	0	1	0	0	0100
sj442	0	1	0	0	0100
sj453	1	1	0	1	1101
sj458	0	1	0	0	0100
sj459	1	1	0	1	1101
sj463	0	1	0	0	0100
sj506	0	1	0	0	0100
sj522	0	0	0	0	0000
sj523	0	0	0	0	0000
sj534	0	0	0	0	0000
sj561	0	0	0	0	0000
sj569	0	0	0	0	0000

Appendix B: Raw Data, with duplicates
Plant Classification Duplicates

Smithsonian site #	2+ plant class	Plant class	Freshwater distance class	Shoreline distance Class	2+ soil classes present	Geomorph class	Microenvironment class code
SJ176	0	7	2	3	1	1	72311
sj177	0	4	3	1	0	1	43201
sj185	1	7	3	1	1	1	73111
sj185	1	6	3	1	1	1	63111
sj186	1	7	3	1	0	1	73101
sj186	1	6	3	1	0	1	63101
Sj200	0	3	2	1	1	3	32113
sj205	0	2	4	2	1	3	24213
sj215	0	5	2	3	1	3	52313
sj252	1	7	1	1	1	4	71114
sj252	1	5	1	1	1	4	51114
sj254	0	3	2	1	0	1	32101
sj255	1	7	2	1	1	1	72111
sj255	1	6	2	1	1	1	62111
sj256	0	7	2	3	0	2	72302
sj257	1	7	1	1	1	1	71111
sj257	1	6	1	1	1	1	61111
sj259	1	7	2	1	1	1	72111
sj259	1	6	2	1	1	1	62111
sj260	0	7	1	1	0	1	71101
sj261	1	7	3	2	0	1	73201
sj261	1	6	3	2	0	1	63201
sj263	1	3	1	1	1	2	31112
sj263	1	6	1	1	1	2	61112
sj265	0	7	4	1	1	4	74114
sj266	0	7	2	3	1	1	72311
sj267	1	7	4	1	0	1	74101
sj267	1	6	4	1	0	1	64101
sj268	0	7	5	1	0	1	75101
sj269	0	7	5	1	0	1	75101
sj270	1	2	6	1	0	1	26101
sj270	1	7	6	1	0	1	76101
sj271	0	4	1	1	1	4	41114
sj272	0	7	2	1	0	1	72101
sj273	1	7	1	1	1	1	71111
sj273	1	6	1	1	1	1	61111
sj274	0	7	3	1	1	1	73111
sj276	1	7	2	1	1	1	72111
sj276	1	6	2	1	1	1	62111
sj277	1	4	3	1	0	1	43101
sj277	1	6	3	1	0	1	63101

Smithsonian site #	2+ plant class	Plant class	Freshwater distance class	Shoreline distance Class	2+ soil classes present	Geomorph class	Microenvironment class code
sj278	0	3	3	1	0	1	33101
sj279	1	6	2	1	1	1	62111
sj279	1	7	2	1	1	1	72111
sj280	0	7	2	1	0	1	72101
sj281	1	6	3	1	1	5	63115
sj281	1	4	3	1	1	5	43115
sj288	0	1	6	1	1	5	16115
sj368	0	4	2	3	1	5	42315
sj370	0	3	2	3	1	1	32311
sj371	1	7	3	1	0	1	73101
sj371	1	6	3	1	0	1	63101
sj411	0	2	2	3	0	4	22304
sj418	1	1	5	3	1	4	15314
sj418	1	3	5	3	1	4	35314
sj419	1	2	4	3	1	2	24312
sj419	1	7	4	3	1	2	74312
sj420	0	4	1	2	1	1	41211
sj423	1	7	1	2	1	2	71212
sj423	1	6	1	2	1	2	61212
sj440	0	7	2	1	0	1	72101
sj441	0	7	3	2	0	1	73201
sj442	0	7	2	1	0	1	72101
sj453	1	4	2	1	0	2	42102
sj453	1	2	2	1	0	2	22102
sj458	0	3	2	1	1	4	32114
sj459	1	2	2	1	0	3	22103
sj459	1	4	2	1	0	3	42103
sj463	1	3	2	3	1	4	32314
sj463	1	6	2	3	1	4	62314
sj506	0	2	3	1	0	1	23101
sj522	1	1	7	1	0	3	17103
sj522	1	2	7	1	0	3	27103
sj522	1	3	7	1	0	3	37103
sj523	1	1	7	1	0	3	17103
sj523	1	3	7	1	0	3	37103
sj534	1	4	1	3	1	5	41315
sj534	1	5	1	3	1	5	51315
sj561	1	2	3	3	0	4	23304
sj561	1	3	3	3	0	4	33304
sj569	0	7	3	1	0	1	73101

