Time of Change:
Late Pleistocene / Early Holocene Landscape Transformation and Human Presence in Southwest Coastal British Columbia, Canada

by

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ABSTRACT

This thesis is designed to increase awareness of the value of late-glacial landforms in the study of early settlement patterns in southwest coastal British Columbia. Knowing local paleoenvironmental events, such as glacial advances, relative sea level changes and paraglacial landscape modifications, is critical to understanding potential early site locations.

A lack of systematic surveys, poor site visibility, deep alluvial burial, and site locations away from modern shorelines have been identified in this thesis as main reasons for the lack of evidence for late Pleistocene human occupational sites. Field research of raised landforms, such as paleo-deltas, provided data on local late Pleistocene and early Holocene paleoenvironmental history.

I conclude that a comparison to other research projects along the Pacific Northwest might highlight some new ideas and techniques, applicable for the study of a hypothesized early marine / estuarine oriented human population.

Keywords: Relative sea level; Late Pleistocene; Pebble tools; Pacific Northwest Archaeology; Raised landforms; Paleoecology

Subject Terms: Paleoecology -- North America -- Pleistocene; Glacial epoch -- North America; Paleo-Indians -- North America; Paleo-Indians -- British Columbia; Tools, Prehistoric -- British Columbia; British Columbia -- Antiquities
DEDICATION

I dedicate this thesis to my partner Caroline, and daughters Siena and Adrienne.

This project could not have been accomplished without their unconditional support, patience and encouragement during my extended university career.
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CHAPTER 1: INTRODUCTION

1.1 Introduction

The integration of paleoecology, geology and archaeology has recently revived the debate about the timing and location of early human presence on the Northwest Coast of America. New evidence has brought old assumptions into question and has led to a re-evaluation of others. Ideas such as the Coastal Migration Theory, which was first clearly expressed by Calvin J. Heusser in the 1960s, and elaborated by Knut Fladmark in 1979, are gaining increasing support among scholars studying human populations of the early Holocene (Dalton 2003; Dixon 1993, 1999; Easton 1992; Hetherington et al. 2004; Koppel 2003). Recent geological and paleoecological studies document deglaciation and the existence of ice-free areas throughout major coastal areas of British Columbia by 13,000 BP (Barrie et al. 2000, 2002; Blaise et al. 1990; Bobrowsky et al. 1990; Fedje et al. 2004, 2000; Hetherington et al. 2003; Josenhans et al. 1995, 1997). Marine cores from the edges of the continental shelf in British Columbia, for example, indicate an unglaciated forested environment by at least 13,000 BP.

By at least 10,000 years ago parts of the American west coast were occupied by maritime peoples with diversified collecting, fishing, and hunting economies (Fedje et al. 2005b; Keefer et al. 1998; Llagostera 1979; Sandweiss et al. 1998, 1999). By 9,000 years ago, evidence from a number of sites suggests that shellfish, fish and plant foods served as staples within these diverse economies. These early sites, described in Chapter 2, provide some of the first evidence for a well-defined maritime tradition anywhere in North America. If early dates from Monte Verde, Coastal Peru, California's Channel Islands, and the coasts of British Columbia and Alaska are verified, the antiquity of such adaptations may be extended by a millennium or more (Fedje et al. 2005b; Fiedel 2000a; Keefer et al. 1998).

Combined with genetic and paleontological evidence, this provides a new picture of the environmental and cultural history of the Pacific Northwest during the late
Pleistocene, which was not only habitable for large animals such as brown bears, caribou, mountain goats, and bison, but potentially for humans as well (Al-Suwaidi et al. 2006; Heaton and Grady 1993, 2003; Heaton et al. 1996; Ward et al. 2003; Wilson et al. 2003, and in preparation). Traces of such a possible early human habitation are examined in this research, especially the presence of the pre-microblade, Old Cordilleran / Pebble Tool Tradition that appears in the archaeological record from southern Alaska to the Oregon coast as early as 10,500 BP, and has been identified in my research area (Ackerman 1992, 1996a and b; Carlson 1990:60-69, 2003; Carlson and Dalla Bona 1996; Matson and Coupland 1995; McLaren 2003; Mitchell and Pokotylo 1996).

It has often been stated that most cultural evidence for an early human coastal presence is currently submerged under up to 150 m of water due to global sea level rise during the melting of the massive Pleistocene ice sheets (e.g. Bonnichsen and Turmire 1999:9; Dillehay and Meltzer 1991:291). However, many researchers also point out that, due to local isostatic rebound of the continental landmass after deglaciation, there were a significant number of inner coastal areas that were sub-aerial (above water) and environmentally capable of supporting terrestrial flora and fauna at an early time (Al-Suwaidi et al. 2006; Clague et al. 2004; Fedje et al. 2004; Hobler 2000).

The primary focus of the research presented here is on these inland coastal areas with their associated raised shoreline features, as well as deeply buried riverine landforms dating to the late Pleistocene. While such landforms located in the lower mainland of southwestern British Columbia likely cannot be expected to yield sites directly associated with earliest migrations from Asia, due to relatively late deglaciation, sites on islands of the Strait of Georgia and Puget Sound, for example, were ice-free and vegetated at least by 13,000 BP (Dethier et al. 1995; Easterbrook 1986 and 1992). It also should be noted that sites dating between 11,500 and 10,000 BP, potentially present on the mainland, could shed important clues as to the origin of migrants passing along the outer coast some thousands of years earlier.

During this project I came to realize that knowledge of the Quaternary earth sciences, in particular geomorphology, is crucial for finding and correctly interpreting early Holocene / late Pleistocene archaeological sites. Geomorphic processes of landscape evolution affect the surface visibility, integrity, and survival of early
archaeological sites. Such sites are associated with different paleoenvironmental and geological conditions and therefore environmental reconstruction is an important avenue of research since no appropriate modern analogues for environments of late Pleistocene times exist. The transition between the Holocene and Pleistocene epochs [Pleistocene-Holocene boundary] has been set by arbitrary convention at 10,000 BP to coincide as close as possible with deglaciation of the northern hemisphere. However, on the Northwest Coast the actual geological transition between the glacial maxima and the onset of deglaciation is extremely varied, falling between 16,000 and 9,000 BP. A fundamental requirement for archaeological research into an early human presence in this region is therefore the recognition and dating of the actual time of deglaciation and understanding the climatic, geological, environmental and potential cultural events that accompanied this transition. Thus, the intended focus of this thesis is to study the interaction between local paleoenvironmental events such as sea level change, delta progradation, and other geological processes as they relate to the creation of landforms suitable for use by early human populations.

1.2 Objectives

This thesis is designed to increase awareness of the potential value of early postglacial landforms in the study of early settlement patterns along the Pacific Coast of Canada. Background research summarizes past work and identifies potential areas of future interest on a local and regional level. Field research was undertaken to garner more geomorphological, paleoenvironmental and prehistorical information for the southwestern coast of British Columbia. Study of raised landforms, such as paleo-deltas, consisting of glaciomarine clay, and sand and gravel deposits in the Pitt River drainage system of the lower Fraser valley, provided data on the local paleoenvironmental history during the late Pleistocene and early Holocene.

The objectives of the study were:

1. To study and identify geomorphologic evidence of local relative sea-level histories and post glacial paleo-geography of the southwest coast of British Columbia;
2. to establish whether any paleo-shorelines are identifiable;
3. to describe the sedimentology of suspected late-glacial and early postglacial sediments in order to understand their origins and modes of deposition;
4. to provide a framework for early postglacial landform characteristics that can be used to aid subsequent identification in the field;
5. to investigate whether such potential early postglacial landforms have
   associated archaeological sites; and
6. to integrate geomorphological, paleontological, and archaeological research to
   identify ideal locations for human activities during the late Pleistocene and early
   Holocene on a local and regional level.

The broader objective of this thesis is to understand the potential early human
prehistory of the study-area within the context of paleoenvironmental change and
compare it with the broader research on human prehistory along the Pacific coast of
America. It is also hoped that this research might highlight new ideas and techniques
applicable for the study of late Pleistocene settlement along potentially early corridors
of migration.

1.3 Background to the Primary Research Area

The focus of this research is southwestern coastal British Columbia [B.C.],
which includes the lower Fraser River valley, the Strait of Georgia, and the south-
eastern part of Vancouver Island. For my fieldwork a small sub-area, Pitt Lake and the
upper Pitt River valley, was chosen (Figure 1.1). For background information and for
purpose of comparison other localities along the Northwest Coast, generally defined to
include the Pacific coast of North America from the Alaskan Panhandle to the Oregon /
California boundary, are used.

There are a variety of reasons why the Pitt valley locality and its close
surroundings have good potential for such geoarchaeological / geomorphological
investigations. Most importantly, the fact that the Pitt Lake and valley have not been
affected by any large-scale urban or hydro-electric developments makes them valuable
for investigating late Pleistocene / early Holocene landscapes. Neighbouring
watersheds such as the Coquitlam and Stave valleys have been dammed for
freshwater and/or power production, submerging potential early human use sites.
Other valleys on the Vancouver North Shore or in Howe Sound, with recorded early
paleo-shoreline features, have been impacted by urban housing, essentially destroying
any possible evidence of early human use (Clague, pers. comm.). Moreover, the Pitt
Lake watershed includes several relatively large tributary streams, which would have
aided the development of paleo-delta formations during times of higher sea levels,
when these streams would have drained directly into a marine bay. Recent research
also suggests that the Fraser River floodplain experienced several catastrophic floods
due to the breakage of late Pleistocene glacial ice dams, draining large glacial lakes in the interior of B.C. (Blais-Stevens et al. 2001, 2003; Johnsen and Brennand 2004). Such gigantic floods would have destroyed and removed most pre-existing archaeological evidence of human habitation in unprotected, low-lying areas of the main valley of the Fraser River.

Figure 1.1 The Pitt Lake and River Valley within the Lower Mainland of British Columbia

![Map of the Pitt Lake and River Valley](image)

Map by author [produced with NRCAN Atlas of Canada base data]

Proponents of the coastal migration hypothesis suggest an initial economy focused on intertidal resources, some saltwater and river fishing, small marine mammal hunting, and terrestrial game when available. I identified the Pitt River valley as a suitable study area because it represents the interface between the Fraser and Pitt river drainage systems and the tidal range of the ocean, which I believe would have made it an attractive area for human maritime utilization during the late Pleistocene and early Holocene. The main advantage of coastlines and river mouth locations is that they are the most productive "ecotone", or boundary between two or more different
ecological zones. Therefore, people adapted to littoral / estuarine life had access to the resources of land, river and sea. Most other early Holocene sites on the west coast of North America are associated with an estuarine / marine environment as well (Fedje et al. 2005b; Sandweiss 1998). Below I examine three different time periods in the late Pleistocene and early Holocene and explain why they make the research area a suitable location for early human settlement and utilization. For a general overview of the study area and surrounding environs from an archaeological, ethnographical and oral tradition point of view see Carlson, K.T. (2001).

1). Ca. 12,500 B.P.:
Deglaciation began in the lower Fraser River mainland by at least 13,000 BP. The major remaining ice flow was fed by numerous valley glaciers and occupied the Fraser lowlands, with the glacial margin likely ending at about what now is Aldergrove and Fort Langley. There, the receding glacier calved into the ocean which, due to reduced but still significant isostatic depression, reached 120 –140 m above its present levels (James et al. 2002). The land, as it was gradually freed from the remaining glacial weight, started to rebound, which resulted in steadily dropping local sea levels.

Figure 1.2 The Fraser Lowlands at ca. 12,500 BP

Map from Clague and Turner (2003). Used with permission of Tricouni Press Ltd.
in spite of rises in global water volume. Some higher ground, such as Burnaby Mountain and the Surrey Upland, started to emerge as dry islands; while the Pitt, Stave, Alouette, and Coquitlam Valleys were still occupied by smaller valley glaciers that also calved directly into the ocean forming large submarine outwash fans and deltas (Armstrong 1960 and 1981; Clague et al. 1983). While the area was still dominated by a glacial landscape, it would have by now provided some dry ground, forested mainly with lodgepole pine. Creeks and coastal zones may have provided limited marine and littoral resources for mammals and, in turn, people (Mathewes and Heusser 1981; Pellatt et al. 2002; Souch 1989). Other areas, including exposed coastal shelf areas along the British Columbian coast, may have been deglaciated beginning about 16,000 BP possibly providing a coastal corridor for the movement of plants, animals, and humans (Al-Suwaidi et al. 2006; Josenhans et al. 1997; Wilson and Ward 2006).

2). 11,500 B.P.:

At this time, the area of the Pitt Valley was occupied by a large inland fjord opening into a broad bay in its lower reaches (the location of present-day Port Coquitlam, Pitt Meadows, and Maple Ridge). Continued falling sea levels exposed more dry land, enlarging the emerging islands which formed around this bay. The Fraser Valley glacier had receded past Mission, and the Abbotsford uplands had become exposed and vegetated (Clague 1981, Clague et al. 1983). The proposed research location would have represented the northern end of a relatively flat coastal area continuing southwards into what is now Washington State and supporting large land mammals, such as mammoth and bison. The associated emerging landscape represents the northernmost point of the West Coast of North America that would have been accessible for early land-based hunters moving north along the coast, without using watercraft technology, while at the same time it would have provided a maritime culture with protected bays and islands. Marine resources would also have significantly increased and land mammals would have found suitable habitat at this time (Harington 1996:264; Mackie 1987; Wilson et al. 2003). Birds that migrate to areas of high productivity in the Arctic for summer nesting may have found a similar environment of high productivity in the lakes and bays of the region during the late Pleistocene. Alternatively they may have made a stopover before continuing along the generally still
glaciated and mountainous coast. Southwest B.C. would have offered the added benefit of a possibly rich littoral zone.

3). 10,500 B.P.:

The mouth of the Fraser River had prograded into present-day Maple Ridge, where it emptied into the paleo-bay of the lower Pitt river drainage system and started to build a delta into this bay (Clague et al. 1983; Williams and Roberts 1989). The extensive coastal plains along British Columbia’s outer coast were now largely submerged by the rising global sea level, making this delta the first major flat landmass and wetland area south of still exposed coastal plains surrounding Haida Gwaii. This may have attracted migrating birds into the area, increasing the food resources available to early inhabitants.

1.4 Methodology

An important part of this thesis is to review various papers and field studies in order to document depositional agencies and events and their associated geological deposits and landforms as they relate to archaeological records for the Late Pleistocene and early Holocene epochs of coastal areas in North America. Identified patterns, research methods and results then will be compared with the local research area.

The late Pleistocene and early Holocene environments of the Pitt Lake and River region were characterized by a series of dynamic glacial and marine level events that resulted in its present geomorphological features. To understand the changing landscape and environment of the early Holocene, I reviewed previous studies and conducted field research in the Pitt Lake and neighbouring areas. I incorporated data from various earth sciences as they relate to the formation of the Fraser lowland, the Pitt valley and local sea level changes (Clague et al. 1983; Friele and Clague 2002; James et al. 2002).

In this thesis, dates are given in uncalibrated radiocarbon years [$^{14}$C years] before present [BP] or kiloyears before present [ka BP]
1.5 Thesis Layout

In the first part of this thesis [Chapters 2 and 3] I review past and current knowledge and theory about the settlement of the Americas, and the Pleistocene / Holocene transition on the Northwest coast. It is essential to link the problems facing local late Pleistocene research with the larger picture of how and where initial settlement of the continent took place. In the second part [Chapters 4 and 5], a review of current scientific knowledge of postglacial geological changes is intended to help to understand how site locations removed from modern shorelines and riverbanks were created and how they may be located. Also, local paleoenvironment, geomorphology, and the low visibility of simple cobble tool technology, are discussed. The last section [Chapters 6 to 8] contains fieldwork results and ends with a discussion and conclusion.
CHAPTER 2: BACKGROUND TO LATE PLEISTOCENE ARCHAEOLOGY

2.1 The Debate - Introduction

Recent geological, paleoenvironmental, climatological and DNA data related to the colonization of Beringia, the timing of a corridor between the Laurentide and Cordilleran ice sheets, glacial refugia along the Northwest Coast, and people inhabiting the region south of the ice sheets, have greatly increased our knowledge concerning the first arrival of humankind in North America. Newly recorded sites seem to bring into question long established theories and assumptions. Refinements in stable isotope, paleobotanical and zooarchaeological analyses have led to new insights into subsistence diversity among these first migrants.

In addition, technological innovations and more sophisticated archaeological methods have helped to bring more detail and clarity to certain long-standing questions. This chapter attempts to summarize past and current knowledge in Late Pleistocene archaeology and to point out promising new research directions.

2.1.1 Old Paradigms

Archaeologists studying the early settlement of the Americas have for decades advocated that the first Americans were nomadic big game hunters who arrived from northeast Asia around 11,300 BP at the end of the last ice age and moved rapidly through the New World within a few centuries (Bonnichsen and Schneider 1999:499; Dillehay 2000; Fagan 2004; Haynes 1969, 1987, 1991; Meltzer 1997). They supposedly moved from Siberia into Alaska across the Bering landbridge, tracking animal herds, and then spread south through an “ice-free corridor” on the east side of the Rocky Mountains (Carlson 1991; Kelly and Todd 1988). The first archaeological culture universally recognized south of the ice sheets is Clovis, representing megafauna hunters who left behind distinctive fluted projectile points. However, under closer inspection this theory has many problems. For instance, several recent
excavations in various parts of the Americas show that these early hunters also consumed different foods, such as turtles, fish and other small game, aquatic plants, snails, shellfish, and tubers (Bonnichsen and Turnmire 1991). Also, evidence for the large numbers of herd animals such as bison and caribou needed to support the Clovis lifestyle is absent from many parts of the Americas, especially the forested regions of the eastern United States and South America. Further, Clovis was a short-lived culture. All radiocarbon dates from Clovis sites in North America cluster tightly between 11,200 and 10,800 BP. This raises questions about how humans could have reached the southern tip of South America by 11,000 BP or earlier. Also, there are no clear archaeological traces of the Clovis culture or likely precedents in Siberia. If Clovis points were invented south of the ice sheet, then the Clovis theory cannot explain the peopling of America (Dincauze 1984; Fagan 2004; Meltzer 1989 and 1997).

2.1.2 Pre Clovis

Other branches of science, such as historical linguistics, have claimed that only a span of more than 30,000 years can explain the antiquity and diversity of New World languages (Hill 2004; Nichols 2002). Similarly, research into the mitochondrial DNA and Y-chromosome of present-day Native Americans shows so many differences that a single, relatively recent ancestral group seems unlikely. Many molecular anthropologists believe that the genetic diversity of New World peoples requires a human presence lasting more than 25,000 years, while others argue for multiple or single arrivals no earlier than 15,000 years ago or a diverse colonizing group (Bergen et al. 1999; Bianchi et al. 1998; Bonatto and Salzano 1997; Derenko et al. 1998; Easton et al. 1996; Lell et al. 2002; Merriwether and Ferrell 1996; Schmitz 2004; Schurr 2005; Smith et al. 2005; Torroni 1993). These data sets, supplemented by biological, dental and osteological analyses of human remains, form a theoretical framework for archaeological research (Brace et al. 2001, 2004; Chatters 2000; Gonzales 2002; Laughin 1986, 1988; Rogers 1985; Rogers et al. 1991; Schanfield 1992; Steele and Powell 1992, 2002; Turner 1971, 2002). It does however, allow for a wide range of possible dates and migration scenarios.

Archaeological research conducted in the last 20 years has uncovered evidence of pre-Clovis archaeological sites, most prominently the Monte Verde site in Chile, which indicates that people were in southern South America at least 12,500...
years ago (Dillehay 1989, 1997, 2000; Lepper and Bonnichsen 2004; Straus et al. 1996, 1998; but see Fiedel 1999a; and Lynch 1990, 1991). Research in Monte Verde and other potentially early sites, such as Cactus Hill and Topper in North America, indicates that these early Late Pleistocene cultures are distinct from Clovis and are characterized by different technologies and generalized hunting and gathering lifeways (Dillehay 1999, 2000; Goodyear 2005). They had varied lithic, wood, and bone technologies, and exploited a wide range of foods, including marine resources, birds, small game, and plants. This implies that they crossed into North America at least several hundreds to a thousand years earlier (Adovasio and Pedler 1997; Fiedel 2000a; Meltzer 1997, 2004; Meltzer et al. 1997). If it can be demonstrated that reported radiocarbon dates of ca. 15,000 BP accurately date lithic material in lower levels of Monte Verde (Dillehay 1989), the sub-Clovis horizon at Cactus Hill, Virginia (McAvoy 1997) and deeply buried levels at Topper in South Carolina (Goodyear 1997, 2005:106-107; Rose 1999) then they would be about 4000 years before Clovis (Adovasio and Pedler 2001; Marshall 2001; Meltzer and Dillehay 1999). Ancestors of this population must have traversed either the coast or interior of North America at an earlier date; but no clearly proven sites of comparable or greater antiquity have been found further north in North America. A possible relationship has been suggested between Monte Verde and widespread, relatively early lithic traditions known from sites in South America, and the Basin, Plateau, and Northwest Coast regions of North America. Examples of these tool assemblages include Western Stemmed Point and Pebble Tool assemblages in North America, Lerma in Mesoamerica and El Jobo in South America (Carlson 1990: 61-62; Stanford et al. 2005:331).

South America is very different archaeologically from North America because no single early culture dominated the way that Clovis dominated North America. In South America, the earliest technologies consisted of different kinds of stone tools, including a wide variety of unfluted, thin, leaf-shaped, bifacial points and crude expedient tools. Furthermore, many areas in South America witnessed the development of broad hunter and gatherer diets before 11,000 BP, a pattern usually thought to be associated with later Holocene or early Archaic cultures (Borrero et al. 1998; Dillehay 1999: 214-215; Dillehay et al. 1992). Until recently, most specialists thought that it was only with the decline and extinction of large mammals at the end of the Pleistocene period and with increases of human populations that material cultures and subsistence patterns became more generalized.
Dillehay (1999: 210-211) states that much cultural diversity existed by 11,000 BP, resulting from populations that had grown regionally isolated and adapted to diverse environments. That would necessitate the arrival of people south of the ice sheet several millennia earlier (Dillehay 1999 and 2000). Numerous scenarios have been proposed as to the number, timing, and routes used by the earliest Americans, of which several leading models are summarized below.

2.1.3 Early Migrations

Some scientists have made claims for archaeological sites dating as much as 100,000 BP in the New World, without clear explanations of how those people could have gotten here (Bryan 1986; Gruhn 1987; Irving 1985; Simpson et al. 1986). Based on the available evidence none of these early sites have survived careful professional examination (eg. Wilson and Burns 1999:216-221). Other models have been less controversial and will be examined more closely.

Arguably the least plausible, the “Transpacific Route”, first supported by scientific data by Rivet (1957), proposed rafting from Australia to South America via Antarctica and the South Pacific Islands, and was based largely on statistical comparisons of cranial and linguistic data. With relatively credible recent evidence for 50,000-year-old archaeological sites in Australia (Roberts et al. 1994), researchers have now revisited this theory, suggesting dates as early as 40,000 to 15,000 years ago for the settlement of America. While the settlement of Australia would have required watercraft capable of crossing an ocean strait approximately 80 to 100 km wide even during periods of globally low sea levels, such a voyage could have been accomplished in a few days, compared to the many months it would have taken to cross the entire Pacific. If South America had been colonized via Polynesia, one also would expect to find evidence of their passage, but no sites of the antiquity proposed for this migration have been discovered in that region (Barton et al. 2004)

Linked to formal similarities in lithic technology of European Upper Paleolithic people and pre Clovis sites in the eastern United States, the “Transatlantic model”, originating with Hibben (1941) also proposes transoceanic migration. In the most recent model proposed by Stanford and Bradley (2000 and 2002), the first Americans crossed the North Atlantic along the southern edge of the North Atlantic pack ice, presumably in skin boats, spanning a distance of some 5,000 kilometers. In this
scenario, Upper Paleolithic Iberian Solutreans are seen as the source population of a pre-Clovis population who arrived on the North American east coast, between 17,000 and 14,000 BP, during the height of the last ice age. The material culture of these people is supposed to be present at the Topper and Cactus Hill sites, representing a distinctive stone technology, which evolved into the Clovis technology. While there are some typological similarities supporting this perspective, no diagnostic Paleo-Indian fluted points appear in Solutrean sites and other similar characteristics appear worldwide during Upper Paleolithic times (Barton et al. 2004, Clark 2000, 2004, Straus 2000). In addition, the Solutrean did not persist beyond 19,000 BP, several thousand years earlier than the oldest dated finds in the Americas. Furthermore, there is no direct or indirect evidence that the Solutreans had boats capable of sustaining long open sea voyages, nor that they had developed a maritime adaptation such as specialized fishing technology necessary for these voyages (Straus 2000).

The "Ice-Free Corridor" model linked to the "Clovis first" theory proposes that big-game hunters crossed the Bering Land Bridge from Northeast Asia between 15,000 and 12,000 years ago and followed their megafaunal prey south (Haynes 1971; 1980). The only route available would have led them through western Canada via an "ice-free corridor" between the Laurentide and Cordilleran ice sheets, which covered much of northern North America during the Wisconsin Glaciation (Pearson 2004; Rutter 1980, 1984; Wilson and Burns 1999:222). Once south of the ice, they rapidly radiated throughout the rest of North and South America, leaving traces of their passage in the form of megafaunal kill sites associated with Paleoindian projectile points. This model became accepted in the 1970's when there was thought to be no evidence that the ice sheets had fully coalesced east of the Canadian Rockies (Reeves 1973). However, a lack of evidence to support the existence of any significant biotic communities plus the presence of huge glacial lakes, outwash plains devoid of vegetation and severe temperatures due to katabatic winds, cooled by the nearby glacial ice, led Fladmark (1975, 1978, 1979, 1983) to contest these findings. These conditions would have precluded or limited the use of the corridor for migration of large animal herds as well as humans.

While there is supporting paleoenvironmental and archaeological evidence for megafaunal presence in interior Alaska and northeastern Siberia earlier than 11,500 BP, there is still none within the so-called ice-free corridor. A number of related
research findings and analysis have recently shown that such a corridor was not available at a time suitable to account for sites dating earlier than 11,200 BP (Arnold 2006; Burns 1996; Catto 1996; Clague et al. 2004; Hoffecker et al. 1993; Jackson et al. 1997; Jackson and Duk-Rodkin 1996; Levsen and Rutter 1996; Mandryk 1990, 1996, 2004; Mandryk and Rutter 1996; West 1996; Wilson 1996). According to them major portions of the corridor were blocked by ice from 30,000 to at least 11,500 BP, therefore it was not a possible route travelled by ancestors of the Monte Verde people (Mandryk et al. 2001: 303). In addition to a lack of flora and fauna that might have sustained human migrations, it has also been noted that very few early archaeological sites have been found along the corridor, most dating to less than 10,000 years ago. Not only do the few sites that are slightly older show decreasing ages from south to north, it has also been shown that bison moved from the south towards the north when the corridor became passable (Shapiro et al. 2004).

The "Coastal route model" or coastal-entry hypothesis, first clearly expressed by Calvin J. Heusser in the 1960's, and elaborated by Knut Fladmark in 1978, was based on evidence that coastal areas exposed at lower sea levels would have had a more moderate climate compared to the ice-free corridor, with its powerful katabatic winds and sterile, iceberg-laden meltwater lakes. Unglaciated coastal areas also would have at least some terrestrial animal life, and likely a rich marine life compared to a "corridor" that still lacks significant signs of fauna after decades of research (Hetherington et al. 2004b). This hypothesis has also recently been revived as an alternative to the Ice-Free Corridor model, due to the necessity to explain "early" sites such as Monte Verde, Cactus Hill and Topper, and the absence of Clovis fluted points in South America as well as on the North American Pacific coast. Fladmark (1979) proposed that a chain of coastal refugia would have enabled a human migration southward along the Pacific Coast during the late Pleistocene. This model also assumes that the first migrants, who probably originated on the north-eastern Pacific coast of Asia, had a maritime adaptation that allowed them to leapfrog around still glaciated areas of southern Beringia and the Pacific Coast of North America in small boats. The migrants eventually reached the southern tip of South America by around 12,500 years ago (Fladmark 1978, 1979, 1986a; Gruhn 1994; Pearson 2004).

Since the serious revival of this model various researchers have claimed that early sites, particularly those in South America, might have arisen from such a coastal
migration (Dixon 1993, 2001; Moss and Erlandson 1995; Sandweiss at al. 1999). Some researchers believe this mode of travel could have enabled the early settlers to reach the tip of South America in as little as 100 years. In addition, it has been argued that the diversity of languages, subdivision of language phyla, and great number of language isolates along the Pacific Coast, from Alaska to the tip of South America, was the result of one or several such coastal migrations (Greenberg et al. 1986; Greenberg and Ruhlen 1992; Gruhn 1988). These migrations could have occurred between 30,000 and 13,000 years ago. Evidence for long distance sea voyages dates to at least 20,000 BP when people in Japan were making trips of more than 200 km (Oda 1990; Yamaura 1998), an action implying planning and foresight as the distance would preclude the visibility of the presumed destination. It has also been argued that it would be much easier and safer for migrating people to move along the coast, rather than inland. While travelling in small boats along a glaciated coast was certainly risky for the young and elderly, it seems far safer than trekking and climbing over more than a thousand kilometers of frozen landscape and trying to cross innumerable glacial outwash streams and large lakes. Children and elderly adults could also help harvesting shellfish and small fish, therefore family groups would not be dependent on the success of a few hunters (Dixon 1999).

There is growing archaeological, chronological and paleoenvironmental evidence for this scenario at sites on islands of the coast of California (Erlandson 1994, 2001; Erlandson et al. 1996 a and b; Wisner 2003) and British Columbia (Fedje et al. 2004; Fedje and Josenhans 2000). Some researchers, who note that there is no direct archaeological evidence to support this route because Holocene sea-level transgression has inundated the Pleistocene coastline, have questioned this evidence (e.g., Barton 2004; Carlson 1996; Fidel 1999b and 2000; Meltzer 1989). Erlandson (2002:81), a proponent of the Pacific coastal migration route, has stated that more tangible evidence will be required to prove that such a migration actually occurred. In addition, Fladmark has himself pointed out that while moving from one coastal refugium to another south of the Kodiak Islands was certainly possible for boat using migrants, it is hard to imagine that these people could have navigated around the fully glaciated 800 km stretch of coast existing on the Alaskan Peninsula during the brief peak of the late Wisconsinan glaciation (Yesner 2001:317; Fladmark 1983; Fladmark, pers. comm.; Mann and Hamilton 1995; Mann and Peteet 1994). However, this ice
“barrier” was not long lived and larger ice-free areas were available by 16,000 BP (Mann and Peteet 1994:146; Wilson and Ward 2006).

Other models combine the ice-free corridor, big-game-hunting model of migration with the coastal Pacific route and postulate coastal migration by groups of maritime coastal-adapted foragers. These might have been followed by one or possibly two later groups (Dikov 1993; Greenberg at al. 1986; Orekhov 1987; Turner 1971), while at the same or later time another group reached the mid-continent via the ice-free corridor. These models are supported by [largely theoretical] chronological, spatial, dental, linguistic, genetic, and some archaeological evidence in North America and Siberia.

2.2 Current Status of Research in Late Pleistocene Settlement of North America

Evidence supporting a fresh look at the peopling of the Americas comes from early sites found south of areas glaciated during the last ice age, including Monte Verde in Chile, Tequendama in Colombia, the Itaparica Phase sites in Brazil, and several coastal sites in Northern Chile and Southern Peru that exhibit coastal adaptations (Dillehay and Meltzer 1991; Keefer et al. 1998; Sandweiss and McInnis 1998), as well as several sites in North America, such as the Topper and Cactus Hill sites, and sites on offshore islands along the California and British Columbia coasts (Erlandson and Moss 1996; Erlandson 2002; Fedje 2003; Fedje et al. 2005b, 2005c; Goodyear 2005). These sites were excavated by professional archaeologists, and with modern techniques thus avoiding many problems mentioned above, and have consequently been taken more seriously than earlier excavations. These sites imply that people had reached the southern tip of South America prior to the recession of the giant ice sheets, leading archaeologists and geologists to examine the region’s glacial past in more detail to reconstruct a potential new entry for early peoples along the Northwest Coast of North America.

2.2.1 Early Subsistence

The pre-Clovis site of Monte Verde, Chile, dated to 12,500 BP, includes stone tools, human footprints, waterlogged worked wood, bones, ivory and cordage, two large and many small hearths and 12 dwellings constructed in part from animal skins.
Faunal remains included mastodon, llamas, small mammals, fish, and mollusks. Remains of plants derived from coastal to Andean habitats were recovered. Most of the stone tools found at the site were made of local raw material and consisted of cobbles with a few flakes removed to make simple but functional working edges, in addition to two bifacially flaked points (Dillehay 1989 and 2000; Dillehay et al. 1992).

These findings challenge the idea, entertained by most archaeologists until recently, that it was with the decline and extinction of large ice-age mammals at the end of the Pleistocene that material cultures and subsistence patterns became more generalized. These varied adaptations were supposed to have occurred at the beginning of the Holocene around 10,000 to 9,000 BP representing the “Archaic period” in American archaeology (Dillehay 2000; Johnson 1995).

I would argue that this cultural distinction has become outdated in many parts of the Americas as it has become clear that big-game hunting always has existed alongside generalized hunting and gathering lifeways, which include early coastal, maritime adaptations. The divide between the late Pleistocene and early Holocene therefore is essentially based on climatic and geological events marking the end of the last glaciation and not a cultural divide. I will consequently try to avoid the use of the terms Paleo-Indian and Archaic periods, in their present meaning, for times and places with varied subsistence patterns.

A growing number of sites indicate that early people in most areas of the Americas combined occasional scavenging or hunting of large mammals with more reliable smaller game, fish, shellfish and plant resources (Bryan 1991; Greiser 1985; Meltzer et al. 1997). Many sites contain no evidence as to the paleo-diet of early inhabitants due to the fact that plants and bone fragments of small animals such as fish, are archaeologically fragile and may not be preserved. In other cases no evidence for such remains were collected due to now outdated research designs. In fact, most late Pleistocene and early Holocene sites excavated in the last twenty years contain at least some evidence for such a generalized, broad-spectrum economy, including all so-called pre-Clovis site candidates, as well as numerous sites contemporary with Clovis both in North and South America (Greiser 1985).

According to Dillehay (2000:221), 10,000 to 12,500 years ago in South America the most densely populated areas were close to wetlands along the coasts and open forests in major riverine systems, where a broad-spectrum economy would have been
the basis of subsistence. Increased evidence for such an early, generalized subsistence pattern has been found along the coastlines from Peru to southern Chile, dated between roughly 11,500 and 9,680 BP (Dillehay 2000).

Thus, several recent excavations on the south coast of Peru by David Keefer at Quebrada Tacahuay, and by Daniel Sandweiss at Quebrada Jaguay have revealed evidence for exploitation of sea resources (Jodry 2005:151; Sandweiss et al. 1999). At Quebrada Tacahuay, people were fishing for anchovies, and several other species of fish, and hunting seabirds, particularly cormorants, suggesting a maritime adaptation. In fact, 99.8% of the faunal remains consist of maritime elements, and a specialized fish-netting technology is indicated by the catch of small schooling fish species (Keefer et al. 1998:1834). The site dates from between 10,770 to 10,530 BP and contains hearths, unifacial tools, flakes, and a few bifaces (Keefer et al. 1998).

At the Quebrada Jaguay site, people also fished, gathered clams and other mollusks as well as crustaceans. This site is dated between 11,105 and 9,850 BP, with most dates falling between 10,700 and 10,300 BP. The lithic remains include flaking debitage, unifacial pebble tools, and again a few bifaces. Obsidian from 130 kilometers to the east in the Andes has also been recovered, suggesting either direct procurement or an exchange network with neighbouring interior groups (Sandweiss and McInnis 1998:1832).

A similar site excavated a decade earlier is the Ring site, located on a raised marine terrace about 50 meters above the present sea level, 20 km north of Quebrada Tacahuay. It consists of a shell midden associated with an old lagoon and relict shoreline radiocarbon dated between 10,500 and 7,500 BP. The cultural material associated with the large shell midden consists of unifacially worked and unworked lithics, modified shell remains, uncarbonized plant remains, and ash lenses. The earliest cultural levels contain few marine mollusks, because the shoreline was farther away, but an abundance of marine birds, mammals, and fish. Again there is some archaeological evidence for the exchange of cultural items between the interior coastal plain and the late Pleistocene coastline (Sandweiss et al. 1989).

Another shell midden site showing clear evidence for an early maritime adaptation on the north coast of Chile dates to 10,800 BP. The people at the Huentelafquen site exploited a wide variety of both terrestrial and marine species and used a stone tool industry based on pebble tools, including small numbers of edged-
trimmed unifacial tools (Dillehay 1999:212). Another somewhat younger site in north coastal Chile is Quebrada de Las Conchas, dated between 9,680 and 9,400 BP and featuring a maritime economy and technology similar to that found at Huentelafquen. Here, 24 species of fish have been identified, seven now extinct, in addition to dolphin and sea lion remains (Llagostera 1979:314).

The archaeological data from these coastal South American sites demonstrate a long dependence on a broadly based marine diet and represent seasonal exploitation of the late Pleistocene and early Holocene coast. While terrestrial fauna is present in all sites, large numbers of fish remains suggest net fishing. Furthermore, evidence of gathering shellfish and hunting sea mammals and sea birds show an emphasis on marine species exploitation. While these sites probably do not represent the first migrations along the Pacific coast, they show that mixed terrestrial/marine resources were exploited at an early date and could have been used by ancestors of the people that settled ultimately at Monte Verde (Eriksen and Straus 1998).

Sites in North America also fitting this pattern occur from the Columbia River valley and the Queen Charlotte Islands (Haida Gwaii) on the Pacific Northwest to the Atlantic coast. The Shawnee Minisink site in Pennsylvania, for example, contains a variety of plant and animal remains in its Clovis-age level (Dent 1999; Dent and Kauffman 1985:71). Most of the procurement and processing seem to have centered on plants and fish. The diversity of tool types, edge wear and edge angles on the tools support the interpretation of a diverse foraging base at this site. A wide variety of activities, such as manufacturing of wood and bone implements for hide scraping, processing sinew and fibers, shredding, heavy bone-working, making and repairing fishing implements, and fish processing activities have been suggested (Barton et al. 2004; McNett 1985).

Early site locations on North America’s Pacific coast include the California Channel Islands, recording early coastal shell midden and cordage use (Connolly and Gero 1995:316; Erlandson 2002; Erlandson and Moss 1996). These sites also represent the earliest indirect evidence for boat use, as these islands were always separated from the mainland by deep marine channels and strong currents. Faunal remains uncovered at some early sites indicate that the inhabitants had a maritime-adapted subsistence, hunting dolphins, sea lions and seals, and collecting mussels (Cassidy et al. 2004; Rincon 2004).
Another site dating as far back as 10,000 BP near the Pacific coast of North America lies at The Dalles, on the Columbia River, in Washington State. Recent re-examinations indicate an anthropogenic source for most of the large deposits of salmonid bones and bone fragments (Butler and O’Connor 2004:7). These deposits have associated radiocarbon dates confirming that people, able to exploit this resource, occupied the site as long ago as 9,300 BP ago. The abundance of salmon remains indicates that salmon was then a major food source and suggests that migratory salmonids had well-established spawning populations by at least the late Pleistocene, early Holocene transition (Carlson 1983; Butler 1961; Butler and O’Connor 2004). Evidence for gathering of shellfish, and hunting of marine mammals and sea birds, including large numbers of albatross bones, has also recently been discovered at a site on Haida Gwaii [Queen Charlotte Islands] in coastal northern British Columbia, and will be discussed further in the next chapter (Fedje et al. 2005b:201).

Of particular interest at several of above sites is the high number of sea bird remains found together with other marine species. While larger migratory birds could have used both the interior ice-free corridor and the Pacific coast for continental migrations, coastal ice-free waters and glacial refugia were available for rest and food resources even during the height of the Wisconsinan glaciation and therefore represents the likely longer established of the routes. Research in the interior of Alaska and the Yukon shows that the climate was not as severe during the late Pleistocene as assumed in the past, and that birds were well established and hunted by early inhabitants (Elias 2000, 1997; Yesner 1994, 1996a, 1996b, 2000). At the Broken Mammoth site, for example, nearly 40 percent of meat consumption was apparently derived from birds, such as swans, brant, geese, and ducks (Yesner 2000, 1994:155).

Fiedel, (2000a:81, 2000b) has suggested that these migratory bird flyways may have prompted humans to venture further south during the late Pleistocene, and that these human migrants sustained themselves by catching injured or fatigued birds with the use of nets. These would have been easy prey and a reliable food source as generally about 20 percent of migrating birds succumb during their yearly migration (Barton et al. 2004; Fiedel 2000a, 2000b; Pringle 2005; Schmitz 2004)
2.2.2 Technology

As evident in the late Pleistocene / early Holocene sites described above, and pointed out by various other authors, a great number of sites along the Pacific coast of the Americas, as well as in central and eastern North America, have assemblages where projectile points and bifacial tools constitute the minority of finished stone tools. (Barton 2004; Dillehay 2000; Gibbons 1996; Gramly 1982; Fedje et al. 2005b:196; Funk and Wellman 1984; McAvoy and McAvoy 1997; McNett 1985; Sandweiss and McInnis 1998). Sites containing only small amounts of refined tools and none of the associated organic, faunal or shellfish remains have commonly been thought of as representing short-term occupations or small, specialized camps. Particularly on the west coast of North America it has been assumed that larger sites with familiar bifacial tool kits have simply not yet been found.

However, according to Alan Bryan, early foragers in North America were probably equipped with a simple lithic technology, composed of flakes and simple core and “pebble tools” which could then be used to make objects from wood, fiber, sinew, skin, bone and antler. He also states that this hypothetical lithic / organic technology would contain few standardized tools (Bryan 1986). Recent advances in techniques for finding and preserving perishable cultural remains will help to improve models of Late Pleistocene adaptations along the Pacific Coast. For example, recent finds in a waterlogged site on Haida Gwaii include cordage and wooden implements dated to the early Holocene (Fedje 2003; Fedje et al. 2005b:198). Further, sandal and cordage fragments found on the California coast dating to between 10,000 and 8,500 BP have been interpreted to indicate a basketry tradition that was previously unknown (Virtual Museum of Canada; Connolly and Gero 1995:316). Knotted cordage, combined with faunal remains of small fish also suggests a net-fishing technology in coastal Peru by 11,000 BP (Jodry 2005:151; Sandweiss and McInnis 1998:1830). These artifacts
enhance our understanding of a material culture, for these early coastal peoples, far more "elaborate" than inferred just from simple stone tools.

Support for Bryan's assessment comes from some of the late Pleistocene sites described earlier, but also from a wide range of other sites. Projectile points, for example, constituted just over 2 percent of the total artifact assemblage at the Paleoindian Debert Site in Nova Scotia (MacDonald 1968) and at Vail, a Paleoindian site in Maine, end scrapers are nearly ten times more numerous than fluted projectile points (Gramly 1982). These sites have most often been described as camps of mobile foragers who used a combination of bifacial and expedient core technologies, perhaps in cases of local raw-material abundance (Barton 2004). Thus, the availability of lithic raw materials, combined with economic decisions tied to subsistence patterns, could have affected what types of tools were made and whether or not a bifacial tool industry was in place (Cassidy et al. 2004;123).

On the Pacific coast of America many early assemblages include choppers and unifacial flake tools made for the most part from cobbles and rarely contain refined bifacial tools. In some areas the bifacial and unifacial traditions overlapped and blended, while in other areas they were separate in space or time (Carlson 1990; Dillehay 2000). Cobble tool assemblages in South America have yielded late Pleistocene dates starting from 12,500 BP at Monte Verde to 10,000 BP at other sites and continued to be employed during the early Holocene (Dillehay 2000; Keefer et al. 1998; Sandweiss and McInnis 1998). Sites of the so-called "Pebble Tool" or "Old Cordilleran tradition" along the Pacific coast of North America have not shown similar antiquity. Some date between 9,000 to 10,000 BP, while many more date to between 5000 and 9000 BP. The more dynamic geological processes during deglaciation and most of the early Holocene along the Pacific Northwest, as compared to the more arid and placid conditions along the coast of South America, could arguably have caused this discrepancy.

It should be addressed at this point that the archaeological terms "Pebble tool" or "Pebble Tool Tradition" are not accurate in a geological sense and in many cases used wrongly to describe lithic tools (Carlson and DellaBona 1996: 6). The Wentworth Scale, most commonly used in the earth sciences in North America, defines pebbles as measuring between 4 mm and 64 mm whereas cobbles measure between 64 mm and 256 mm (Dirac Delta Consultants 2006). Therefore most choppers and other tools made from fluvially rounded lithic materials reported as "pebble tools" should be properly named cobble tools. Pebbles are of gravel size and could rarely made into tools.
In fact, it is not that early sites with cobble tools on the Pacific Northwest coast are missing, but that reliable sites with any technology predating 10,500 BP remain to be recovered. While the lack of known late Pleistocene sites in this region is a serious concern to the study of early coastal migrations, the existence of younger sites containing abundant cobble tools on the North Pacific coast is still of interest. Here cobble tool sites date from at least 9000 BP to 4000 BP, with a concentration around 6000 BP, apparently associated with seasonal procurement activities such as salmon fishing and smoking and preservation of plant and animal resources (Borden 1968; Carlson 1990, 1998; Haley 1987; Lepofsky and Lenert 2005; Matson 1976). These sites are commonly found very close to glacio-fluvial deposits, or rivers carrying large amounts of coarse lithic materials, including rounded cobble tool “blanks”. The variety and accessibility of raw materials contained in these widely transported deposits, combined with locally available food resources could again have been factors in the distribution and timing of as yet undiscovered early sites.