Geomorphology Class Duplicates

Smithsonian site #	Plant class	Freshwater distance class	Shoreline distance Class	2+ geomorph present	2+ soil classes present	Geomorph class	Microenvironment class code
SJ176	7	2	3	0	1	1	72311
sj177	4	3	1	0	0	1	43201
sj185	6	3	1	0	1	1	63111
sj186	6	3	1	0	0	1	63101
Sj200	3	2	1	1	1	1	32111
Sj200	3	2	1	1	1	3	32113
sj205	2	4	2	1	1	1	24211
sj205	2	4	2	1	1	3	24213
sj215	5	2	3	0	1	3	52313
sj252	5	1	1	0	1	4	51114
sj254	3	2	1	0	0	1	32101
sj255	6	2	1	0	1	1	62111
sj256	7	2	3	0	0	2	72302
sj257	6	1	1	0	1	1	61111
sj259	6	2	1	0	1	1	62111
sj260	7	1	1	0	0	1	71101
sj261	6	3	2	0	0	1	63201
sj263	6	1	1	0	1	2	61112
sj265	7	4	1	1	1	1	74111
sj265	7	4	1	1	1	4	74114
sj266	7	2	3	0	1	1	72311
sj267	6	4	1	0	0	1	64101
sj268	7	5	1	0	0	1	75101
sj269	7	5	1	0	0	1	75101
sj270	7	6	1	0	0	1	76101
sj271	4	1	1	1	1	1	41111
sj271	4	1	1	1	1	4	41114
sj272	7	2	1	0	0	1	72101
sj273	6	1	1	0	1	1	61111
sj274	7	3	1	0	1	1	73111
sj276	6	2	1	0	1	1	62111
sj277	6	3	1	0	0	1	63101

Smithsonian site #	Plant class	Freshwater distance class	Shoreline distance Class	2+ geomorph present	2+ soil classes present	Geomorph class	Microenvironment class code
sj278	3	3	1	0	0	1	33101
sj279	7	2	1	0	1	1	72111
sj280	7	2	1	0	0	1	72101
sj281	4	3	1	0	1	5	43115
sj288	1	6	1	0	1	5	16115
sj368	4	2	3	0	1	5	42315
sj370	3	2	3	0	1	1	32311
sj371	6	3	1	0	0	1	63101
sj411	2	2	3	0	0	4	22304
sj418	3	5	3	0	1	4	35314
sj419	7	4	3	0	1	2	74312
sj420	4	1	2	0	1	1	41211
sj423	6	1	2	0	1	2	61212
sj440	7	2	1	0	0	1	72101
sj441	7	3	2	0	0	1	73201
sj442	7	2	1	0	0	1	72101
sj453	2	2	1	0	0	2	22102
sj458	3	2	1	1	1	2	32112
sj458	3	2	1	1	1	4	32114
sj459	2	2	1	1	0	1	22101
sj459	2	2	1	1	0	3	22103
sj463	6	2	3	0	1	4	62314
sj506	2	3	1	0	0	1	23101
sj522	3	7	1	0	0	3	37103
sj523	3	7	1	0	0	3	37103
sj534	5	1	3	0	1	5	51315
sj561	2	3	3	1	0	3	23303
sj561	2	3	3	1	0	4	23304
sj569	7	3	1	0	0	1	73101