Sites containing bifacial and cobble tool assemblages on the northern Northwest Coast date from between 10,000 BP to about 9000 BP, and predate the distinct Microblade Tradition which dominated until about 5000 BP (Ackerman 1992 and 1996a, 1996b; Fladmark et al. 1990; Mandryk et al. 2001). Similar to the above discussed Quebrada Jaguay site in coastal Peru, obsidian from island sites on the southern Alaskan coast has been traced to an inland location and indicates multi-day travel by boat and by land, or already established interior trade connections (Erlandson et al. 1992:92). One possible scenario is that this adaptation is linked to people with a generalized late-Paleolithic bifacial adaptation like that from the Ushki layer VII assemblage and possibly originating from the maritime regions of Japan or northern China (Dikov 1996; Goebel et al. 2003; Koppel 2003:264). This population could have migrated to the Northwest Coast along the south coast of Beringia ca. 14,000 to 12,000 BP and might be ancestral to non-microblade groups using similar technology on the Northwest Coast (Mandryk et al. 2001:310). New osteological data also seem to support the existence of such a population along the Pacific coast of North America (Chatters 2000; Gonzales 2002; Koppel 2003:263).

Because of the “simplicity” of this lithic technology, and the lack of preservation of the hypothesized associated wood and bone technology, it is believed that sites containing such assemblages could be widely under-reported. Small sites missing
organic, faunal or shellfish preservation may only possess a few simple flake and cobble tools and would easily be missed, particularly if encountered accidentally by work crews or archaeological amateurs. I believe that the lack of reported late Pleistocene sites in my study area might relate to the "low visibility" of such a hypothetical tool assemblage. Discarded cobble tools and associated flakes may indeed be very difficult to identify, especially on landforms such as raised deltas or beaches that contain large amounts of pebble and cobble raw materials. In addition, assemblages of flaked or split cobbles without any associated other definite cultural materials are often regarded as created naturally. While most such interpretations are probably correct and the lithics rightfully considered "geofacts", in some cases a cultural origin could be possible. However, that can only be accepted when supported by multiple lines of evidence.

2.2.3 Remaining Questions

If, as a majority of geologists presently conclude, the ice-free corridor was not accessible until after 11,500 BP (Jackson and Wilson 2004) and one accepts the antiquity of Monte Verde and possibly a few other pre Clovis sites, then there must have either been an earlier human migration, or the use of another route.

There is no acceptable evidence that America was settled during the Mid-Wisconsinan prior to 25,000 BP, as even the earliest controversial dates at Monte Verde, Cactus Hill and Topper do not predate 15,000 BP. Some environmentally suitable periods for migration, to account for these dates, however exist. A brief window of opportunity has recently been suggested by Al-Suwaidi et al (2006:327) allowing for movement along the outer Pacific Northwest, with generally ice-free conditions from coastal Alaska to Vancouver Island at ca. 16,000 BP. The Port Moody Interstade, a glacial retreat from about 19,000 to 17,000 BP, may represent another possible interval for migration along the Strait of Georgia and Puget Sound. This ice-free period, allowing the establishment of forests in the Vancouver area, is believed to be a regional event (Hicock and Lian 1995; Hicock et al. 1982; Lian et al. 2001; Lian and Hickin 1996). Evidence for it has been sparse, since the following Fraser Glaciation erased almost all soil layers dating to this time. However, there is a possibility that this interstade could have affected the entire North Pacific coast, allowing for a human southward coastal migration at that time.
If, however, we accept the likelihood that there was no pre-terminal Pleistocene migration into the Americas then the only migration theory that can account for the generally accepted 12,500 BP date of Monte Verde, with any credibility, is a coastal route dating to between 14,000 and 13,000 BP. While much of the evidence for such a migration is only indirect, new supporting information has been uncovered in the last decade (Dixon 1999). However, there is still uncertainty among geologists regarding the extent and duration of glacial ice sheets on the eastern shores of Beringia (northwestern Siberia), the land bridge itself (Grosswald 1998; Hughes 1994; Reeves 1983; West 1996), and sections of the Northwest Coast (Mann and Hamilton 1995; Mann and Peteet 1994). The suitability of the climate, vegetation, and animal communities for human survival in Beringia, and interior and coastal Alaska, also has been a topic of debate (Adams 1998; Clague et al. 2004; Elias 1997, 2000; Elias and Brigham-Grette 2001; Guthrie 1968, 1984a, 1984b, 1990; Hu et al. 1995; Heusser 1960, 1985; Mandryk et al. 2001; Sarnthein et al. 2006; Zazula et al. 2003). It is hoped that much more dedicated and focused geological as well as archaeological work will be conducted to address these and many other questions in this relatively sparsely populated and under-researched region.

The coastal-entry hypothesis has further been criticized for the fact that there is no clear evidence for the early use of boats (Anderson and Gillam 2000; Engelbrecht and Seyfert 1994; Erlandson 2001:323; 2002; Hamilton and Goebel 1999). However, as Fladmark and others have pointed out, the possibility of finding perishable materials used to construct boats is slim (Rincon 2004), and many researchers will not accept anything but tangible proof. Besides the fact that Australia, the Solomon Islands, and islands of Japan were settled by crossing significant bodies of waters at different times during the Pleistocene (Jodry 2005:134; Yamaura 1998; Oda 1990; Wickler and Spriggs 1988), new evidence supporting such a scenario has emerged along the Pacific coast of America. The oldest site recorded on the Channel Islands of California's Coast comes from San Miguel Island, which was occupied by ca. 10,500 BP, again providing strong circumstantial evidence of boat travel (Erlandson 2002; Erlandson et al. 1996a, 1996b; Jodry 2005:150; Virtual Museum of Canada). Recent redating of the Arlington Woman skeletal remains may yet prove that the Islands were occupied even earlier, contemporary with Clovis sites (Erlandson 1994; Jodry 2005:150; Johnson et al. 2000, Johnson 2002; Koppel 2003:253). Furthermore, research conducted on tools dating between 9,000 - 8,000 BP from San Clemente
Island, indicate that they are similar to the implements employed by ethnographic boat-building Chumash Indians, lacking "sophisticated" bifacial technology (Cassidy et al. 2004:124; Rincon 2004).

A further question hotly debated and unfortunately misinterpreted by both the media and general public is the origin of potential early coastal migrants. Several early human remains analysed in the last decade showed osteological and dental patterns more similar to the so-called "Caucasoid pattern" which includes modern people of Europe, but also some groups in Asia, such as the native Ainu people of Japan. These finds include the "Kennewick Man" skeleton dated to 9,300 BP found on the Columbia River. Since these skeletal remains were found in western North America it has been suggested that an early Caucasoid population existed on the West Coast that was incorporated or replaced by later peoples with Mongoloid characteristics. These findings concur with the possibility, mentioned above, of a migration along the coast from the maritime regions of Japan or northern China (Bonnichsen and Turnmire 1999; Gonzales 2002; Chatters 2000). DNA testing of these bones, and others from the Pacific Northwest and California dating to around 10,000 BP, while controversial, may lead to very interesting results highly relevant to the study of the first migrants to the Americas.

Current knowledge indicates that the "Ice-Free Corridor" was not available for any "Pre-Clovis" migration, therefore lending the "Coastal Entry Hypothesis" increased credibility (Jackson and Wilson 2004). However, questions such as how people sustained themselves in a severe glacial environment and how they crossed the large, late Wisconsinan glaciers that probably blocked extensive stretches of coastline and fjords have not been sufficiently explained. In the following chapter I intend to shed some light on current facts and hypotheses regarding these questions, by discussing recent research on the Northwest Coast.
CHAPTER 3: GEOLOGY, ENVIRONMENT, AND CULTURES OF THE PLEISTOCENE / HOLOCENE TRANSITION ON THE PACIFIC NORTHWEST

3.1 The Pleistocene / Holocene Boundary - Introduction

The apparent absence of clear evidence for late Pleistocene cultures along the Pacific coast of North America is often explained in terms of environmental factors, such as rising sea levels, having erased all evidence, or the lack of a suitable environment to support a significant population. To further research in this area archaeologists need to correlate climatic and geological events with early human migrations into new areas and to understand why and how people adapted to new local circumstances. This is complicated by the fact that at the end of the Pleistocene, a series of extreme environmental and geological events occurred, including rapid recession of the glaciers, large-scale sea level changes, multiple catastrophic flooding events, and extensive deposition of glacial outwash sediments in regional river valleys. While a selected few areas have seen teams of paleoecologists, earth scientists, and archaeologists producing integrated regional overviews relevant to the first human occupations of the Pacific Northwest, many other areas have seen little or no integrated research.

In this chapter I first examine past and current research into the glacial and post-glacial landscape, sea levels, and associated sediments and landforms. Second, I focus on reconstructions of the terrestrial paleoenvironment using palynological data, and finally review archaeological data bearing on early coastal migrations.

3.2 The Late Wisconsinan, (Fraser) Glaciation

The Late Wisconsinan Glacial stage occurred between ca. 32,000 and 10,000 years ago. Two main ice sheets, the Laurentide covering most of eastern and central Canada and the Cordilleran between the Rocky Mountains and the Pacific Coast of Canada were its dominant features in North America. During the late glacial maximum
ca. 18,000 to 15,000 BP these two sheets expanded, coalesced and made travel between them, or along the Atlantic and Pacific shores, virtually impossible. The coastlines along these ice sheets were dominated by tidewater glaciers and ice shelves, but the enormous mass of water taken up by the ice contributed to significant lowering of global sea levels, exposing large areas of otherwise subaqueous continental shelves. While moisture-laden westerly winds from the Pacific Ocean contributed to the growth of the Cordilleran ice sheet, dry cold air prevented glacial buildup in central Alaska and Yukon Territory. Both the lowering of sea level and dry climate in central Alaska led to the creation of the wide, ice-free Beringian land bridge connecting Asia and America. This land bridge existed to ca. 11,000 BP according to recent studies (Elias et al. 1996:62).

Deglaciation, starting ca. 16,000 BP, was relatively rapid, resulting in an ice-free Pacific coastal strip by ca. 13,000 BP, and in some areas as much as two thousand years earlier. Meltwater streams caused large glacial lakes to form along the glacial margins both to the south of the retreating ice and in the so called ice-free corridor forming on the east of the Rocky Mountains. Breaching of ice dams, holding back many of these pro-glacial lakes, caused jökulhlaup floods potentially exceeding 2,000 cubic kilometers of water, sweeping away and re-depositing large quantities of sediments. In the following parts of this thesis I cover the Cordilleran Glaciation and its effects and associated features on the Northwest Coast.

3.2.1 The Fraser Glaciation on the Pacific Northwest Coast

The last major episode of Wisconsinan glaciation on the Northwest Coast, the Fraser Glaciation, reached its maximum extent ca. 18,000 to 15,000 BP on the northern and 16,000 to 14,500 BP on the southern coast. At that time a thick cover of Cordilleran ice, up to 2500 m thick in places, reached the outer coasts of Vancouver Island and Haida Gwaii (Blaise et al. 1990; Clague 1981; 1983).

Even during times of lesser ice extent, present-day mainland fjords of the Northwest Coast were filled with ice, which at the maximum extended beyond the present coastline and in many places well out onto the continental shelf (Clague and James 2002:72). Small ice-free refugia that existed between the glaciers may have permitted animals and people to move along the shoreline. The massive coastal
glaciers would, however, have presented formidable barriers to such movements during the glacial maximum.

Rapid deglaciation followed, with the outer coast of northern British Columbia and southern Alaska becoming ice-free between 15,000 and 14,000 BP. The landscape was marked by a retreating ice front on the mainland, and a transgressing sea forming calving embayments and estuaries. In some places marine conditions [marine limit] extended up river valleys for over 100 km and up to 200 m above present sea level, since the coast was still isostatically depressed. This deglacial phase was interrupted by still-stands, which produced moraines, deltas and beaches of various age and elevations (Hetherington et al. 2004a).

At the same time, relative sea level was low on the outer coast during and immediately after deglaciation, allowing extensive emergent coastal shelf sections to become vegetated. Braided rivers meandered across these coastal shelves, and deltas formed along the shorelines (Barrie et al. 2005; Barrie and Conway 1999). Many late Pleistocene alluvial plains, deltas, and coastal wetlands, with associated reliable water sources and possibly biologically rich coastal habitats existed along the coast and could have attracted early human hunters and gatherers (Dixon 1999).

After deglaciation commenced, relative sea level trends reversed, with the mainland coast experiencing rapidly falling levels while the outermost coast was undergoing marine transgression due to glacioisostatic forebulge collapse. Mechanisms and effects of such sea-level changes are very complex, as discussed in the next section.

On a local level, the region surrounding the Pitt River study area provides evidence of a long interstadial [non-glacial] period, identified as the Olympia Nonglacial Interval [Mid-Wisconsinan], which commenced around 59 ka BP and ended at about 25 ka BP (Armstrong 1981; Clague et al. 1989; Ryder et al. 1991). Evidence for this time is relatively rare, due to erosion and burial of those deposits by the next glacial event. Peat layers dating to between 48,000 BP and 32,000 BP have been recorded in the Lynn and lower Seymour valleys (Lian and Hickin 1996:96-97). Other such deposits are present on southern Vancouver Island (Alley and Hicock 1986; Huntley et al. 2001:34). This period was followed by the last glaciation [Fraser Glaciation] ca. 25 to 10 ka BP, and the current postglacial period (Armstrong 1981; Armstrong et al. 1965; Ryder et al. 1991).
The Fraser Glaciation involved a series of stadial and interstadial episodes (Clague and James 2002:75). The first glacial advance is called the Coquitlam Stade [Evans Creek Stade in the US] and reached the area ca. 22,000 BP to 28,000 BP (Armstrong 1981; Clague et al. 2005; Hicock and Armstrong 1981). It was followed by a glacial retreat from about 19,000 to 17,000 BP named the Port Moody Interstade, with the establishment of forests in this area (Hicock et al. 1982; Hicock and Lian 1995; Lian et al. 2001; Lian and Hickin 1996; Ward and Thompson 2004:893). Following the Port Moody Interstade, the main Fraser age glacial advance (the Vashon Stade), overrode the lowlands of southwestern British Columbia by about 18,000 BP (Clague et al. 1980) and about 2000 years later the local mountains (Ryder and Clague 1989; Clague et al. 1988, 1989). Maximum ice thickness and extent was reached between 15,000 to 14,000 BP when the Puget lobe reached Olympia, Washington and the Juan de Fuca lobe extended west onto the continental shelf, more than 200 kilometers southwest of the study area. Ice also flowed across Vancouver Island, reaching the Pacific Ocean, in places calving into the sea (Clague and James 2002:72; Clague et al. 1989). The sedimentology and paucity of faunal remains, observed at a sea cave on northern Vancouver Island, suggests that this area was ice-covered between 15,500 and 14,000 BP (Al-Suwaidi et al. 2006; Ward et al. 2003).

The Holocene began 10,000 BP, but times of deglaciation vary significantly. Some areas on the outer coast of Vancouver Island, the San Juan and Gulf islands, Puget Sound and inland areas of south-eastern Vancouver Island were ice-free by at least 14,000 BP (Anundsen et al. 1994; Dethier et al. 1995; Easterbrook 1986 and 1992; Hewitt and Mosher 2001; Lyman 2000; Mosher and Hewitt 2004), while more interior valleys in the Coast Range remained glaciated until about 10,000 BP (Armstrong 1981; Friele and Clague 2002; Huntley et al. 2001; Porter and Swanson 1998). The Strait of Georgia lowlands were ice-free by 13,000 BP, but partially inundated by higher relative sea levels (Clague et al. 1997; Huntley et al. 2001). Greater Vancouver, for example, then consisted of a group of islands and peninsulas resulting from relatively high sea levels that only exposed the higher ridges and upland areas of the region. A fjord similar to today’s Indian Arm extended at this time into the Pitt and Stave Valleys (Gilbert and Desloges 1992). A date of 13,180 BP has been recorded for sea lion remains from Bowen Island, located at the head of another nearby fjord (Harington et al. 2004). This indicates that marine fauna rapidly colonized such ice-free areas (McLaren 2003). After this initial rapid retreat, glaciers stabilized in
up-valley locations for a period, but re-advanced several times during the so-called Sumas Stade between 13,000 and 10,500 BP. The furthest advance of ca. 20 km terminated in the vicinity of the Stave Valley (Clague et al. 1997).

3.2.2 The Younger Dryas

The Younger Dryas refers to a brief cold episode during the generally warming climate of the late Pleistocene and is globally dated to ca. 11,000 to 10,000 BP (Mott et al. 1986). It has been speculated that this cooling event was caused by the release of huge quantities of fresh water from large proglacial lakes south of the Laurentide ice sheet draining into the North Atlantic (Alley 2000; Anderson et al. 1997; Peteet 1995). The Sumas glacial advance on the Northwest Coast was originally believed to be of Younger Dryas age (Mathewes 1993; Mathewes et al. 1993), but the number of advances, and driving mechanisms are now under discussion. While the Younger Dryas had major effects on the North Atlantic region, it may not be linked to the Sumas readvance (Clague et al. 1997:273; Friele and Clague 2002; Pellatt et al. 2002).

3.2.3 Relative Sea Levels

As seen above, a factor that may have affected the archaeological visibility of early postglacial populations in this region is changes in relative sea level (RSL). A vastly different landscape during the late Pleistocene and early Holocene makes our interpretation of the archaeological record very complex. With much lower relative sea levels, the outer coast of British Columbia and southern Alaska would be hardly recognizable. Large areas of flat, coastal shelf were exposed, supporting plant and animal communities on the east side of Haida Gwaii and along the central coast of British Columbia. Dry corridors or narrow ocean channels allowed for animal migrations between the mainland and islands.

The position of the ocean surface relative to the land can change through land movements, changes in water volume, or both. World wide sea-level changes, which result from fluctuations in the amount of water in the ocean basins, are termed eustatic.

Land movements can be a result of tectonic activity associated with the migration of the continental plates across the surface of the globe and change over a long time span. Others, more localized in their effects, and of shorter duration are termed isostatic movements. The term isostasy refers to a state of balance that exists
within the earth's crust or lithosphere and underlying mantle or asthenosphere. A state of isostatic equilibrium is maintained by the flowage, away from zones of loading, of viscous mantle material below the Earths crust, within the asthenosphere. The depression of the crust by the addition of a load (sediment, lava, ice, water, etc.) in one locality will be compensated for by a rise in the crust elsewhere. If the crust is depressed along a body of water, relative sea level is caused to rise (Siegert 2001:27-28; Clague et al.1982:598)

Along margins of glaciated regions, the asthenosphere, displaced by the weight of the ice sheet depressing the Earth's lithosphere, flows outward laterally away from the ice load, forming a peripheral forebulge tens to hundreds of metres in amplitude and potentially several hundred kilometres beyond the ice limit (Siegert 2001:21; Fitzgerald and Rosen 1987:91). During deglaciation, the forebulge rapidly collapses or migrates back towards the former ice sheet centre. Due to the viscous nature of the asthenosphere, there is a lag between the time of deglaciation and the time of re-establishment of isostatic equilibrium, so that many formerly glaciated regions, such as Scandinavia and the Hudson's Bay region of Canada, still experience continued glacio-isostatic uplift 10,000 years after the ice sheets melted (Hutchinson et al. 2004:192; Siegert 2001:46).

In summary, during glacial episodes eustatic sea levels were low, while at the same time the crust was locally depressed or bulged upwards by the weight of varied late Wisconsinan ice loads. Following deglaciation both land uplift or subsistence and sea-level rise occurred, which created varied sequences of raised or drowned shorelines.

Particularly large ranges in RSL along the Pacific Northwest of America were due to the rapid migration and collapse of the forebulge [also called the "continental shelf tilt" in this region], during the late Pleistocene and early Holocene (Barrie and Conway 2002:174). Limited ice thickness on the continental shelf, combined with low mantle viscosity in that area, resulted in the development of an isostatic bulge, as mantle material was displaced by the weight of the ice cover on the continental mainland (Clague and James 2002). For example, the shelf tilt across the northern Pacific margin of Canada ranged between 50 m of submergence at Prince Rupert on the mainland, to greater than 150 m of emergence on the western edge of Haida Gwaii, by 12,500 BP (Barrie and Conway 2002:175; Clague et al.1982).
3.3 Current Research on the Northwest Coast

3.3.1 The Post-glacial Environment

As discussed above, rapid deglaciation commenced on the Pacific Northwest between 16,000 and 14,600 BP in the north and two thousand years later further south in the Vancouver Island / Puget Sound area. A maximum lowering of relative sea level to greater than -150 m on the outer coast, due to isostatic rebound, forebulge effect, and continued low eustatic sea-levels, remained until approximately 12,400 BP, after which a rapid marine transgression occurred (Barrie and Conway 2002:174). Between these time periods extensive coastal shelf areas were sub-aerially exposed and were colonized by flora and fauna that had survived in glacial refugia, or around the southern or northern edges of the Cordilleran ice sheet. It has been argued for both the “Ice-Free Corridor”, and the early post-glacial Pacific Northwest, that the climate was too severe to sustain any substantial plant or animal communities. While no remains of large animals or tree species have been found to date in the centre of the proposed ice-free corridor predating 11,500 BP, the situation is different on the Northwest Coast, where forest development is indicated by 14,000 BP. Data bearing on early floral and faunal remains found along the Pacific Northwest are discussed later in this chapter. I here, however, briefly examine the theoretical, general suitability of such a late glacial environment for such plant and animal communities that, in turn, could sustain human populations.

In the early post-glacial period those exposed landscapes were still close to and sometimes surrounded on three sides by the receding glaciers or stagnant ice and influenced by cold katabatic winds and large, icy expanses of meltwater streams. While such conditions seem inhospitable, one has to remember that biological communities had adapted and flourished along similar glacial margins for thousands of years. It has also been suggested that sediments forming along glacial margins not only encourage new plant growth but that they may in fact be superior to other soil types due to large amounts of nutrients found in them. In addition, marine nutrients were available along the coastline and on newly exposed uplifted coastal shelves, likely helping to promote plant growth.

Thus, Geist (1999:78) and Turner et al. (1999:42) noted that if the three major nutrients potassium, phosphate, and nitrogen are present, marginal glacial ecosystems
can be very productive. Studies have shown that nitrate was present in Pleistocene ice sheets and that nitrogen is released through meltwater runoff. Potassium and phosphate are released in large quantities when igneous or metamorphic rocks are abraded beneath active glaciers. The nutrients in such silt-sized “rock flour” are highly soluble and would have easily been deposited along the large braided floodplains of the late Pleistocene coast. According to Turner et al.,

The presence of essential plant nutrients in water that saturates unconsolidated glacial deposits may have permitted a kind of natural hydroponic plant growth, accelerating soil formation. Once soils had begun to form, the presence of nutrient-containing solutions would permit an unusually high level of productivity to be maintained in stable ice-marginal regions. [Turner et al. 1999: 42]

In addition, such fine nutrient-rich silt deposits also would have been further distributed by the constant katabatic winds blowing away from the glacial front. These are the loess deposits that today cover extensive regions near former ice margins providing the bases for some of the most fertile soils on Earth. Such conditions would also have existed in glacial refugia that were present along the outer Northwest Coast during the Late Wisconsinan glaciation, and flora and fauna could have followed the retreating ice front fairly rapidly (Turner et al. 1999:67). It also has been suggested that a similar nutrient-rich environment might have existed in areas where glacial meltwater drained into the oceans during the Pleistocene, possibly increasing phytoplankton and in turn other marine animals (Geist 1999:91). Less seasonal and therefore more equable climate near the glacial margin may also have allowed a more complex mix of plant and animal species to develop, resulting in an environmental mosaic with no exact analogue in the world today (Geist 1999; Matthews 1992).

Loess areas, with abundant summer growth of herbs and grasses for natural winter hay, also would have been attractive to grazing animals, such as late Pleistocene bison (Bison antiquus), of which remains have recently been found along the southern Northwest Coast at Orcas and Vancouver Island (Wilson et al. 2003; in preparation 1 and 2). These animals could only have arrived on Orcas Island across some kind of outwash plain, in very close proximity to the receding glacial margin. Evidence from other faunal remains of large herbivores along former glacial fronts seems to suggest that large concentrations of animals were present in ice-marginal zones, and that the large size of late Pleistocene mammals is associated with food
abundance, implicating fertile, nutrient-rich landscapes (Geist 1999; Guthrie 1984a and 1984b; Turner et al. 1999). Therefore, growth and colonization in recently deglaciated landscapes seem not to have been limited by a lack of sediment deposition or sufficient concentrations of plant nutrients.

### 3.3.2 Flora and Fauna of the Late Pleistocene

Reconstruction of vegetation patterns during glaciation and deglaciation is based mainly on pollen records contained in bog and lake sediments. Plants of the Mid-Wisconsinan non-glacial period were displaced by changing climate and spreading ice sheets. However, some seem to have persisted throughout the glacial age on refugia on the exposed continental shelves of the Pacific coast and possibly in some unglaciated high elevation areas or western coastal edges of Vancouver Island and Haida Gwaii, from which they could have expanded as soon as the ice receded (Brown and Hebda 2003; Hebda et al. 1997; Heusser 1989; Mathewes 1989, 1997; Warner et al. 1982). Contrary to earlier assumptions, the landscape of large parts of the outer Northwest Coast at the end of the Fraser Glaciation would not have been a sparse, mountainous, frozen land, but a largely flat, coastal environment of open tundra populated with grasses, sedges, herbs, and dwarf willows. These vegetated coastal lands, lakes and braided river systems with associated deltas, marshes, and wetlands were likely populated by a variety of bird and mammal species. Migrating waterfowl also would have found them an almost ideal habitat. Forests became established by about 13,000 to 12,000 BP (Barrie et al. 1993; Clague et al. 1982; Fedje, 2003; Josenhans et al. 1997; Luternauer et al. 1989; Mandryk et al. 2001; Mathewes 1997).

Non-arboreal plant communities, including expanses of treeless grass, herb, and dwarf shrub tundra existed on parts of the outer islands and along the now submerged continental shelf when large parts of the adjacent mainland were ice covered. These shrub and herb communities included edible species such as crowberry (*Empetrum*), horsetail (*Equisetum*), sage (*Artemisia*), fireweed (*Epilobium*), dock (*Rumex*), burnet (*Sanguisorba canadensis*), bistort (*Polygonum viviparum*), and tubers such as chocolate lilies (*Fritillaria lanceolata*). These and many other plant species have been recorded from the Olympic Peninsula in Washington, upland and coastal areas on Vancouver Island, Haida Gwaii, and south-eastern Alaska dating to between 15,000 and 13,000 BP (Brown and Hedba 2003; Heusser 1985; Lacourse and

At Cape Ball, on north-eastern Haida Gwaii, tundra-like terrestrial and wetland plant communities were present by at least 15,000 BP according to plant fossil remains found in a paleo-lake bed (Warner 1984). These simple plant communities thrived for a considerable time, with the addition of dwarf willows (Salix reticulata) or (Salix stolonifera) at 13,000 BP, and the arrival of the first lodgepole pines (Pinus contorta) by ca. 12,500 BP. Spruce (Picea) followed 1000 years later, in turn followed by western hemlock (Tsuga heterophylla), indicating a continued warming period (Lacourse and Mathewes 2005; Mathewes 1985). Lacourse et al (2003) suggested that the richness of the flora at this time, when adjacent areas were presumed to be glaciated, indicates the presence of nearby refugia, as previously proposed by various researchers (Fladmark 1975, 1978, 1979; Heusser 1960, 1989). Evidence for such refugia is also known from the Brooks Peninsula on the north-western tip of Vancouver Island (Hedba et al. 1997).

Pollen from sediment cores recovered from offshore shelf areas, such as Dogfish Bank or Laskeek Bank in Hecate Strait between the mainland and Haida Gwaii, suggests that a similar grass/herb tundra grew on the shelf by at least 13,500 BP (Barrie et al. 1993). In addition, mollusc beds, found at various sites along the late Pleistocene paleo-shoreline, suggest productive littoral zones extending from Vancouver Island to the Queen Charlotte Islands as early as 13,000 BP (Dyke et al. 1996:151; Hebda and Frederick 1990; Hetherington and Reid 2003).

Evidence for the transition of coastal lowlands from tundra to forest has been recovered from a variety of locations, including Cook Bank, offshore north of Northern Vancouver Island, where terrestrial plant, wood and root materials were found below 95 metres of water and dated to between 10,700 and 10,200 BP (Luternauer et al. 1989). The presence of intertidal molluscs there and at Goose Bank, about halfway between Haida Gwaii and Vancouver Island, at a depth of 130m dating to the same time period, also indicate continuous rich littoral habitats (Barrie and Conway 2002).

An offshore sampling project in Juan Perez Sound, on the southeast coast of Haida Gwaii, recovered an in situ pine tree stump still rooted in peat soil at 145 metres depth (Fedje and Josenhans 2000:100; Lacourse et al. 2003). It was dated at 12,200
BP, confirming that forests grew here at approximately the same time as on Cape Ball. This find also confirmed the previous evidence from pollen sampling, which is complicated by the possibility of long distance movement of pollen by wind or water currents. In addition, molluscs such as littleneck (Protothaca staminea) and butter clam (Saxidomus giganteus) were recovered near the tree stump, indicating a coastal habitat with both forest and intertidal resources by at least 12,200 BP.

Other research that showed evidence for these forest communities, dominated by lodgepole pine, but also including alder, willow and a variety of fern species, and dating to ca. 12,500 to 12,000 BP, was conducted on northern Vancouver Island (Lacourse 2005). In fact, similar findings range from coastal Alaska to Oregon (Ager 1999; Grigg and Whitlock 1998; Hansen and Engstrom 1996). That indicates a relatively uniform vegetation cover over a considerable distance, which would have facilitated movement of animals as well as humans adapted to such an ecological community.

As summarized above, deglaciation began by 16,000 BP on the northern Pacific Northwest, with terrestrial vegetation present shortly after, as reported from Cape Ball (Barrie et al. 2005; Lacourse et al. 2005). Faunal remains also have approached this age, with brown bear bones from K1 (Kitgoro) cave on the west coast of Haida Gwaii dating to between 14,400 and 12,000 BP (Fedje 2005; Wigen 2005:106). Another cave, Gaadu Din, on the south-eastern coast shows abundant salmon remains starting at 12,000 BP and mule deer a thousand years later (Wigen 2005:107-108). While evidence points to a large vegetated coastal strip ice-free by at least 13,000 BP, the presence of large mammals like bears more than a thousand years earlier raises some questions (Ramsey et al. 2004). Did they travel across sea-ice as modern polar bears do, or did they persist through the height of the glaciation in refugia? Or, were more of the as-yet poorly researched coastal areas actually ice-free at an earlier time, allowing for movement along the coast as suggested by Al-Suwaidi et al. (2006:327)?

Several cave sites in the Alexander Archipelago of south-eastern Alaska, just north of Haida Gwaii, have produced large quantities of late Pleistocene fish, bird and mammal remains. Ages span the last glacial maxima with the exception of two thousand years between 17,000 and 15,000 BP (Heaton and Grady 1993, 2002, 2003b, 2004). Bird bones of mostly aquatic species, such as geese, cormorants, diving
ducks, puffins and auklets, seem to occur in most sediment layers, indicating an almost continuous presence during this time period (Heaton and Grady 2003a). A marked change of mammal fauna was recorded from pre-glacial communities similar to the immediate post-glacial period, to a more cold-adapted arctic type during the glacial maxima ca. 20,000 to 16,000 BP. Ringed seal remains were most common, as well as arctic foxes, but also less cold-adapted species, such as harbour seals, Steller sea lions and red fox. During some of this time severe arctic conditions seem to have prevailed with pack ice, with which ringed seals are commonly associated, likely being present.

While no brown bear bones were found dating to the glacial maxima, remains dating from between 40,000 and 26,000 BP and from between 12,400 and 7,200 BP have been recovered. Genetic analysis showed that brown bears both from before and after the glacial maxima exhibit the same DNA as do modern brown bears on islands along the Alaskan coast. Brown bears from the mainland, however, exhibit a very different DNA makeup, strongly suggesting that coastal bears have survived and inhabited the area throughout the last glacial period, whereas mainland bears repopulated the region from the south after glaciers had receded. Researchers have pointed out the these coastal brown bears are genetically more closely related to polar bears than to any other brown bears (Barnes et al. 2002; Heaton et al. 1996; Heaton and Grady 2000; Leonard et al. 2000; Talbot and Shields 1996). This indicates not only that these bears survived the glacial maxima on coastal refugia, but also suggests that they may have behaved differently from modern brown bears. They may have hunted ringed seals and travelled on pack ice just as modern polar bears do today.

Similar genetic research supporting possible glacial refugia on the coastal shelf near Haida Gwaii has also been conducted on black bear, marten, and weasel (Byun et al. 1997, 1999). In addition, several endemic plant and insect species and subspecies of owls, woodpeckers, Steller's jays and ermines found only on Haida Gwaii are also considered to result from isolation and survival in Pleistocene glacial refugia (Brodo 1995; Cowan 1989; Kavanaugh 1989; Reimchen and Byun 2005; Schofield 1989; Taylor 1989). However, some of the insular forms and variations, for example the recently extinct dwarf Dawson caribou and a beetle species, appear to be the result of rapid evolution in recent, postglacial insular settings (Clarke et al. 2001; Byun et al. 2002; Reimchen and Byun 2005).
Evidence for the existence of mammals, birds, plants and intertidal resources throughout the late glacial period makes it feasible for human populations to have survived in this environment as well. Especially the presence of bear populations by 14,000 BP shows that a sufficiently large territory with sufficient quantities of prey were available, in turn indicating that the landscape was also suitable for human exploitation (Dixon 1999; Fedje and Josenhans 2000; Heaton 1995, 2001 a and b, 2002; Ramsey et al. 2004)

3.3.3 Early Cultural Remains

There is evidence for early Holocene human occupation of the Pacific Northwest coast in southern Alaska, Haida Gwaii, and the central British Columbia coast at Namu, in addition to sites further south that are examined in the following chapter (Dixon et al. 1997; Erlandson et al. 1992). Some sites have now been dated back to 10,500 BP, therefore falling into the late Pleistocene (Fedje 2005). Such early sites exhibit a technology distinct from the Northwest Coast Microblade Tradition, which appeared locally at about 9000 BP (Ackerman 1992; Fladmark et al. 1990; Mandryk et al. 2001).

Early sites reported in the last few decades along the Alaskan coast include Hidden Falls on Baranof Island and Ground Hog Bay on the mainland, dating to between 9,700-9,000 BP (Ackerman 1992, 1996a, 1996b; Davis 1980, 1996). However, only the earliest component at Ground Hog Bay does not contain microblades, which occur in other layers mixed with cobble tools and other artifact types. Further, an isolated bone tool from On Your Knees Cave [PET-408], on Prince of Wales Island, Southeastern Alaska, was dated to ca. 10,300 BP. This was also the location where human male skeletal remains dated at 9,800 BP (ca. 9,200 BP, if marine reservoir corrections are applied) were uncovered. Isotopic studies on these bones showed that the diet of this as yet earliest known person on the Northwest Coast consisted almost entirely of marine resources (Dixon et al. 1997; Dixon 1999:117; Dixon 2001:286). Trace element analysis demonstrates that some of the lithic artifacts recovered at Ground Hog Bay, as well as from PET-408, were made from obsidian that came from Mount Edziza, up to 500 km away and 220 km inland, on the British Columbia mainland. Since both Baranof and Prince of Wales islands were not connected to the mainland at the time these sites were occupied, these lithic materials
could only have reached the site if humans using watercraft transported them (Ackerman 1996a:429, 1996b:127, Dixon pers. comm. 2004; Jodry 2005:150). In addition, many valleys of the Coast Range may still have been glaciated, suggesting the need for an intimate knowledge of routes, and skills to cross glaciated, mountainous areas.

Evidence of an early human population, aside from the single bone tool found at the PET-408 cave site, also come from the caves on Haida Gwaii that yielded a range of faunal remains dating to the late Pleistocene. At the K1 cave two projectile point bases were preliminary assigned by radiocarbon dating of associated sediments to date between 10,900 and 10,400 BP. They would have been likely lodged in animals that died in the cave (Fedje 2005). Gaadu Din Cave also contained two projectile points and flakes dated to between 10,500 and 10,000 BP.

Other pre-microblade sites may include several intertidal-zone undated sites at Haida Gwaii (Ackerman 1996b:125; Fladmark 1986b, 1990:192; Hobler 1978:2) and Namu, dated to ca. 9700 BP, on the central coast of British Columbia (Cannon 2003; Carlson 1996:83). The early layers of the Richardson Island site dating to between 9300 and 8900 BP and the Kilgii Gwaay site on Haida Gwaii also do not contain microblades (Fedje et al. 2005b:187, 2005:237). Cultural materials earlier than ca. 9500 BP on Haida Gwaii should, because of reasons elaborated above, generally be below modern sea-level. An example of the potential to find underwater sites was provided when, after seabed mapping and identification of drowned landforms, a lithic tool was found in 53 m of water depth off the south-eastern coast of Moresby Island on a delta floodplain (Fedje and Josenhans 2000:101). This research, that also led to the recovery of above mentioned in-situ pine tree stump, provides an example of how underwater surveys could identify sites and recover data (Barrie et al. 2005; Barrie and Conway 2002; Fedje and Josenhans 2000). While drowned and intertidal zones can be expected to be disturbed due to tidal action, creating lag deposits, the relatively fast change of RSL around Haida Gwaii and other Northwest Coast areas could have minimized damage to assemblages buried under at least some sediment cover.

One such intertidal site was recently found at Kilgii Gwaay, where archaeological materials, including intact subsurface deposits dating to between 9450 and 9400 BP, were deposited in a depression, likely along a former pond (Fedje et al. 2005b). Artifact integrity was preserved due to sediment cover and protection from
wave action, and included, due to extended waterlogging, perishable organic materials such as wooden tools, cordage and faunal remains. Analysis of the faunal remains identified bones of more than a dozen species of birds, including loon, duck, snow geese, and in particular albatross that do not normally come close to shore. Numerous fish species, including salmon, lingcod and rockfish and several species of marine mammals such as otter and sea lion were present, among with terrestrial mammals such as bear (Fedje 2003; Fedje et al. 2005b; Virtual Museum of Canada/SFU Museum of Archaeology and Ethnology 2005). The presence of offshore birds and a predominance of marine species, including deepwater fish such as halibut, indicate a maritime-adapted culture much as in later times, living along the coast and exploiting both coastal and offshore resources. No microblades were present at this site and virtually all formed tools are unifacial (Fedje et al. 2005b:196).

Early Microblade sites from the Haida Gwaii Islands include Lawn Point and Kaska (Bobrowsky et al. 1990:115; Fladmark 1986c, 1990), Arrow Creek and Richardson Island (Fedje and Christensen 1999; Fedje et al. 1996, 2005c), and others scattered on the mainland coast and islands of southern Alaska and British Columbia (Ackerman 1996a; Erlandson and Moss 1996; Fladmark 1990; Josenhans et al. 1997). These sites have a common lithic technology and are usually associated with a maritime subsistence reflecting their shoreline location.

Collectively these sites indicate that by at least 9700 BP, and likely as much as 1000 years earlier, humans along the northern Northwest Coast were adapted to marine resources, and travelled and traded by boat over considerable distances. It has been argued that an earlier human occupation was necessary in order to establish such a broad regional adaptation, evidence that strengthens the theory that humans may have first entered the Americas using watercraft along the Pacific coast during the late Pleistocene (Bonnichsen and Turnmire 1999).
CHAPTER 4: THE GLACIAL LANDSCAPE / GLACIAL GEOMORPHOLOGY IN ARCHAEOLOGICAL CONTEXT

4.1 The Glacial Landscape

Because of remoteness, dense vegetation, ruggedness, and a lack of industrial economic incentives, large tracts of the Northwest have received comparatively little attention from geologists and geomorphologists. The general timing and process of the last coastal glaciation however, seems relatively well known. At the time of glacial maxima, the Coast Mountain and northern Cascade ranges were covered by mountain ice caps, which were thick near-continuous bodies of glacier ice extending over high plateaus and mountain terrain. These ice caps or sheets are traditionally thought to have formed when distributary valley glaciers grew large enough to coalesce across mountain ridges and were only broken where high peaks protruded as nunataks. Where mountain valleys opened onto broad plateaus or coastal plains, valley glaciers expanded into extensive lobes or piedmont glaciers, such as the Puget and Juan de Fuca lobes. Some of these major ice lobes extended to ocean margins forming ice shelves of largely unknown extent. A number of valley / fjord glaciers also extended to the ocean where they formed tidewater glaciers.

Many Pacific Northwest coastal fjords and valleys have a steep-sided glacial valley U-shape caused by glacial erosion during the Fraser Glaciation. Fjords act as storage basins since they were often over-deepened by glacial erosion. Furthermore, sediment escape is limited because a shallow sill of bedrock or glaciogenic deposits commonly crosses their mouths, therefore trapping a record of sediment accumulation spanning the late glacial – post glacial period (Fitzgerald and Rosen 1987:34). Examples of such fjords include Howe Sound, which is crossed by a subaqueous Sumas Stade terminal moraine at Porteau cove (Friele et al. 1999:2030; Friele and Clague 2002:48), and Vancouver’s Burrard Inlet / Indian Arm [< 200 m deep] separated from the Strait of Georgia by a bedrock sill ca. 15 meters below sea level. The same mechanisms and processes also apply to fjord lakes such as Pitt and Stave lakes in
the coastal mountains adjacent to the Fraser River lowlands. These lakes were originally saltwater fjords that became separated from the sea by subsequent sedimentation or isostatic uplift. Tidewater marine glaciers that occupied these waters were a major source of sediment. Glacial deposits seaward of retreating tidewater glaciers can include sub-aqueous moraines and fine glaciomarine deposits, such as glaciomarine clay that settled out in significant quantity away from the glacial margin. Iceberg calving was also a frequent occurrence, transporting and releasing coarse debris contained within the ice, potentially considerable distances away (see Fitzgerald and Rosen 1987).

Where glaciers were present in near-coastal mountains and retreated inland during the late Pleistocene, outwash streams were the major contributor of marine sediments. However, progradation of deltas, such as are evident in the lower Fraser, Squamish, and Comox River valleys in southwestern British Columbia, buffered bays and fjords from coarse-grained deposition and constituted the distal portion of extensive sandur or outwash plains. Such deltas, containing potentially large amounts of sediments, are similar to those encountered in large proglacial lakes with the exception of the presence of seawater versus freshwater organisms. Reworked coarse glaciofluvial sediments also formed beaches, but because of rapid changes in relative sea level, these may only remain discernible if a multi-year sea level still-stand occurred. Away from the prograding fjord head or estuary, fine-grained silt and clay deposits predominate (Fitzgerald and Rosen 1987).

Valley, fjord and piedmont glaciers were the most important forces in the distribution of glaciogenic sediments and creation of landforms now visible in the region. These sediments and landforms are very complex and only years of experience make it possible to correctly interpret the multi-component sediment layers that may be encountered during geological or geoarchaeological fieldwork. Components of the glacial record can vary from unsorted boulder-rich or silt-rich till to well sorted glaciofluvial or glaciolacustrine / marine gravels, sands, silts and clays forming various landforms. However, often they occur in a great variety of lateral and vertical combinations reflecting the variety of sedimentary processes produced directly or indirectly by ice. For descriptions of glaciogenic landforms and sediments see Bennett and Glasser (1996), Eyles and Eyles (1992), Gray et al. (1991), and Sollid and Sorbel (1994).
4.2 Human Use of Glaciogenic Landforms

4.2.1 Glacial Landforms

Drumlins and terminal or end-moraines are elevated ridges in relatively flat surroundings and are composed of well-drained sediments formed in contact with glaciers. They therefore lend themselves to being chosen as outlook positions during hunting or for travelling and as campsites in marshy / wet areas in valley bottom localities. Lithic scatters and small campsites might be expected. Due to the elevation above the surrounding landscape they also may not have been covered by extensive Holocene sedimentation and therefore associated archaeological sites might only be shallowly buried. Eskers, another glacial landform, prominent east of the Rocky Mountains are not commonly found in mountainous areas. Examples of prominent end moraines in the research area are located sub-aqueously across Howe Sound at Porteau Cove, and on land between Miracle Valley and Cascade Valley at Stave Lake.

4.2.2 Fluvioglacial Landforms

Glaciofluvial landforms, such as outwash plains and their associated sediments and freshwater channels, were among the first large, flat continental surfaces that became available for colonization by plants, animals and humans during and immediately after deglaciation. As discussed in the previous chapter this environment may have been ecologically richer and more diverse than the surrounding mountainous terrain, encouraging fishing and hunting activities. However, as also mentioned earlier, continued aggradation could have buried many outwash plains under tens of meters of sediments, hiding any associated cultural materials. Kettle lake and kame topography also may have provided a combination of protected well-drained surfaces for campsites and reliable water sources. Kame-terraces and deltas on the other hand are often the only flat-topped surfaces available along steep mountain valleys, lending themselves to be chosen for campsites during subalpine hunting or lithic procurement forays, or during trading missions into neighbouring valleys.

4.2.3 Glaciolacustrine and Glaciomarine Landforms

Glaciolacustrine clay and silt deposits become stranded when glacial lakes drain and glaciomarine clay deposits often become exposed as uplifted terrestrial landforms.
They typically form steep-sided escarpments adjacent to watercourses. When such deposits yield mollusks, microfossils, and plant materials, they provide dateable paleoenvironmental data, and may mark the presence of nearby shorelines that could have been used by early coastal populations. Deltas were also likely places utilized early by human populations. They were often the only flat land available along the fjords and bays of the Northwest Coast during the late Pleistocene and represented the heads of valleys that may have been frequented for a variety of reasons by such early inhabitants. Especially in areas that can only be reached by boat such deltas would have been the logical place to land and set up a base camp. Extensive sedimentation and channel shifting, however, may have destroyed such sites or buried them deeply, rendering them inaccessible.

4.2.4 Paraglacial Landforms

Slope failures were widespread following late Pleistocene deglaciation, resulting from sudden stress release caused by the removal of supporting ice masses, in addition to thawing of frozen sediments due to a rise in temperature. Resulting rockfall and talus debris formed the base material of paraglacial sediments that, in combination with glaciogenic sediments, created landforms such as alluvial fans, debris cones and valley fills (Ryder 1971; Church and Ryder 1972; Ryder et al. 1991; Friele et al. 1999:2030). Such landforms have generally developed their main extent and form within the first one or two thousand years after deglaciation (Jackson et al. 1982; Lian and Hickin 1996).

Alluvial fans form when high-energy streams discharge onto a more level surface such as a coastal plain, or at the juncture of a tributary stream with a main river valley. Often debris cones are reworked to form alluvial fans. Such fans are complex cone-shaped landforms composed of several different sets of sediments derived from debris flows, sheetflood, and sheetwash events that affected different sections of the fan, building up one portion or another. While such fans are relatively steep-angled they are often much more level that the surrounding mountain slopes and have been shown to contain archaeological remains in many mountainous regions around the world (Fedje et al. 1995; Rapp and Hill 2006:67-68; Wilson 1986). Such alluvial gravel facies characteristically include massive, crudely bedded and poorly sorted fluvial gravels and debris-flow diamictons (which can be mistaken for tills) containing
occasional paleosols with associated flora, fauna and cultural deposits developed during inactivity, and periodic aeolian silts, volcanic ash or charcoal layers from forest fires (Church and Ryder 1972; Clague et al. 2003b; Eyles and Kocsis 1988; Eyles et al. 1988; Ryder 1971). A local example of a large (25 km²) paraglacial alluvial fan, illustrating the complexity of such landforms is the lower Cheekye fan, near Squamish, British Columbia. It is composed of deltaic deposits of an early Squamish River raised delta, followed by debris flow sediments of a collapsed flank of Mount Garibaldi (Friele et al. 1999). In addition, melt-out kettle lakes indicate that parts of the fan were built during an active glacial ice-wasting period (Friele et al. 1999:2030).

Paraglacial as well as other glaciogenic landforms are the locations where early human cultural evidence can be expected to be found. However, whether and in what landforms such sites will be preserved in a relatively undisturbed fashion, or the accessibility of such sites, depends on various environmental, technological and methodological factors (Wilson 1983, 1986; Wilson and Hardy 1987). These factors are further explored in the following section by examination of sites found in such settings throughout North America and the methods employed to make these discoveries. Problems encountered with various types of glaciogenic landforms and sediments, making recovery and interpretation of cultural evidence difficult, are also discussed.

4.3 Potential Site Locations and Site Preservation Factors

4.3.1 Geoarchaeological Consideration - Introduction

Raised landforms such as paleo-deltas and beach ridges created during higher relative sea levels are obvious locations on which early migrants into the study region could have left traces of their presence. Having conducted fieldwork on these landforms, I reserve discussion of them for following chapters. Thick fluvial deposits in alluvial floodplains are the second important landscape features that may retain early sites. A related issue is the deep burial of former living surfaces by alluvial fan deposition along steep-sided valley margins. In some cases these processes are linked to the first issue; for instance, floodplain aggradation or fan build-up can bury former landforms such as raised deltas or river terraces, removing potential associated sites even further from discovery (Wilson 1986:85). In some valley portions where erosion
outweighed deposition, river terraces or benches representing former glacial outwash or later alluvial plains, also may contain archaeological finds (Wilson 1986:72).

In large numbers of coastal floodplains in British Columbia, vertical aggradation was a predominant mode of change during the late Pleistocene and early Holocene, thereby potentially burying archaeological evidence, rendering it largely invisible. This is due to the fact that rivers are constrained in glacial valleys of the Coast Mountains, resulting in a large sediment supply, which in combination with changes in late Pleistocene base level / sea level tended to produce deep alluvial deposits. Sedimentary aggradation was particularly pronounced during periods of rising base levels for these rivers, for example, after sea level started to rise from a low of $-10$ m to $-50$ m at around 11,000 BP in some areas of southwestern BC. In some valleys initial aggradation, during the late glacial period, was reversed when sea levels started to fall, leaving raised benches marking the original outwash floodplains. It is important to note that a great deal of local variation also existed along the coast and within valleys, with some river bottoms exhibiting both erosional and aggradational surfaces over a relatively short distance. Greater amounts of channel shifting during these periods might also place earlier archaeological remains away from the modern channels of rivers. In addition, catastrophic late Pleistocene outburst floods, as well as occasional extreme Holocene flood events, might have stripped and redeposited cultural remains. Further landforms potentially conducive to preservation of early archaeological materials are caves and rockshelters, also present in the research area.

One important point that needs to be emphasized is that shell beds and other paleoenvironmental and archaeological evidence could be found below glacial till. As discussed earlier, glaciers go through a series of advance and retreat cycles, sometimes retreating for several decades, allowing vegetation and soils to form, only to be covered again by the advancing glacier front. The last such readvance during the late Pleistocene, on the Pacific Northwest, was the Sumas glaciation, which together with Holocene advances (Neoglacial and Little Ice Age events) could have covered potentially early sites. It can therefore never be assumed that no cultural or paleoenvironmental remains will be found when glacial sediments are encountered during an archaeological excavation in areas that experienced such late-glacial advances (Wilson 1986:67). Thus, while glacial as well as fluvioglacial sediments may be culturally “sterile” themselves, they could cover surfaces used by earlier inhabitants.
If till is encountered in archaeological excavations in areas that clearly possess only one late Quaternary ice-advance, then excavation could cease, provided the archaeologist is able to differentiate between till and other colluvial or alluvial sediments (Figure 4.1). Debris flow sediments, in particular, consist of nearly identical characteristics when compared to till. The principal characteristics distinguishing till from other diamicts are subangular clasts of all sizes; lack of sorting which means the presence of some cobbles or boulders much larger than the dominant clay, silt or sand; lack of lamination or graded bedding; and a mixture of mineral and rock types, some originating a long distance away and not represented in the local strata.

**Figure 4.1** Thick till deposits in lower Chilliwack Valley. This deposit could potentially cap cultural materials

Photo by author

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The following section is intended to shed light on research conducted elsewhere in North America that combined archaeological work with significant geomorphological knowledge in the discovery of late Pleistocene site locations and highlights the potential for its application on the southern British Columbian coast. Associated techniques such as backhoe sampling are also reviewed.

4.3.2 Alluvial Burial

This general overview is intended to illustrate the possibilities and value of alluvial floodplain archaeology. Fiedel (2000a:84) noted that stratified sites of a late Pleistocene age are most likely to occur within deep alluvial deposits in river valleys and gives examples of several sites found buried at a depth of more than 3 m below the surface, dating to between 11,350 and 10,200 BP. Dincauze (1993:284) suggests that locations such as the deeply buried Shawnee Minisink site in Pennsylvania may indicate where we should look for similar evidence.

The floodplain of the Fraser River, where it emerges from the canyon at Hope, as well as that of large portions of the Pitt River, aggraded during most of the late Pleistocene and Holocene (Roberts and Morningstar 1998). In addition, local relative sea levels were up to −10 m below present between ca. 10,500 to 8,000 BP (James et al. 2002; Williams and Roberts 1989; Wooldridge 2002:111). This has led to the deep burial of the initial late Pleistocene outwash plain with its associated landforms. This is illustrated by the recording, with ground penetrating radar, of a paleo-delta ca. 50 km upriver from the modern mouth of the Fraser River, near the confluence with the Harrison River. This landform has been covered by 17 m of fluvial sediment since it was graded to a lower sea level of −10 m, ca.10,200 years ago (Wooldridge 2002:112). Several recent or planned GPR tests in the Fraser valley floodplain by researchers from the Geography, Earth Sciences and Archaeology departments at Simon Fraser University (Lepofsky pers. comm. 2005; Hutchinson pers. comm. 2004; Clague pers. comm. 2005) may record more postglacial landforms or river paleo-channels in this vicinity.

No deep alluvial floodplain archaeological investigations specifically targeting late Pleistocene landforms have been conducted in southwestern British Columbia until now. Some backhoe excavation trenching, however, has been conducted by Stó:lō Nation archaeologists in the central Fraser lowlands as part of archaeological impact
assessments. These trenches, dug to various depths have revealed flood-plain sediments, paleo-sol horizons, and at least two archaeological sites (Schaepe pers. comm. 2006).

In eastern North America early Holocene type artifacts deeply buried in riverbanks were reported from Maine, where 22 dated sites of that age have been recorded, with 17 located inland on deep riverine alluvium (Putnam 1994). The Brigham and Sharrow sites, for example, the basis of much of the current Paleoindian research in northern New England, contain cultural deposits in deep alluvium extending to at least two meters below modern ground surface and dated to 10,300 and 9500 BP (Petersen and Putnam 1992:27). The relative stability of the river channels has ensured regular and deep buildup of alluvial deposits from the late Pleistocene onward. This has resulted in separating successive cultural strata with regular sediment aggradation, thus allowing over 55 cultural features, usually interpreted as short-term events, to be defined. Both of these sites are located near the confluence of two rivers, approximately 100 km inland. Further to the south, the well stratified Shawnee Minisink site in the Upper Delaware Valley of Pennsylvania also contains a Paleoindian level buried in deep alluvium, containing floral and faunal remains dated to 10,900 BP (Dent 1999; Dent and Kauffman 1985).

Goodyear (1999:432) reviewed several studies of alluvial depositional environments during the late Pleistocene in the south-eastern United States. Extensive deep-site excavations conducted by university and state agencies combined archaeological and geological approaches in the study of the depositional history of river floodplains in the southern Appalachians. Extensive backhoe trenching revealed alluvial stratigraphy from the late Pleistocene to the present. Several buried and stratified sites along the Cumberland River, for example, yielded culturally modified horizons of burned clay, charcoal, lithic artifacts, and organic matter, with the lowest at a depth of 8 m possessing a date of 11,700 BP (Goodyear 1999:433).

Sites in the Canadian prairies have also been unearthed by deep-sampling strategies, often unintentionally. For example, bison bone recovered (by intentional sampling) at 3 m depth and dated to only 3000 BP at Forty Mile Coulee, Alberta, suggests that material of late Pleistocene age could be expected to be buried significantly deeper, particularly if the rate of sediment deposition has declined during the Holocene (Wilson and Burns 1999:233). Several sites in the Calgary area ranging
from 8200 to 5100 BP were discovered by backhoe testing of a buried former land surface, after an initial site was found during construction of a basement, at a depth of 3 m. Deep sediment testing revealed that the landform containing these sites was an infilled channel and delineation of it resulted in a successful predictive model for additional sites associated with that landform (Wilson 1974, 1983:350).

Wilson and Burns (1999:234) also state that postglacial fills in certain Plains settings can be tens of meters thick. This also will be the case in most valleys emerging from the Coast Mountains, such as the Pitt or Fraser River valleys. While these rivers now incise late Pleistocene sediments, rates of erosion vary and in many cases are only on the order of a few meters over the span of the Holocene. In other cases such as in narrow steep-sided valleys with alluvial fan and debris flow activity, or where large rivers emerge from narrow canyons (e.g. the Fraser River at Hope), no incision has taken place due to a continued high sediment supply.

A local example of buried floodplain cultural deposits is represented at the Stave Lake hydro-electrical reservoir within the study area (Figure 4.2). There, sites, mainly located on the former floodplain of Cascade Creek, were covered by the waters of the Stave Lake Reservoir and have since experienced lag deposition of cultural materials due to erosional effects of the lowering and raising of the reservoir level.

However, test excavations have revealed continuous deposits below the surface, including intact stratified material buried well below the original land surface. A large number of these sites also are on elevated river levees and glacial outwash terraces of unknown age, present on either side of the former river, ca. 40 m back from the last active river channel, running nearly continuously for several kilometers along the floodplain. They produced numerous clusters of artifacts, including early type lithic materials (Eldridge and McLaren 1998; McLaren 2003; McLaren et al. 1998, 1997; Ryder 1998). The 2004 / 2005 excavation season at the Stave Lake sites produced one cultural deposit dated to between 8590 and 9270 BP, making it the earliest dated site in southwestern British Columbia (McLaren 2005:18).

While floodplain alluvial sites hold great potential, in some watersheds the onset of late Pleistocene aggradation was so energetic and rapid, that many potential sites may have been washed away. Alternatively, due to an immense supply of glacial sediments, such sites also may be very deeply buried, rendering access even by backhoe difficult and dangerous, if not impossible (Wilson and Burns 1999). In addition,
Figure 4.2  [a] Stave Lake Reservoir, during lake low-stand and [b] excavation of subsurface cultural deposits by McLaren et al.

Photos by author
these buried landforms may cover a large area and discovery of associated archaeological sites may be very difficult. Therefore, it is critical to employ geological experts and conduct geological surveys prior to any attempt to locate such potential sites. For a more general coverage of floodplain geoarchaeology see Brown (1997), Brown and Keough (1992), Rapp and Hill (2006), and Waters (1992).

Evidence suggests that lake and river systems were important locations for early inhabitants in many coastal areas during the late Pleistocene / early Holocene. Sites along lakes and rivers were prime locations for exploitation of various fish species and would have facilitated travel either on foot or by boat. The exploitation of anadromous fish species, which may have become available in certain rivers at an early time in the late Pleistocene, could have been part of a seasonal pattern also including use of marine resources and migratory bird populations along coastal bays and estuaries. The importance of riverine and marine resources to the early inhabitants of the coast has been previously proposed, however, clear evidence supporting these claims needs to be secured.

4.3.3 Channel Shifting

Where rivers emerge on broad coastal plains, transporting large amounts of sediments derived from coastal mountain ranges, as in the case of the Fraser River, greater lateral channel migration develops and archaeological deposits may be hidden in marginal locations away from current streams or other locations normally associated with archaeological sites. A recent archaeologically related backhoe excavation into alluvial floodplain deposits on the west coast of Canada was conducted in 2005 as part of the 2004 McCallum site excavation (Lepofsky and Lenert 2005) near the Fraser River. Its goal was not to find archaeological materials but to investigate a paleo-channel of the Fraser River, dating to the early Holocene, which would have served the inhabitants of the McCallum site as a transportation corridor as well as a source of food. This 6000-year-old “pebble tool site” is currently far removed from any active river channels. The excavation was successful in locating such a channel ca. 2 km away from the modern river course at between 4 and 5 m depth (Lepofsky, pers. comm.). This is a good example of the great extent of lateral channel shifting that took place, until modern dyking was introduced. Future GPR research and subsequent backhoe
excavation of buried late Pleistocene landforms could be targeted to locations likely to contain archaeological sites.

4.3.4 Catastrophic Floods

Meltwater at the margins of retreating late Pleistocene glaciers was frequently trapped by ice dams, forming temporary ice-marginal lakes. When such ice barriers gave way they produced catastrophic floods called jökulhlaups, causing great quantities of sediment to be introduced and transported down-slope across unglaciated or recently deglaciated landscapes (Björnsson 1992).

While written for the glacial environment of western Alberta, the following quote also applies to some coastal areas of the Pacific Northwest.

...areas repeatedly were swept and scoured by outburst floods from ephemeral proglacial meltwater lakes as the Laurentian ice sheet retreated; such floods could have devastated human and megafaunal populations but also could have led to erosional loss of early archaeological sites if not deep burial of others in depositional areas downstream. [Wilson and Burns 1999:213]

Multiple jökulhlaups originating from glacial Lake Missoula in Montana have been recorded in the Columbia River Basin, creating the channelled scablands of central Washington State. Such catastrophic floods likely destroyed any cultural evidence along the Columbia and Willamette valleys dating prior to these events. Late Pleistocene sites on the Columbia River estuary would have been swept out onto the continental shelf. The dating of these glacial-lake outburst floods is very difficult. However, comparison of the number of rhythmites above and below 13,000 year old Mt. St. Helens ash dates dozens of scabland floods to between 15,300 and 12,700 BP (Baker and Bunker 1985; Clague et al. 2003a:250; Normark and Reid 2003; Waitt 1984).

Other large undated floods down the Columbia valley occurred sometime later, and from potentially different sources (Leseman and Shaw 2000). Similar, although lower-magnitude, floods have been proposed for the Fraser River valley. Pollen from a 40–50 cm thick sediment layer, deposited ca. 10,500 BP in a marine basin on the south-eastern coast of Vancouver Island, indicates that microfossils originated in the Fraser Valley on the British Columbia mainland (Blais-Stevens et al. 2001 and 2003:2330). These sediments were likely transported by massive flood events caused
by the collapse of glacial dams in the central and upper Fraser Valley of interior British Columbia (Johnsen and Brennand 2004:1367). These large, catastrophic floods sweeping through the late Pleistocene landscape of the Fraser Valley would have severely impacted any predating populations and associated cultural remains that were not either deeply buried or removed at a sufficient high elevation.

4.3.5 Alluvial Fans

Wilson and Burns (1999:233) provide a good overview of the potential for archaeological site burial by debris-flow activity. Alluvial fans are geomorphologically complex, containing many laterally shifting individual debris flows composed of sometimes widely differing diamicts. Since such diamicts can be made up of various source materials they can easily be mistaken for till deposits (Jackson et al. 1982; Wilson 1986, 1990:65), and archaeological work may be halted when such seemingly sterile layers are encountered. Some of the oldest site components known in the research area, namely the lowest layers of the Milliken site in the Fraser Canyon, were capped by such deposits at almost 8 m depth (Carlson 1990:63), and were nearly missed. Another cultural deposit deeply buried under debris flow sediments and found using backhoe site-testing was at the Vermilion Lakes site in Banff National Park, Alberta, dating to 10,500 BP (Fedje at a1.1995; Wilson and Burns 1999).

4.3.6 River Terraces

Cordilleran valley glaciers carried great loads of sediment to their margins, creating moraines, kames, and other landforms. Most of these sediments were then reworked and deposited down-valley by glacial-outwash streams. In locations where river base-levels changed or sediment supply diminished during the early Holocene, valley floors then became dissected and were left hanging at various elevations as terraces or benches. They can provide evidence for former sea-levels and climate through their gradients and often contain rich floral and faunal remains. Such bench or terrace locations also contain a large portion of the early sites known along the Pacific coast of the Americas, including most sites earlier discussed in California and Peru. However, many archaeologists have reported that such terrace sites are geologically complex and that many conclusions drawn in the past were too simple (Dillehay 2000:84).
Studies have shown that hydraulic forces, erosion and sedimentation rates differ markedly even along individual streams, with numbers and ages of terraces varying between drainage systems. This variation is further accentuated by far more powerful forces during initial glacial retreat in valleys covered by the Cordilleran ice-sheet. In addition many buried terrace surfaces may have originally been erosional features, containing mixed lag deposits, making associations between datable organic materials and archaeological assemblages suspect. Radiocarbon dating of a variety of terrace sites in South America showed that the ages of culture bearing layers varied considerably both vertically and horizontally. This raises serious questions about the validity of associations between originally assumed ages and archaeological deposits (Dillehay 2000:85).

While such river-bench sites are common and highly visible in interior regions they are often hard to detect along the Northwest Coast. This is due to the relatively narrow and steep-sided topography of many coastal valleys, which is not conductive to preservation, and extensive vegetation cover of existing small terrace remnants.

4.3.7 Caves and Rockshelters

Cave sites that have been proposed to contain pre-Clovis cultural evidence include Wilson Bute Cave, Fort Rock Cave, Meadowcroft Rockshelter and Bluefish Caves, among others (Bonnichsen and Steele 1994; Bonnichsen and Schneider 1999; Bonnichsen and Lepper 2005:12). Without exception, every such site has since been criticised as having questionable dates or associations of dated faunal remains with stone tools. Caves and rock shelters often experienced later disturbances from animal, human and natural sources throughout the Holocene, complicating clear associations with carbon dated samples. However, they may also act as sediment traps and their deposits are largely protected from sub-aerial weathering effects (Rapp and Hill 2006:85). Not only may rockshelters and caves retain a considerable part of the late Quaternary stratigraphic and faunal record, they also could trap and preserve datable early human remains. This would be the most reliable data to demonstrate the presence of early populations in a particular area.

Sites of the Western Stemmed point tradition, likely coeval with Clovis in western North America, are very commonly associated with caves and rockshelters.
Therefore, close attention should be given to such landforms along the Pacific coast as they may relate to an early coastal population.

Caves can develop in many different rock types, but are most extensive and complex in limestone. Consequently, the majority of paleoenvironmental and cultural information from caves on the Pacific Northwest coast has come from limestone karst regions of the Alexander Archipelago, Vancouver Island, and Haida Gwaii (Heaton and Grady 2000, 2004; Ramsey et al. 2004). Wave-cut caves along present and former coastlines are another frequently occurring type (Ward et al. 2003).

4.4 Paleoenvironmental Research Methods and Analysis

Increasingly, Quaternary scientists and archaeologists are employing a variety of new or improved techniques to further their knowledge about the geographical and environmental setting encountered by the first inhabitants along the Pacific Northwest coast. Later in this chapter, I indicate the relevance of such applications for Late Pleistocene archaeological research.

Technology:

An increasingly employed method for scanning shallow unconsolidated sediments is ground-penetrating radar (GPR), using a short pulse of high frequency electromagnetic energy. GPR has been most successfully applied to stratified alluvial, fluvial, deltaic, and beach deposits making it very useful to paleolandform research. In particular, buried paleo river channels and deltas, potentially containing evidence of early human use, can be located by this technique (Rapp and Hill 2006:116; Friele et al. 1999; Gutsell et al. 2004; Wooldridge 2002:7). In addition, direct cultural evidence, such as pit depressions from habitations or larger hearth features, can be located (Herz and Garrison 1998:173). Such GPR studies or other geological evidence can then be followed up with backhoe excavation as has been practiced in various geoarchaeological research projects elsewhere in North America.

Another useful recent development is Lidar, an aircraft-based remote sensing tool which uses laser-driven pulses of light and multispectral cameras to scan and process digital information about landscape features. Lidar data can be used to reveal elevation, slope, and dimensions of ground features at a precision of a few centimeters, ignoring any vegetation cover, and can produce a high-resolution model of
the landscape (Williamson and Nickens, 2000). While expensive, this technology could be very effective at locating raised beach ridges on densely vegetated slopes that may not otherwise be detectable. A series of beach ridges, for example, were found with this technology near the study area, on Whidbey Island in Washington State (Kovanen and Slaymaker 2004). These ridges were recorded at precise elevations and by linking them to the local relative sea level approximate dates can be derived. This data set was, however, not collected for archaeological purposes and none of these old beaches have yet been tested.

For other geophysical exploration methods such as seismic refraction/reflection, electrical/electromagnetic resistivity and conductivity, etc., see Herz and Garrison 1998 (147-180) and Roberts et al. (1992).

**Sea level curves:**

RSL change can be illustrated as a curve constructed from various field observations, such as datable sediments from lake cores and terraces or deltas preserved along actively uplifting coastlines, recording high-stands in sea level (Clague and James 2002:78; Siegert 2001:21).

Recent local sea level curves have primarily been constructed by the "lake isolation" method, which normally consists of sediment coring in lakes relatively close to marine shores and can be used to record small amplitude fluctuations in sea level (Hutchinson et al. 2004; James et al. 2002:2; Reasoner 1993). This method dates boundaries between marine and lacustrine sediments in lakes or bogs that have been isolated (or inundated) by changing sea levels. These boundaries are identified by lithostratigraphic (e.g., changes from glacio-marine clay to organic lake deposits called gyttja) and biostratigraphic (e.g., diatom analysis) indicators of salinity changes and radiocarbon dated using samples of faunal or floral remains found on either side of these boundaries (Hutchinson et al. 2004; James et al. 2002). Quaternary diatom and foraminifer remains have proven useful as indicators of local climate and aquatic habitat changes in lakes, as well as in shallow and deep-sea marine sediments (Guilbault et al. 2003; Patterson et al. 2005). Changes from salt to freshwater conditions can be directly attributed to sea level fluctuations relative to the elevation of the lake-basin. These sea level curves provide the most accurate record of sea-level fluctuation for an area, but are frequently spatially restricted and thus their extrapolation over a larger area might not be very accurate.
Another useful approach is to inquire and to interview local residents about local occurrences of marine mollusks in now terrestrial sediments. These in situ deposits are relatively widespread, often occurring in raised beach gravels and estuarine clays, and when dated can fairly accurately indicate past sea levels. Not only do these deposits help in the construction of sea level curves they also may be used by archaeologists to identify late Pleistocene beaches and other shoreline features.

Lake sediment cores can also be examined for changes in pollen content over time to reconstruct Quaternary environments. Former vegetation patterns can also be reconstructed by the study of plant macrofossils. They include wood fragments, roots, cones, seeds, stamens, leaves, spores, buds, and fruits recovered from waterlogged lacustrine sites, acidic peats or some alluvial sediments.
CHAPTER 5: ARCHAEOLOGY AND QUATERNARY GEOMORPHOLOGY OF THE SOUTHERN COAST OF BRITISH COLUMBIA

5.1 Geographical and Environmental Setting

The southwestern coast of British Columbia can be roughly divided into Vancouver Island, the Gulf Islands, the western Fraser River lowland, also known as the Lower Mainland, and the Sunshine Coast. Adjacent and part of the same environmental and cultural landscape are the mainland coast and San Juan Islands of Washington State. Adjoining major waterways are the Strait of Georgia, the Juan de Fuca Strait, and Puget Sound. The relatively narrow coastal lowlands are bounded on the north and east by the Coast Mountains and on the south and southeast by the Cascade and Olympic Mountains.

The impact of Quaternary glaciation on pre-existing landscapes varied from south to north, and depending on elevation. The higher peaks, for example, retain their mature, ragged character since they were infrequently covered by ice, and glacial erosion has therefore been minimal. At lower elevations glaciation accentuated previous drainage patterns by scouring valley floors and bedrock. Troughs were excavated as deep as 400 m below sea level in zones of accelerated flow or more effective erosion, creating fjords such as Howe Sound and Indian Arm or inland valley lakes such as Pitt, Stave and Harrison Lakes. These low-lying areas then were either buried by till sheets or by glacio-fluvial or marine sediments at the end of the Fraser Glaciation. Glacio-marine processes have been locally important, with thick deposits blanketing some lowland areas and lake and fjord bottoms.

Postglacial climatic change is documented by pollen analyses of lake and bog sediments. Based on such studies performed over the past 40 years, a fairly detailed floral and climatic reconstruction is available for the Northwest Coast. Climate has been generally temperate since 14 ka BP, with the exception of a dry period right after the end of glaciation and a cooling interval ca. 11-10 ka BP (Mathewes 1985). On the exposed coastal shelf and some higher elevations of Vancouver Island, vegetation
communities may have survived throughout the Fraser Glaciation. While flora and fauna went through constant changes during the first 3000 years after deglaciation, by early to middle Holocene time the regional forest cover nearly resembled the modern forest (Brown and Hebda 2003).

5.2 Previous Research on the Late Pleistocene Paleoenvironment and Geology

Detailed analysis of six collections of narratives relating to the Genesis of First Nations in the Lower Fraser River Valley led McLaren (2003:38) to conclude that there was a common pattern of landscape change in these stories. In general, the early part of the sequence starts with the draining of water during the creation of the world. That was followed by the arrival of people in a landscape relatively poor of resources, and the transformation of the land, flora and fauna, and cultural patterns into forms recognizable today. A massive flood then disrupts this landscape.

It is exciting to find that much of this sequence is supported by scientific research. The exception is that a human presence has not yet been shown to be contemporary with all inferred geological and paleoenvironmental changes that took place in the Late Pleistocene.

Some areas of southwestern British Columbia have seen considerable Quaternary paleoenvironmental work and are relatively well documented. However, much of the work has concentrated on large-scale, regional aspects of the last glaciation and less on particular glacial landforms or restricted localities. While large-scale geological and paleoenvironmental research is invaluable, smaller-scale studies would be of particular use in the location of potential early archaeological sites. Of great importance to the study of early settlement in my research area is the timing of the onset of late glacial aggradation (till/fluvial contact) that would be critical for burial and preservation of early cultural remains. In the following section, I summarize previous research about the extent, chronology, and isostatic effects of the late Fraser Glaciation, associated outburst floods, and general late Pleistocene paleoenvironments in the Pitt River study area.
5.2.1 Local Late Pleistocene Sedimentation

As mentioned above, the identification of landforms suitable for early settlement in the research area depends on the timing of the onset of late glacial aggradation and sea level regression.

Sediments of older pre Fraser glacial and nonglacial periods are present in deep valley fills and on the ocean floor, and are sometimes exposed in thick deposits along coastal bluffs (Figure 5.1 and Table 5.1) (Hicock and Armstrong 1983, Huntley et al.2001:34). Valley fills in the Fraser lowlands, for example, can be more than 300 m thick, recording several sequences of glaciogenic sediments (Halstead 1986:7-8,17-18). In addition, near-surface Olympia Mid-Wisconsinan nonglacial organic deposits dating to between 59 and 25 ka BP and Coquitlam Stade glacial sediments dating to ca. 28 to 22 ka BP are rare but have been recorded in the Seymour, Lynn, Coquitlam and Chehalis Valleys near the study area (Ward and Thompson 2004). They are, however, not considered to be relevant to the present study and are not further discussed.

Figure 5.1 Stratified sediments deposited during the last glaciation at Point Roberts

Photo by author
Evidence of the Port Moody Interglacial Stade dating from ca. 19 to 17 ka BP, with the growth of spruce-fir forests, found at various locations in the lower Fraser River lowlands (Lian et al. 2001; Ward and Thompson 2004), might be of interest if a pre-16,000 BP human colonization for the Americas is ever demonstrated. However, because of the very small size of these deposits and limited duration of this interstadial period, they would not be likely to yield cultural deposits.

**Table 5-1 Stratigraphic scheme of Glacial and Nonglacial intervals in the Fraser Lowlands**

<table>
<thead>
<tr>
<th>GEOLOGIC-CLIMATE UNITS</th>
<th>$^{14}$C years BP x 1000 (not to scale)</th>
<th>FRASER LOWLAND Geologic-Event and Lithostratigraphic Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Postglacial</td>
<td>5–10</td>
<td>Fraser River sediments, Salish sediments</td>
</tr>
<tr>
<td>Fraser Glaciation</td>
<td>11–14</td>
<td>Sumas Stade</td>
</tr>
<tr>
<td>Olympia nonglacial interval</td>
<td>15–17</td>
<td>Capilano sediments, Ft. Langley interval</td>
</tr>
<tr>
<td>Semiahmoo Glaciation</td>
<td>19</td>
<td>Vashon Stade</td>
</tr>
<tr>
<td></td>
<td>25–36</td>
<td>Port Moody Interstade</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Coquitlam Stade</td>
</tr>
<tr>
<td></td>
<td>50–50</td>
<td>Quadra Sand</td>
</tr>
<tr>
<td></td>
<td>Not calibrated</td>
<td>Cowichan Head Formation</td>
</tr>
</tbody>
</table>

Table from Ward and Thomson (2004). Used with permission.
The latest glacial advance, the Vashon Stade, 17 - 14 ka BP, involved the largest ice sheet of the Fraser Glaciation. Erosional areas, such as bedrock outcrops along fjords and U-shaped valleys, display cross-cutting striations on rock surfaces (Clague and Ward, SFU fieldtrip 2003). Depositional areas, commonly constrained to coastal lowlands and valley bottoms, display thick glaciogenic deposits accumulated during both advance and decay of the ice mass. During the advance of glaciers from the Coast Mountains into coastal lowlands, thick layers of fluvial and lacustrine outwash, termed Quadra Sand, were deposited along advancing glacier fronts. When the ice sheet overrode these proglacial sediments, glacial erosion removed much and sometimes all of these sediments from valley bottoms and redeposited them at the outer glacial margins or the deepest valley troughs. Such glacially derived deposits, including till and subglacial fluvial gravel and sand are termed Vashon Drift (Clague 1986; Clague and Ward, SFU fieldtrip 2003).

Once the ice-sheets started decaying, large volumes of glaciofluvial sediments were deposited in valley floodplains, glaciolacustrine sediments in marginal or mid-valley ice-dammed lakes, and glaciomarine sediments in submerged coastal lowlands. These Fraser Glaciation retreat-phase deposits are termed Capilano Sediments. While sediment sequences in coastal lowlands of the south-west coast can contain several thick pre Fraser Glaciation deposits, Coast Mountain valley deposits often contain only one (Vashon Stade) and rarely two or more glacial sequences (Armstrong 1981; Clague 2000; Clague and Luternauer 1982).
According to Clague (2000:37) a complete sequence of the Fraser Glaciation in coastal lowland and valley locations would comprise the sequence shown in the following table.

**Table 5-2 Southwest Coastal British Columbia Sediment Sequence**

<table>
<thead>
<tr>
<th>Coastal Lowlands</th>
<th>Coastal Mountain Valleys</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Advance glaciofluvial and deltaic gravel and sand</td>
<td>• Glaciofluvial gravel and sand, commonly several tens of metres thick</td>
</tr>
<tr>
<td></td>
<td>• Advance glaciolacustrine sediments, including sand and silt deposited some distance from glacier margins and diamicton deposited adjacent to ice or to a valley wall</td>
</tr>
<tr>
<td>• Till and ice-contact gravel</td>
<td>• Till</td>
</tr>
<tr>
<td>• Retreat glaciomarine sediments, including diamicton, ice-contact and deltaic gravel and sand, and silt and clay</td>
<td>• Retreat glaciolacustrine sediments including diamicton, ice-contact and deltaic gravel and sand, and rhythmically bedded silt and clay</td>
</tr>
<tr>
<td>• Littoral gravel and sand</td>
<td>• Retreat glaciofluvial gravel and sand</td>
</tr>
<tr>
<td>• Retreat glaciofluvial gravel</td>
<td></td>
</tr>
</tbody>
</table>

Such a complete stratigraphic sequence however, is not usually present and one or more unit commonly is missing locally. For example, in valley fills, advance and retreat glaciolacustrine deposits could potentially be in contact, if no intervening till layer was deposited (Clague 2000). Therefore, careful examination of sediment layers for unconformities or changes in sediment properties is critical to correctly identify a glacial sequence for any particular deposit exposure. As discussed in previous sections, paraglacial effects also may remove one or more layers or deposit alluvial/colluvial sediments to cover these glacial sequences.
5.2.2 Regional Sea-level Studies

As noted, Pleistocene sea level changes generally were due to a combination of eustatic, isostatic, and tectonic factors, whereas glacio-isostasy, followed by eustasy were the dominant forces in sea level change along the British Columbia coast. At the onset of the Fraser Glaciation regional isostatic depression was concentrated beneath the Coast Mountains, where glacier ice first formed and expanded as glaciers advanced out onto the Strait of Georgia lowlands. This depression was partially offset in coastal areas by isostatic uplift due to the fall of global sea level and consequent removal of up to 100 m of water in the coastal area (Clague 1983; Clague and Luternauer 1982; Clague and James 2002; James et al. 1999). However, the relatively shallow depth of water removed, compared with the amount of glacial loading, would have made this effect only significant during initial glaciation.

At the height of the Fraser Glaciation, the southwestern margin of the Cordilleran Ice Sheet extended to the Pacific Ocean across the Strait of Georgia and Puget Sound, overriding or abutting local ice caps centred in the mountains of Vancouver Island and the Olympic Peninsula.

Due to this ice-loading, marine limit (maximum height of sea level) along outer parts of the Pacific Northwest, reached 200 m above present at Kitimat (Clague 1983; Clague et al. 1982), +230 m in Juneau (Mann and Hamilton 1995), +200 m on the Sunshine coast, +150 m in the Greater Vancouver region, +150 to 100 m on the east coast of Vancouver Island, +75 m in Victoria, and +50 m on the west coast of Vancouver Island (Clague et al. 1982; Clague and James 2002; Hutchinson et al. 2004). Conversely, relative sea levels around Haida Gwaii and the outer coast of Central and Northern British Columbia were as much as 150 m below present, due to forebulge effects, combined with a thinner ice cover (Barrie and Conway 2002:174; Josenhans et al. 1997). Sea levels are therefore dependent on distances from centers of ice loading and the timing of local glacier retreat. For example, marine limits can be expected to be low in most mainland valleys and fjords in the study area, because valley glaciers occupied them until isostatic rebound was largely complete.

Radiocarbon ages on mollusks, plant macrofossils, and organic lake sediments called gyttja are used to constrain the effects and timing of regional isostatic uplift. In particular, near coastal lakes and bogs generally display a sequence from glaciomarine
to organic freshwater sediments (Hutchinson 1992; Hutchinson et al. 2004; James et al. 2002). Due to the comparably fast decay of the Cordilleran Ice Sheet, isostatic rebound was rapid on the Pacific Northwest coast and uplift was complete in most areas by mid Holocene times (Clague 1983; Clague et al. 1982, Clague and James 2002). These relatively fast isostatic adjustments suggest that the asthenosphere is very responsive to ice loading and unloading in this area (Clague and James 2002; James et al. 1999). Local variations of relative sea level fall were a consequence of the response of the Earth’s crust to the timing of local deglaciation and of water added to the oceans from the melting of Pleistocene ice sheets.
This rapid rebound of the isostatically depressed landmass resulted in up to 300 m of uplift which, combined with 100 m of eustatic sea level rise, resulted in relative sea levels falling from up to 200 m asl to their lowest levels of -12 m during the first half of the Holocene (Clague 1983; Clague et al. 1996). In some areas along the Strait of Georgia sea levels fell over 100 m in a few hundred years during the late Pleistocene, while in others the same amount of change took nearly 2000 years.

Again, sea level curves established from lake and shallow marine cores, and macrofossils and mollusks from outcrops in the central Strait of Georgia show that relative sea level fell from 150 m asl to about minus 15 m from 14,000 BP to 11,500 BP. While cores at higher elevations exhibit abrupt changes in diatom assemblages indicating rapid marine-freshwater transition in the late Pleistocene, sediments at lower elevations suggest slower rates of uplift during the early Holocene. By about 9000 BP to 8500 BP sea level rose to about 1 m asl, before slowly falling to present levels (Hutchinson et al. 2004:189). On southern Vancouver Island, sea level fell from above 60 m asl to around minus 50 m below present between 12,500 and 11,500 BP (Hutchinson et al. 2004:191). The Fraser River lowland data (Figure 5.2) indicate that sea level fell from ca. 180 m to about 80 m asl between 12,500 and 12,000 BP and after a brief slowing to 20-30 m asl by 11,000 and to about 10 m asl by 10,000 BP (James et al. 2002:4). Shorelines were as low as 12 m below present from 10,000 to ca. 9000 BP and rose to near current levels by 8000 BP (Clague et al. 1982:600; Clague et al. 1983; Clague and James 2002; James et al. 2002; Hutchinson et al. 1995; Williams and Roberts 1989). When reviewing this data it becomes clear that relative sea levels were complex and highly dynamic, with major differences over fairly short distances and time intervals.

5.2.3 Late Pleistocene Landforms in Southwestern British Columbia

Geomorphological evidence for relative sea level change is recorded on southwestern Vancouver Island where wave-cut terraces in glacial and deltaic sediments in the Mill Bay area and on Saanich Peninsula occur at about 5, 20, 40 and 80 m above present sea level (Huntley et al. 2001:36). In the Fraser lowlands wave-cut terraces were reported from slopes of upland areas between Surrey and Langley (Armstrong and Hicock 1979, 1980; Wagner 1959:2) (See Figure 5.3 for locations).
Figure 5.3 Southwestern British Columbia and the Fraser River lowlands, with locations reported in text. [Maps by Author]
Raised beaches also were recorded by Arcas Consultants in the Tsawwassen upland area at an elevation of between 3 and 10 m (Arcas Consulting Archeologists 1996:136; Brolly et.al. 1999) and are estimated to have formed at 11,000 BP. Such wave-cut terraces and raised beaches likely represent episodes when glacio-isostatic rebound and eustatic sea-level rise were approximately equal and allowed for the required time to create these features. If relative sea-level falls rapidly no beach or wave cut terraces can be expected.

Numerous raised deltas on Vancouver Island include the Comox and Courtenay River deltas (dated to 12,500 BP at 150 m asl), the Parksville delta (ca. 12,000 BP at 52 m asl), and the Colwood delta near Victoria that marks the marine limit at 75 m asl in that area (James et al. 2000:1535; James et al. 2002:2; Mathews et al. 1970:695).

Raised marine deltas are also present at Magnesia Creek at 150 m above sea level and Britannia Creek and Furry Creek at ca. 45 m asl in Howe Sound (Armstrong 1981; Friele and Clague 2002:47; Mathews et al. 1970:696; Wooldridge 2002:95). At the head of Howe Sound a paleodelta of the Stawamus River (Figure 5.4) between 56 and 15m asl, dated at 45m asl to between 10,200 and 10,600 BP, indicates the maximum marine inundation at that time (Friele et al. 1999:2026; Friele and Clague 2002:53).

Deltaic deposits in the Fraser lowlands are found underlying the Langley and Maple Ridge uplands, and southeast of Aldergrove where a delta covers an area of 30 square kilometers (Armstrong 1981, 1984; Clague et al. 1982; Clague and Luternauer 1982 and 1983:68-70; Halstead 1986:9 and 21). It is connected to an abandoned meltwater channel now occupied by the small Campbell River (Armstrong and Hicock 1980; Halstead 1986:21). These delta sediments were deposited during the late stage of the Fraser Glaciation between 12,900 and 11,600 BP. Raised deltas or beach deposits of similar age have been recorded at elevations of up to 155 m asl (Halstead 1986:9), for example at a gravel pit near Maple Ridge (Tribe and Grimm 2000:6). Several deltas were present on Vancouver’s north shore (Armstrong 1960, 1981; Armstrong et al. 1965; Mathews et al. 1970:695), but most have since been removed by gravel extraction.
Figure 5.4  [a] Glaciofluvial sediments of a raised lacustrine delta at Squamish and [b] typical foreset / topset bedding

Photos by author
Ground-penetrating radar surveys along the Fraser and Squamish Rivers revealed late Pleistocene deltaic foresets, now buried beneath Holocene alluvial deposits, recording the former positions of delta fronts. The rate of delta progradation down the Squamish Valley during higher relative sea level, can be timed by comparison of elevations on delta foreset tops with relative sea level curves for the area (Ekes and Hickin 2001; Friele et al. 1999:2026; Wooldridge 2002).

The top of paleo-delta foresets beneath current Fraser River sediments is minus 10 m elevation, which implies that the delta was forming at a time when relative sea level was lower. This low relative sea level is estimated to have occurred between 10,000 to 9,000 BP (James et al. 2002; Williams and Roberts 1989). It appears however that delta deposition commenced somewhat earlier, as the GPR data shows that the delta was graded initially to a higher sea level. Since deposition this delta has been buried under up to 24 m of alluvial sediments.

Organic samples in delta sediments at 45 m elevation are dated to 10,200 BP in the Squamish Valley (Friele et al. 1999:2026), while a recent sea level curve for the Fraser lowland shows sea level reached a similar elevation about 11,600 to 11,340 years ago (James et al., 2002). This shows that isostatic rebound in the Squamish Valley commenced later and that the valley became deglaciated approximately 1300 years later than the Fraser Lowland (Clague and James 2002:79; Friele and Clague 2002; Wooldridge 2002:111). The recording of an elevated, late Pleistocene delta, 21 m asl at Zeballos, at a fjord head on west-central Vancouver Island, further demonstrates GPR survey applications (Gutsell et al. 2004). The burial of these paleodeltas below thick alluvial fill illustrates the great depth of late Pleistocene land surfaces and potential archaeological sites in local floodplains.

Another example of deep alluvial burial are peat deposits dated between 8360 and 7500 BP buried under 11.6 m of silt and sand near the confluence of the Pitt and Fraser Rivers at Pitt Meadows, on both sides of the Port Mann bridge at Surrey and Coquitlam, and northeast of Sumas (Clague et al. 1983; Mathews et al. 1970:696). Underlying these deposits are older sediment sequences from Fraser and pre-Fraser glaciations, extending to a depth of 300 m in the Pitt Meadows area (Halstead 1986:17 and 18).

While the above examples show that late-glacial landforms exist in the region, many late Pleistocene and early Holocene landforms have already been or will be
destroyed by construction and gravel extraction. This sentiment is summed up in following quote:

At one time sites like the Maccallum site would have been relatively common on the archaeological landscape of the Fraser Valley. Today, however, many of the landforms on which these sites are located have already been destroyed by development, and others are currently threatened. Comparatively little is known about the prehistory of this early period; it is imperative that sites like the Maccallum site are protected for the future. [Lepofsky and Lenert, 2005:101]

Other regions, mostly in urban areas across North America and Europe have taken these concerns to be serious and have started to protect landforms of late glacial age. Northern Ireland, for example, has adopted an inventory of endangered landforms and has given protection to rare landforms threatened by development (Environment and Heritage Service Northern Ireland 2005). Describing Quaternary landforms, it is stated that:

The landforms and associated deposits derived from all of these processes are essentially fossil. Once damaged or destroyed they cannot be replaced since the processes or process combinations that created them no longer exist. They therefore represent a finite scientific and economic resource and are a notable determinant of landscape character. [Unknown Author, Environment and Heritage Service Northern Ireland 2005]

5.2.4 Glacial Floods

According to Blais-Stevens et al. (2001, 2003:2328) a 40–50 cm thick, grey, non-glaciomarine sediment unit was emplaced in a very short time-span about 10,500 BP in a marine basin at Saanich Peninsula, on the south-eastern coast of Vancouver Island. Pollen analyses showed that this thick unit contains abundant, reworked Tertiary microfossils originating in the Fraser Valley on the British Columbia mainland. It has been interpreted as resulting from massive flood events caused by the collapse of glacial dams in the upper Fraser Valley of interior British Columbia (Conway et al. 2001; Blais-Stevens et al. 2001, 2003:2332). At least two catastrophic floods swept through the late Pleistocene Fraser Valley and across the Strait of Georgia to Vancouver Island. Research in the British Columbia Interior now indicates that such jökulhlaups, of a magnitude of 20km³ of floodwater, could have originated from the
draining of Glacial Lake Thompson and Glacial Lake Deadman between ca. 11,940 and 10,190 BP (Johnsen and Brennand 2004:1367).

5.2.5 Flora and Fauna

Oral traditions from the Katzie traditional territory, centred in the Pitt River valley, as told by Old Pierre [Simon Pierre], a widely honoured Katzie elder and medicine man, spoke of a time when the first humans encountered a land that was strangely different (McLaren 2003:35; Jenness 1955):

...in the waters of the sea and the rivers there were clams and mussels, but no salmon, eulachon, or sturgeon, no seals, and no sea-lions. [Jenness 1955:10]

Early postglacial evidence of molluscs is widespread in deposits at elevations correlating with the relative sea level at various times during the late Pleistocene (Draycot 1951; Hutchinson 1992; Hebbda and Frederick 1990; Mathews et al. 1970). In fact, such deposits were noted by early geologists in this region (Lamplugh 1886), and dates from shells recovered at such raised locations are an important part of relative sea level constructions (Hutchinson et al. 2004:190; James et al. 2002). Wagner (1959), for example, recorded over 110 sites containing over 70 species of molluscs, recovered from raised late Pleistocene deposits in southwestern B.C. at elevations of up to 155 m. All of these species, with one exception, are still found in Northwest coast waters today (Wagner 1959:5). Further, water temperatures and therefore mollusc species composition in southwestern B.C. have been shown to be largely unchanged across the late Pleistocene and Holocene periods (Dyke 1996:151).

While marine conditions remained stable (Guilbault et al. 2003), the late Pleistocene and early Holocene were marked by rapid changes in terrestrial vegetation, fauna, and climate. Palynological data from lakes on southern Vancouver Island indicate that areas above 900 m may not have been glaciated during the last glacial advance since evidence for plants such as grasses and ferns, and pine and alder is present before 14,680 BP. After this date spruce and hemlock trees also became established (Brown and Hebda 2003). Dates on lake sediments from the Pitt Valley vicinity and other locations along the southern British Columbia mainland coast also show that at least parts of the surrounding topography were vegetated before 12,600 BP (Mathews et al. 1970:691) and that tundra-like vegetation existed briefly,
followed by lodgepole pine, spruce, true fir, alder and willow, indicating cold, dry continental conditions (Mathewes and Heusser 1981; Pellatt et al. 2001, 2002; Souch 1989). By 10,000 BP nearly modern forest vegetation was widespread, as evidenced by Douglas fir logs of more than 4 m circumference recovered from Heal Lake near Victoria, British Columbia (Hebda 1996:291).

Remains of larger mammals also have been recorded from the Northern Olympic peninsula (caribou, mastodon and bison, ca. 11,000 to 10,000 BP), near Seattle (giant sloth ca. 12,700 BP), Bowen Island (Steller’s sea lion ca. 12,500 BP), and Courtenay on Vancouver Island (Steller’s sea lion ca. 12,600 BP) (Gustafson et al. 1979; Harington 1996; Harington et al. 2004; Peterson et al. 1983). Fish bones recovered from the Courtenay locality also show that cod, walleye pollock, and to a lesser degree salmon, were present at 12,500 BP (Harington 1996:267).

Of particular interest are the various bison remains found on Orcas Island, as well as on southern Vancouver Island, dating to ca. 11,750 BP (Harington 1996:264; Mackie 1987; Wilson et al. 2003; Wilson et al. in prep.1 and 2). Orcas Island, situated halfway between southern Vancouver Island and the mainland coast of Washington State, has yielded eight individual bison remains from five sites, generally found at the base of peat deposits overlying glaciomarine, shell-rich clay deposits. The most recent remains of four individuals (three adults and one calf) from Ayer Pond were found below as much as 10 meters of overburden, again illustrating the deep burial of late Pleistocene land-surfaces (Wilson et al. in prep. 2:4-5). Those bison, together with the Vancouver Island specimens, likely arrived from the mainland Washington coast at around 12,000 BP, across a variably emergent dispersal corridor of an as yet unknown extent, vegetated by an open herb and shrub plant community (Wilson et al. in prep. 2:15-16). An additional possibility for dispersal of these late Pleistocene mammals may also exist, originating from emergent coastal shelf areas west of Vancouver Island. Such coastal plains may have supported animal communities that arrived from the mainland at an earlier pre-18,000 BP date (Mathews 1979:146).
5.3 Cultural Adaptations

5.3.1 Introduction - Potential Late Pleistocene Cultures on the South-West Coast of British Columbia

Despite decades of archaeological research and extensive development in urban centres on the southwest coast of British Columbia, no pre-10,000-year-old sites have yet been discovered. Several hypotheses could explain this absence of evidence for a late Pleistocene occupation of this area. They could include the effects of paleoenvironmental constraints, such as relative sea levels, but also a lack of surveys and non-recognition of relevant artifacts by untrained workers. The paleoenvironmental effects of late Pleistocene paraglacial activity, such as the deep burial of sites or erosive forces of glacial-lake outburst floods have been discussed earlier in this thesis but other hypotheses need examination.

For example, while modern lake, river and ocean shorelines have been locally researched in some detail, the limited extent of archaeological surveys and lack of major excavations at more inaccessible and removed locations, such as raised landforms on forested slopes, may be responsible for such a lack of evidence. Wilson and Burns (1999) stated:

Archaeological studies require time, people, and money and none of these has been in good supply in the area until the past two or three decades. Funding is again being cut dramatically as a result of government budget-cutting .......... Much of the effort directed toward environmental-impact studies and salvage archaeology has dealt with more readily visible sites of the middle and late Prehistoric periods, and fewer programs of deep testing have been undertaken to locate deeply buried resources, needles in the proverbial haystack. [Wilson and Burns 1999:222]

On the outer coast of Vancouver Island and on Haida Gwaii, and generally along the non-glaciated coasts of North and South America a drowned site hypothesis has been advocated for the lack of early sites (Dillehay and Meltzer 1991:291; Erlandson 2002; Fedje and Josenhans 2000; Tuck 1991:32). While this hypothesis, albeit based largely on negative evidence and limited in explanation to coastal sites, is widely thought to be valid (Bonnichsen and Schneider 1999:509; Erlandson 1996; Dixon 1999), it does not apply to my study area. Relative sea levels here have fallen since deglaciation and late Pleistocene coastlines are now elevated up to 150 meters.
above contemporary sea level, according to sea level curves for the Lower Mainland and Sunshine coast of British Columbia, the southern and eastern coast of Vancouver Island, and the Gulf Islands, respectively.

Another hypothesis accounting for the lack of early archaeological sites in southwestern British Columbia could involve the fact that the environment did not have the carrying capacity to support an archaeologically significant population until sea level and landscape stabilized. The available paleoenvironmental data for the region neither validate nor reject this hypothesis. However, the similarities between the reconstructed paleoenvironment of the area and other recently deglaciated coastal areas in North America, such as the Maritime Provinces of Canada, New England or the Haida Gwaii Islands in British Columbia, where there is significant evidence for a late Pleistocene occupation, suggests that this is not a factor. Instead, I would argue that the paleoenvironment of southwestern British Columbia was much better suited for general hunter-gatherer groups than many other regions with reported late Pleistocene occupations. The number and distribution of surface artifacts found during previous research in the region and reported in the present study further support this.

If the exploitation of maritime or intertidal resources, such as collecting of shellfish and catching various fish species combined with bird hunting, as reported for other areas of the west coast of the Americas (Butler and O'Connor 2004; De France et al. 2001; Fedje 2003; Fedje et al. 2005b; Keefer 1998; Sandweiss et al. 1999) were important in early local settlement and subsistence strategies, then changes in the regional climate (e.g. the Younger Dryas), would not have affected their availability as much as they would have terrestrial resources. A recent hypothesis about the movement of migratory bird populations into newly deglaciated landscapes would also apply to this region, as lakes and marsh environments were widely available (Dincauze and Jacobson 2001; Fiedel 2000a, 2000b). In addition, the geographical setting of the study area also includes marine fjords, upland lakes, and coastal mountain habitat further diversifying resource availability.

Suggestions that Late Pleistocene environmental conditions led to a general impoverishment of biotic resources are not supported in the available literature for such coastal settings. While it is true that many resources may have been reduced in certain local settings, such as sediment-laden rivers draining still glaciated valleys, other
environments such as upland lakes, smaller coastal rivers, or marsh areas may have been productive at the same time.

The existence of largely deglaciated and forested coastlines, with associated tributary rivers, bays and tidal flats by ca. 12,500 BP, certainly produced a food supply capable of supporting at least small human groups (Hetherington and Reid 2003). The literature concerning the early history and development of the Fraser River and its delta, however, still is rather slim, and does not yet address what resources might have been available, in sufficient detail.

Another hypothesis for a lack of currently known Late Pleistocene sites in this area could involve geomorphological indications that river systems were then not able to support critical resources, especially anadromous fish species. The development of river systems since deglaciation was affected by a variety of factors, such as isostatic rebound, changes in eustatic sea level, lake formation and collapse, floods, and sedimentation, among others. However, generalizations, such as sediment-laden water or waterfalls resulting from rapid sea level change, making all rivers unsuitable to certain fish species, are problematic. Due to the scale and complexity of landscape change during the period of deglaciation, these kinds of statements can only be applied for specific tributaries where evidence of these processes can be demonstrated. Although that hypothesis may certainly hold true for some, especially the large, river systems in the Coast Mountains, it does likely not hold true for the majority. Understanding the geomorphologic histories of individual river systems is in my opinion of great importance to finding any potential early sites in this region.

As paleoenvironmental and geomorphological evidence cannot be used exclusively to prove or disprove the existence of a pre-Holocene human presence, the distribution of artifacts from various near coastal sites will be used to address the potential for the existence of late Pleistocene cultural sites along southwestern British Columbia's coast.

5.3.2 Lithic Evidence and Settlement Patterns

Surface finds reported from the Fraser lowlands and terraces around Birch Bay in Washington State, and seemingly early type artifacts from the Coquitlam valley and the Lower Stave Lake area in British Columbia are located on river systems, embayments, or former islands that surround the paleo-bay of the Fraser River
(Grabert 1979:168; Kidd 1969). Most of these assemblages are not associated with evidence for habitation or any other features indicating social or economic patterns. The lack of any organic materials also hinders accurate dating. These facts led Kidd (1969:240) to theorize that this may indicate a mobile settlement pattern with small encampments that would not contain any substantial structures. The localities of such sites, however, would suggest that seasonal settlement on the south-west coast could have provided easy access to marine resources and that shifts in the terrestrial resources of the coastal mainland did not have as strong an influence on the subsistence of such a population as otherwise expected. Evidence for early inhabitants living or hunting along the lakes and rivers that surround the paleo-bay of the Fraser River therefore suggests that its biotic productivity was not debilitating. A mix of generally more unpredictable woodland with riverine and marine resources could have resulted in a relatively stable resource base. Unfortunately no securely dated sites of Late Pleistocene age have as yet been recorded, due I believe to a lack of attention to raised late Pleistocene landforms and deeply buried alluvial valley bottoms.

In light of current evidence I would suggest that any pre 10,000-year old artifact assemblages on the southwest coast of British Columbia but also along the entire Pacific coast of North America will prove to be different than generally believed in that they will consist in many instances of non-diagnostic expedient cobble tools. Diagnostic foliate leaf-shaped projectile points of an early period have been recorded in the study area (Kenady et al. 2002; Matson 1996; McLaren 2003), but many have been found as isolated surface finds away from stratified archaeological sites. On the other hand many sites of a potentially early Holocene age such as the South Yale, Birch Bay, and McCallum sites contain only a few foliate points but relatively large numbers of expedient pebble tools (Grabert 1979; Haley 1987, 1996; Lepofsky and Lenert 2005:97; Matson 1996). While only some of these sites are stratified and well dated and it is clear that pebble tools were employed throughout the entire Holocene, older sites appear to contain a greater percentage of these implements (Grabert 1979:172; Carlson 1990; 1996:8-9; Lepofsky and Lenert 2005:98).

I consider it possible that a local Late Pleistocene tool kit included pebble tools employed near river and ocean shores for generalized and task-specific usage and more specialized tools, featuring projectile points, for inland hunting activities (see also Grabert 1979:172 and Lepofsky and Lenert 2005:97-101). The late Pleistocene
environmental record for the study area shows that a specialized hunting adaptation was ecologically improbable in the emerging marshy lowlands, islands and bays, and that the subsistence strategy likely was more generalized. Expedient tools that could have been used and then thrown away wherever needed, would likely dominate traces left by such highly mobile foragers. In contrast, specialized hunting would have been possible in a low diversity environment such as the subalpine tundra and first forests that existed in earliest postglacial time, or later at higher elevations. This could lead to temporal changes but also to sites of similar age displaying quite different lithic and stylistic assemblages across this region.

The lithic assemblage of a late Pleistocene population passing through this area, or living in very small groups, might be very difficult to identify, with diagnostic bifaces being rare or absent, especially since no high quality lithic outcrop was available locally. Stone quarries containing economical amounts of desirable materials, such as chert, fine-grained basalt, or obsidian are not common along the coast, being generally located east of the Coast Mountains. A further problem mentioned earlier, is that natural conchoidal fracturing of pebbles and cobbles is widespread in the glacial or fluvial sediments common in the study area, often creating so called "geofacts", resembling cores, flakes, or cobble-tools (Figure 5.5). They may show multiple or overlapping flakes, as well as clear impact points and platforms (Wilson and Burns 1999:217). According to Wilson and Burns (1999) glacial deposits also are full of microdebitage, as well as macroscopically flaked specimens. Curators of Museums and Consulting Archaeologists in southwestern British Columbia have reported that over the years many crude, tool-like lithic assemblages have been brought in by laypersons. Some of these implements would clearly be considered man-made if they had been recovered in unmistaken archaeological context, but cannot be categorized as such if not associated with diagnostic lithic artifacts or other clear cultural evidence (G. Keddie, Royal British Columbia Museum, pers. comm. 1999).

In addition to these particular uncertainties about early lithic technology I believe that archaeological surveys, with some exceptions, have concentrated on landforms suitable for habitation after the landscape stabilized in the Holocene. They have neglected earlier upland locations now removed from coastal or freshwater habitat or deeply buried in alluvial sediments some distance away from current active river-channels. Curiously, the above mentioned pebble tool sites are commonly located
Figure 5.5  [a] Lithic samples from a construction site overburden - geofacts or artifacts? [b] Example of typical cobble tool assemblage at McCallum site

Photos [a] by author and [b] courtesy of Dr. Dana Lepofsky
on benches and terraces above the river and do not seem to be associated with known Holocene habitation sites. If these sites were resource extraction or processing sites, where are the settlements or campsites of these people? Again, I would argue that these, as yet unknown sites, are located on not intensively researched landforms. Such sites would include base camps for resource extraction, habitation sites and temporary campsites.

The locations of such campsites also likely varied considerably over time. While sites of Holocene age depended heavily on resource availability and seasonality, protection from the severe climate and often highly localized environmental hazards may have been more important factors for the location of late Pleistocene sites. Sites may have been chosen for freshwater availability, resource proximity and high and dry terrain to locate habitation structures. While sites further to the south or in the interior could have been located at the same spot for long time periods, sea-level changes and post-glacial paraglacial changes may have forced early coastal inhabitants to change camp very frequently, possibly every year.

It is reasonable to say that nearly all archaeological surveys and site prediction models have so far been based on mid to late Holocene Fraser River and Strait of Georgia settlement and land use patterns. In addition, surveys in heavily forested and rugged areas (Figure 5.6), where many still existing raised late Pleistocene landforms are now located, have been for the most part only preliminary and rudimentary in nature, consisting mostly of walking surveys, with few deep sediment tests or any kind of late Pleistocene landform evaluation.

5.3.3 Past and Current Research into Potential Late Pleistocene Occupation

If early inhabitants of southwestern British Columbia employed a maritime adapted, generalized hunting and foraging strategy, as other groups were using along the Pacific as well as the Atlantic coast of the Americas in the late Pleistocene, then a comparative wealth of information on site preservation and location can be reviewed in order to perhaps better understand the situation in the local study area.

As reported in Chapter 2, coastal eastern North America and the Pacific coast of South America contain several well-stratified late Pleistocene and early Holocene sites that have survived in deeply buried contexts on raised shorelines or alluvial
floodplains. It is locations along rivers with aggrading alluvium and stable river channels, and raised beach and delta terraces that serve to bury deeply, and thereby preserve, early sites. However, since late Pleistocene riverine systems were generally unstable, especially in recently deglaciated areas, the discovery and testing of suitable archaeological contexts for early sites is very difficult. In locations where such evidence was preserved, contexts included deeply stratified sites, and short-term deposits such as single occupational sites. However, again, identification of such site types would normally be very difficult, demanding exceptionally deep excavation and close interval testing (Petersen and Putnam 1992:23). A sampling program would have to be designed to look at specific places where stratified alluvium could be expected to have
preserved potential former living surfaces. While aggraded river floodplains in the study area may have such potential, raised postglacial landforms are generally much smaller and therefore more economical to test. However, not many such locations have been recorded and none have so far been tested to examine archaeological potential. While raised deltaic exposures and wave-cut terraces have been reported in many geological reports (Armstrong 1981; Mathews 1970; Wagner 1959), the only such locality identified in a recent archaeological report are beach ridges located 3 to 10 meters above sea level that are estimated to have formed at 11,000 BP. No archaeological testing has as yet been conducted. The site is located on the Point Roberts / Tsawwassen peninsula, which was an offshore island until about 2500 years ago when it was joined to the mainland by the advancing Fraser river delta (Brolly et al. 1999).

The information potential of sites with deeply buried contexts reviewed in this thesis has many implications. Without exception, sites that have yielded artifacts of a potential late Pleistocene type in my research area, are not from deeply buried contexts, or have been exposed by anthropogenic factors. In most cases they were surface collected from farmers’ fields or beaches, or are from hydroelectric reservoir lake deposits, where seasonal water lowering has caused exposure of lithic artifacts. While they have consequently no preserved strata, the resulting deflated lag artifact clusters still can give us important insights into the potential of finding buried, stratified sites in similar river valley locations nearby.

The Stave Valley survey and excavation project (see Figure 4.2), for example, identified more than 50 sites and more than 2000 artifacts exposed by the deflation of up to one metre of soil, fine silt, and sand by reservoir changes (Eldridge 1998; McLaren and Owens; McLaren et al. 1998, 1997; Ryder 1998). According to McLaren (2003) the distribution of these artifacts provides a rare insight into human activities over a portion of the landscape away from known major habitation and activity areas. Projectile point typology shows that the earliest materials resemble Inter-Montane stemmed Point and Plano Tradition points dated between 11,000 to 9,000 BP. Other artifacts are representative of the Old Cordilleran Tradition, which is generally considered the oldest lithic tradition in the study area (McLaren 2003). Direct radiocarbon dates were acquired from cultural deposits at a depth of 1 m below the eroded deflated land surface and indicate that these sites date back to at least 9270 BP (McLaren 2005:18).
Another similar research locality is the Coquitlam Valley due east of the Pitt and Stave Valleys. There, several deflated sites have been found along the shores of the Coquitlam Reservoir, in a geomorphic context suggesting great antiquity (Wright 1996:205; McLaren 2003). Wright suggested that those upland areas were not only the first to become ice-free but also would have been unaffected by sea-level fluctuations, thereby possibly playing a significant role in subsistence patterns during early human settlement. They also would be elevated enough to be unaffected by late Pleistocene catastrophic floods hypothesized for the Fraser River valley.

The recovery of so many possible (but so far unproven) early sites in these two relatively small upland tributary valley areas, compared to neighbouring valleys with few or no archaeological sites, clearly shows that many such sites exist in locations not usually tested, or are unlikely to be found during conventional survey and testing. It has been noted that almost all intensive archaeological work in the area has been conducted on the banks of the modern Fraser River, or on shell-midden sites on the coastline of the Strait of Georgia, where such early sites would not occur. McLaren (2003) also stated that prior to commencement of surveys in the Stave Lake reservoir it was predicted that no significant archaeological sites should be expected. The lack of data from neighbouring valleys therefore is again likely one of visibility, or lack of study, rather than of non-existence of sites.

In sum, it is deeply buried sites still awaiting discovery, that hold the key to a better understanding of the early archaeological record of the southwest coast of British Columbia. Favourable contexts for the preservation of late Pleistocene sites may be located using combined methods from archaeology, geology, and remote sensing.

5.3.4 Early Holocene Cultures of the Strait of Georgia, Fraser River Valley Region

Human groups have occupied the southwest coast of British Columbia continuously for over 9000 years at the least. While Clovis points have been reported on Whidbey Island and near Bellingham and the Seattle area (Carlson 1990; Meltzer and Dunnell 1987), the earliest securely dated evidence of human occupation pertains to people variously labelled Proto-Western tradition, Old Cordilleran culture, the Pebble Tool tradition, Southwestern Coastal culture, or the Olcott complex in Washington...
State (Butler 1961; Carlson 1983, 1990; Fladmark 1982; Wright 1995). Artifacts commonly found in sites associated with this tradition include unifacial cobble choppers and large flake tools, leaf-shaped bifaces and projectile points, and a variety of other cobble tools.

The Old Cordilleran tradition is centered on the north-western Washington (Birch Bay, Olcott, and Manis) and southwestern British Columbia (Glenrose and Milliken) coasts, but is believed to range from the Oregon coast in the south to the Bear Cove site on northern Vancouver Island. However, the earliest pre-microblade sites reported from southern Alaska, Haida Gwaii on the northern coast, and Namu on the central coast of British Columbia, display great similarities and are likely part of the same late Pleistocene culture. While these northern sites, excavated in the seventies, contained artifacts resembling those on the southern coast (Fladmark 1979; Hobler 1978) but lacking diagnostic projectile points, new excavations have produced leaf-shaped points dating to between 10,900 BP and 10,400 BP (Fedje 2005). If future research is successful in showing even greater time depth for this tradition, it could be directly associated with the earliest migrants not only of the Northwest Pacific but also the late Pleistocene populations further to the south along the entire Pacific coast.

Unfortunately most of the Old Cordilleran sites in northern Washington State are not securely dated. The Manis Mastodon site, near Sequim, is a peat-covered glacial pond basin that has produced a wide variety of lithic and faunal remains (Gustafson et al. 1979; Peterson et al. 1983). However, while younger levels at this site have clear cultural associations, diagnostic artifacts were absent in the earliest levels bearing mastodon and bison bones dated to ca. 12,000 BP. Of interest was the recovery of a bone fragment embedded in a mastodon rib that has been interpreted by some researchers as a bone-point tip. However, it can also be explained as a bone fragment emplaced by natural forces. The Destaffany site on San Juan Island, buried in loess, and containing both lanceolate Olcott and Western Stemmed points, could also represent a late Pleistocene site (Kenady et al. 2002).

The oldest securely dated sites near my local study area are the Glenrose Cannery and Milliken sites, in addition to the newly excavated site at Stave Lake, described above. Glenrose was first settled around 8,200 BP when sea levels were up to 10 meters lower than today. The rapidly growing Fraser River floodplain filled the narrow gap between the New Westminster and Surrey uplands prior to 10,000 BP with
tidal flats existing at 10,000 BP and by 9000 BP a subaerial delta was present at the site (Clague et al. 1983:1323). Therefore, the site was at the marine-freshwater interface, ideally suited to take advantage of both marine and riverine resources. This could also explain why the site does not extend further into the past, as the location would not have had these advantages previously. A similar environmental setting around 10,000 to 10,500 BP would be located ca. 30km upriver in the vicinity of Pitt Meadows and Maple Ridge.

At the lowest levels of Glenrose, Old Cordilleran style pebble tools and simple flaked stone leaf-shaped knives and projectile points were found (Matson 1976, 1996). They are similar to those found at the Milliken site near Yale at 9,000 BP and at the Bear Cove site on northern Vancouver Island at 8,000 BP. At Glenrose and the Bear Cove site, faunal and floral remains suggest exploitation of varied locally available resources. While the Bear Cove site contained high frequencies of maritime species, such as dolphin, porpoise, and sea lion (Carlson C.C. 1979), the Milliken site in the Fraser River Canyon, lacking faunal preservation, was interpreted to be a salmon fishing camp due to its location and presence of floral indicators for late summer / fall seasonality (Carlson 1990, 1998:27; Mitchell and Pokotylo 1996). Most of the other early sites in the region are situated at places where fish or sea mammals could be taken, however as mentioned above, the majority are resource extraction sites on relatively exposed localities, not associated with living surfaces. The early component of the Milliken site needs special mention because it was deeply buried and separated from succeeding cultural layers by a thick layer of alluvial-fan gravel, and could have been easily missed if the excavation had stopped at the gravel layer. In addition, the early components of the Glenrose, Bear Cove and Milliken sites would likely have never been discovered if excavation had not been initiated at those locations because of overlying late Holocene cultural deposits.

Despite extensive site surveys along modern shorelines and riverbanks, archaeologists have been unable to locate any other sites of similar or greater antiquity than those summarized above. Especially troublesome is the lack of sites with clear evidence of either short or long-term habitation structures. Again, this is likely due to site locations removed from modern shorelines and riverbanks and the low visibility of simple cobble tools, especially for the untrained person.
5.3.5 Integrating Archaeological and Sea Level Data

This section discusses the value of models of sea level history for southern coastal British Columbia, and argues for the integration of sea level history with archaeological surveys. Each local sea level model could provide a geological/environmental framework for known archaeological data, and could have different implications for the design of archaeological site surveys.

Again, postglacial relative sea level history in this area is complex, resulting from locally different isostatic crustal rebound due to ice unloading and crustal subsidence due to migration and collapse of a forebulge associated with the Cordilleran Ice Sheet and, to a lesser extent, local ice caps. Therefore, models of sea level change for western Vancouver Island, the Strait of Georgia, the Sunshine coast and the Fraser River basin differ widely. Based primarily on radiocarbon-dated shells and organic materials from beach deposits or lake cores, generally the outer coast displays a more or less continuously rising sea level to the present, whereas in more inland localities, sea level falls below present level between ca. 10000 and 8000 BP and subsequently rises. Again, this suggests that late Pleistocene sites on the mainland and the Strait of Georgia could be located from several meters below to approximately 150 m above current sea level. Similarly, any early sites on Vancouver Island's west coast would now be submerged below present sea level. This model should be substantiated through further research, and future surveys should include a focus on potentially favourable sites close to past sea level.

The age distribution of known prehistoric sites in the Lower Mainland, reveals a marked gap of sites contemporaneous with or older that the Glenrose Cannery site. To address the environmental/cultural significance of this absence of sites, it is critical to establish where representative sites should be located. The initial dates for the Glenrose site coincide with the lowering of the relative sea level to that locality. It also represents the end of large-scale sea level change for this part of the coast. Judging by the location of their settlement directly at the mouth of the Fraser River, the inhabitants of this site did not only take advantage of the riverine environment, but also used maritime resources. Their ancestors were also likely marine/estuarine oriented and occupied sites within easy access of the sea. Understanding the relative position of the sea level and associated landforms at different times of occupation, therefore, is of critical importance in directing archaeological site surveys.
CHAPTER 6: FIELDWORK

6.1 Introduction

Over the last several decades Quaternary scientists have made significant strides in understanding global and regional late Pleistocene glaciation, paleoenvironment, sea level fluctuations, and linkages between these mechanisms. While this research provides an essential context for understanding first human colonization, more local, specific research is needed to actually locate archaeological sites of this period.

In particular, local late Pleistocene / early Holocene landforms need to be found and recorded, and properties such as drainage and proximity to freshwater and food resources assessed. Size and location of potential archaeological sites probably varied considerably, depending on resources and season. Campsite locations likely were chosen primarily because of the availability of water and other resources, and in wet areas, on high and dry terrain. These factors and the geology of landforms supporting or inhibiting preservation and discovery need to be further analysed. To test the viability of finding and being able to make basic assumptions about such late glacial landforms, fieldwork was conducted in the Pitt River watershed, for reasons reiterated in the first chapter of this thesis.

6.2 Location and Physiography of Study Area

The Pitt River watershed, originating at Mount Garibaldi at over 2500 m asl and terminating at ca. 3 m asl at the Fraser River, involves a typical U-shaped glacial valley, 30 km east of Vancouver. Over-deepening of the lower end of the valley over the span of the Wisconsinan glaciation created a trough over 140 m below current sea level. Sometime after initial glacial retreat starting at 13,000 BP, a glaciomarine fjord occupied this basin when relative sea levels were still ca. 120 to 140m asl in the region.
Unlike neighbouring Indian Arm and Howe Sound, this fjord basin became cut off by the sedimentation of the lower Fraser River ca. 10,500 BP forming what is now a tidal fjord lake, ca. 25 km long and up to 4 km wide (Clague et al. 1983:1323).

Inland, beyond the lake, the Upper Pitt River valley features two bedrock canyons, one ca. 17 km and the other 21 km upvalley, with the second containing a hot spring (Figure 6.6 and 6.8). Sediments of the Upper Pitt River drainage are stored within the lake basin and do not contribute to the lower Pitt River floodplain in a significant manner.
The lower Pitt River is relatively short (ca. 18 km) and drains across a broad alluvial floodplain built up generally by thick fine textured fluvial sediments, deposited above glaciomarine and glaciofluvial sediments. At least the upper 10 meters of sediments generally originated from the Fraser River, which at its confluence with the Pitt River is only 25 km away from the Strait of Georgia. Spring flooding was a frequent occurrence before the advent of river dyking. In addition, due to the low elevation and proximity to the sea, tidal currents extend all the way to Pitt Lake and seasonally deposit Fraser River sediments at its mouth. Two tributary rivers, the Alouette River to the east and Widgeon Creek to the west, also cross the lower Pitt River floodplain and contribute minor amounts of sediments. For a more detailed description of the geology of the area see Roddick (1965).

### 6.3 Methods

Research commenced with air-photo and topographic and digital map analysis in order to define locations with potential glaciogenic landforms. Fieldwork was
undertaken during a total of four weeks in April and June 2004 and additional short visits were made to the Pitt valley area in 2005. A surface walking survey was conducted along the main floodplain of the mid Upper Pitt River, mainly exploring exposures along tributary creeks and rivers.

During road reconnaissance in the upper Pitt River valley lithological investigations were carried out on natural and artificial exposures, such as road cuts and gravel pits, so that variations in stratigraphy, both vertically and horizontally, could be identified and recorded. Fortunately, numerous exposures were found, but there were also many situations where it was impossible to observe potentially interesting landforms clearly. To excavate such landforms or to expand small existing exposures was not possible due to problems of time, expense, sediment thickness or the likelihood of waterlogging in proximity to lakes or the floodplain. In addition, an archaeological permit was not obtained for the purpose of this study. If more time and resources were available, additional locations could be tested and information retrieved by excavation, coring or other techniques such as remote sensing. A considerable amount of paleoenvironmental information could be obtained from peat bog and lake sediments using hand-operated coring devices.

All fieldwork by the author, discussed here, is considered of a preliminary observational nature. Results and conclusions must be verified by experts in the geological or geomorphological fields, in order to be considered valid.

6.4 Previous Work

As discussed, many raised deposits of mollusks have been found at various elevations around the study area (Draycot 1951; Wagner 1959). Unfortunately most discoveries have not been dated or were made prior to radiocarbon dating and therefore have not contributed to a refinement of the local sealevel curves. Locations of these shell deposits are generally recorded, and parts of them may in some cases still exist. Such areas could be of interest not only for their paleoecological and sea level information but also as indicators of late Pleistocene shorelines, suitable for habitation, nearby.

Deep floodplain excavations in the area are uncommon, as development tends to stay above elevations prone to flooding. However, pipelines and pillars for bridges often require deep foundations and rare information could be obtained by monitoring
such deep excavations. Katzie First Nation archaeologists, for example, are monitoring the Golden Ears Bridge currently under construction between Maple Ridge and Surrey and samples of deep sediments are being collected.

Paraglacial sedimentation during and after the retreat of Late Pleistocene glaciers has been investigated in several of the deep inland fjord lakes paralleling Pitt Lake north of the lower Fraser River floodplain. Thus, neighbouring Stave Lake, artificially raised ca. 10 meters to 81 m asl and ca. 110 m deep, is in many ways similar to Pitt Lake. While having the same glacial origin, its higher elevation, however, resulted in likely only a brief marine inundation before marine limit fell below that elevation. Seismostratigraphically acquired data revealed a sequence of stratified units interpreted as rapid glaciolacustrine sedimentation, overlain by a sediment unit up to 28 m thick reflecting paraglacial fluvial sedimentation (Gilbert and Desloges 1992). This suggests very rapid sedimentation during glacial retreat, and continued substantial sediment accumulation through paraglacial reworked glaciogenic sediment influx in the early Holocene. Such studies, however, lack deep borehole records that would confirm interpretation of the seismostratigraphic record and inferred rapidity of glaciolacustrine sedimentation.

Pitt Lake likely experienced extensive glaciomarine sedimentation during initial ice retreat, resulting in additional thick glaciomarine deposition. Otherwise sedimentation may be expected to have been similar to Stave Lake, with the exception of fine silt and clay influx at the mouth of the lake caused by tidal reversed flow into the lake.

Identified glacial landforms in the study area are limited and include a terminal moraine ridge situated between Miracle Valley on the southern end of Stave Lake and Hatzic Prairie and Lake, an oxbow lake of the Fraser River. This moraine may have been deposited during the last advance of the Fraser Glaciation, the Sumas readvance, and likely blocked the original floodplain of the Stave watershed, which then found a new outlet at the present location. Deltaic and possibly beach deposits as well as a glacial outwash terrace were found near Maple Ridge and have been previously described (Tribe and Grimm 2000).

Cave sites are not common in the study area, due to the nature of generally igneous rock formations. Some rockshelters however, do exist in the area, potentially containing late Pleistocene sediments, trapping faunal and cultural materials. At least
one such rockshelter known to the author, at ca. 60 m asl, has been recently destroyed by a housing development on Sumas Mountain, near the study area. An archaeologist working for the Sto:lo Nation was denied access by the landowner / developer for the purpose of inspecting the cave / rock shelter prior to its slated destruction (Schaepe pers. comm. 2006).

Archaeological investigations in the study area have not resulted in any sites dating prior to the mid Holocene, however, the previously discussed Glenrose site is located nearby. For an overview and description of archaeological sites and work conducted in the study area see Spurgeon (2001).

6.5 Results

6.5.1 Lower Pitt River

As explained earlier, the area around the lower Pitt River floodplain was the location of a paleo-embayment between ca. 12,500 BP and 11,500 BP. This glacial bay consisted of various, likely vegetated, islands and upland areas surrounded by fjords and valleys still occupied by late Pleistocene glaciers. Large amounts of glaciomarine sediments were likely deposited at this location during a time when relative sea levels were up to 150 m asl, but rapidly falling. Potential landforms forming at this time would have included steep marine deltas fed by small tributary rivers that formed rapidly and therefore may be the only evidence of short-lived high sea level positions. Clearly developed beach platforms only formed whenever sea level change slowed enough to allow for multi-year development and are therefore likely very small or not present at this time. Such a slowdown, however, occurred between 12,000 and 11,500 BP when sea level fell only by about 20 m from ca. 80 to 60 m asl (James et al. 2002:4), theoretically allowing for larger beach development.

After sea level fell to between 20 to 30 m asl at ca. 11,000 BP glaciofluvial sediments resulting from the drainage of a young Fraser River would have entered this bay, cutting off the existing marine fjord and converting it into Pitt Lake. Remnants of terraces occur east of Pitt Meadows, marking an outwash train that was formed at that time (Clague et al. 1983:1322). An estuary / mudflat likely existed shortly thereafter, until Fraser River sediments filled the narrow gap between New Westminster and Surrey downstream from this bay and started to build a delta into the Strait of Georgia.
at around 10,000 BP. A review of earlier research, and excursions into the lower Pitt River area, did not indicate any obvious raised beach or delta deposits aside from a large glaciomarine delta/alluvial fan that developed subaerially at the head of the Coquitlam River Valley very early in the late Pleistocene. Mollusc exposures, including one at ca. 16 m asl in Pitt Meadows, however, have been reported from various locations, indicating possible shoreline features (Wagner 1959).

Other potential landforms such as a delta or estuary mudflats and beaches of the paleo Fraser River, are now likely buried in the floodplain and largely removed from research due to a fall of sea levels to minus 12 meters asl between 10,000 and 7000 BP. An earlier mentioned layer of peat dated between 8360 and 7300 BP, for example, is now buried under 11.5 meters of floodplain silts and sand in the Pitt Meadows area and likely overlies other land surfaces of the early Fraser River (Clague et al. 1983:1321-1323). The Fraser and Pitt Rivers are not actively eroding into these deposits since sea levels rose between 7000 and 5000 BP and large amounts of sand and silts are seasonally derived and deposited from upriver locations. These factors led to aggradation of the floodplain prior to large-scale dyking.

While finding sites in this buried alluvial floodplain is, as discussed earlier, extremely difficult, raised shoreline cultural deposits could still be in existence around this paleo-bay, in locations such as the Maple Ridge, Surrey, White Rock, Coquitlam, Burnaby and Tsawwassen uplands, which emerged from the sea at ca. 12,000 BP and were likely vegetated soon after. Several sets of benches clearly visible along the south side of the Surrey uplands could represent development of beaches during a stillstand or slowdown of sea level adjustment. However, these areas are currently under heavy residential housing development and any potential sites will likely be destroyed if excavation is not monitored.

In addition, creeks currently draining these upland areas have in places eroded deeply into glaciogenic sediments, and exposures of glaciofluvial as well as thick silt and occasional clay layers have been observed by the author around Coquitlam and Surrey. The ravine behind the Glenrose Cannery site, for example, contains several exposures of thick silt and clay deposits at ca. 15 to 30 m above river level (with some having associated illegal excavation [pothunter's] pits) and could date to around 11,000 BP. Another such creek locality exists in Coquitlam at the head of Miller ravine at ca. 110 m asl. There, lithic materials were found by the author in the overburden of a
housing development. The houses did not feature basements and therefore the sediments excavated consisted only of organic soils, silts and sands, as the glacial gravels common in this area were not penetrated. A surficial geology map by Armstrong and Hicock (1980) indicates that the area contains raised beach sediments, which may account for the sands. All lithics present in these silts and sands exhibited some kind of fracturing of unknown origin (Figure 6.3). While the lithic material is likely not cultural, it does illustrate what a potential small late Pleistocene site could look like, and the challenge faced in identifying an expedient tool assemblage.

Such upland post-glacial land surfaces should be consistently monitored as they hold potential for the discovery of late Pleistocene cultural deposits. While housing developments can destroy archaeological sites, they also provide new exposures, and deeply buried late Pleistocene sites may be found (Wilson 1983; Wilson and Hardy 1987:131). Bonnichsen et al. (1991:6), for example, reported that Paleoindian sites on the north-eastern Atlantic coast occur frequently on well-drained marine deltaic or lacustrine sediments along lake, river, pond, or bog edges.

Figure 6.3 Lithic material from a residential construction site at Miller Creek, Coquitlam: artifact or geofact?

Photos by author [taken in field]
6.5.2 Pitt Lake

The steep mountains framing Pitt Lake and the lower parts of the Upper Pitt River are characterized by a glacially eroded bedrock terrain and appear to be largely composed of granodiorite and diorite and do not readily weather (Figure 6.1).

Figure 6.4 Pitt Lake east shore with tributary valley at Vickers Creek

Photo by author

However, the steep cliffs are modified by mass-wasting events, such as avalanches, rock falls or debris flows, likely caused by water saturation and frost action but also triggered by seismic activity. Talus and slide debris mark the break in slope in many locations. Sheets of till cover lower elevation slopes between bedrock outcrops and where observed, average up to 1 m thick. Debris flows, slides, and fluvial activity have reworked and concentrated some of these glacial sediments into debris cones and alluvial fans along the small tributary creeks entering the lake (Figure 6.4). The creeks incise such till and rock debris, as well as bedrock at various locations. Site frequency along these generally steeply dipping shorelines can be expected to be low and likely occur where tributary streams have produced low lying fans.
6.5.3 Upper Pitt River Valley

Following the last stage of the Fraser Glaciation, glaciofluvial and paraglacial modifications immediately started to take place in the valley. Discharge of large volumes of meltwater from the margins of the valley glacier, especially during periods of glacial retreat, resulted in the transportation and deposition of glaciofluvial sediments giving rise to flat valley-trains or outwash braidplains. Postglacial incision, however, produced several bedrock canyons and terraces in the central Upper Pitt River (Figures 6.6; 6.7; and 6.8), reflecting modification of glacial and glaciofluvial sediments in adjustment to local changes in base-level or sediment supply.

Today, the Upper Pitt Valley presents itself as a flat, broad alluvial plain filling the valley bottom between steep bedrock valley sides (Figure 6.2 and 6.5). The valley fill is assumed to be predominantly of glaciofluvial material, and is due to continued large sediment supply, only being occasionally incised. Such infilling of valley floors with fluvioglacial deposits was significant during the terminal period of the Fraser

Figure 6.5 Upper Pitt River floodplain – View upvalley towards Northwest

Photo by author

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Glaciation and tends to accentuate the U-shaped cross-sectional profile of glaciated valleys in the Coast Mountains. No erosion seems to have occurred in the lower valley section and alluvial aggradation is likely still occurring (Figure 6.5). Holocene river base-level has been dependant on water levels of Pitt Lake, which have likely risen slowly since early Holocene times due to the buildup of sediments by the Fraser River floodplain at its mouth.

Figure 6.6  Upper Pitt River topography: Second Canyon with hot springs [Iain McKechnie in photograph]

Photo by author

Only a few terrace benches were observed during fieldwork and all seem to be composed of valley-fill sediments backing directly onto steep, often bedrock, valley
walls (Figure 6.7). In sections where such terraces exist on both sides of the valley, they seem to be of the same elevation, although no exact measurements have been taken. Because of these observations they are likely outwash terraces and present nearly the original land surface left by the postglacial outwash plain. Whether downcutting in this river section is due to a lower base-level during marine regression in the late Pleistocene, the presence of a glacial lake in the valley, or bedrock topography cannot be determined with available data and observations. Study of different gradients of available outwash terraces could yield information of former sea level or lake positions.

Figure 6.7 Surface of glacial outwash terrace, below Second Canyon - Pitt River beyond line of trees on horizon. [See map Fig. 6.8]

Photo by author

While such glacial outwash terraces in mountainous terrain seem unlikely places to expect early cultural material, studies in similar settings in eastern North America suggest otherwise. The Vail site, in Maine, near the US / Canadian boundary for example, dated to between 11,100 and 10,300 BP, is located on an elevated glacial outwash plain bounded by steep ledges, at the margins of an intermontane valley. While
it was associated with an ancient stream channel, the site is now almost a kilometer away from the current river channel (Bonnichsen et al. 1991:12).

Only a few small mounds or ridges of exposed or assumed glacial or glaciofluvial landforms, possibly representing remnants of kames, were observed during the walking survey along the valley bottom. This is likely due to the fact that in mountainous areas like the Upper Pitt River valley it is unlikely that such glacial features would survive deglaciation and paraglacial processes. Kames are formed of subangular to rounded sediments accumulated in subglacial, englacial, supraglacial, and ice-marginal bodies of water and have a mound-like form resulting from the removal of adjacent supporting ice. Such deposits are variably sorted and may be somewhat difficult to identify. The kettle holes represent depressions left by isolated blocks of stagnant glacier ice, against which the sediments accumulated. When the ice melted at a later time these depressions often were filled by water, creating kettle lakes. The location of landforms such as moraines, kettle deposits, or drumlins on the floodplain floor exposes them to the considerable power of proglacial meltwater streams that can easily destroy and redeposit associated sediments. For a general description of glacial processes, sediments and landforms see Bennett and Glasser (1996); Benn and Evans (1998); Benn et al. (2003); Church and Gilbert (1975); Fitzgerald and Rosen (1987); and Price (1973).

Glaciofluvial deposits that commonly survive deglaciation are deltaic deposits associated with higher sea levels or ice-dammed lakes. During the late Pleistocene huge amounts of glacial debris were transported by swollen meltwater streams to glacial lakes and marine bodies causing rapid deposition along newly forming delta fronts. Classic deltaic deposits are composed of thick, steeply dipping, coarse foreset beds (foreset) that grade into finer-grained, thinner-bedded bottomsets and eventually into flat lake-bottom sediments. As delta fronts continuously prograde, glaciofluvial materials form gently sloping topset beds (topsets), which are deposited across the tops of foresets. The tops of foreset beds generally indicate the sea or lake level at the time of deposition.

If, during the time-frame of 10,500 to 9,000 BP, when sea levels in the Fraser River lowlands were between +10 to -10 meters asl, an ancient marine delta existed at the head of the lake, it would likely now be buried in subsequent alluvial valley-fill, similar to the deltas of the Squamish and Fraser rivers described earlier. If, on the
Figure 6.8 Locations of Features and Landforms in Upper Pitt Valley

Map by author [Produced with BC TRIM Map Data]
other hand, a late Pleistocene glacial lake existed in the valley and drained catastrophically, then a glaciolacustrine delta could have survived in the upper part of the valley. Thick incised glaciofluvial sediments in the upper Pitt Valley at an elevation of between 120 to 140 m asl and 21 km from the lake could be associated with such a feature, although no typical deltaic bedding was observed. The same area is also the location of the upper of two bedrock canyons, which potentially also could have formed due to incision after the drainage of a glacial lake. Stagnant ice isolated in the mid-section of the valley could also have broken up into several small glacial lake basins as was common during the wastage of the Cordilleran Ice Sheet (Ryder et al. 1991).

The Upper Pitt River valley also contains debris cones and alluvial fans, with the majority of their bulk likely deposited during late Pleistocene or early Holocene paraglacial events (Figure 6.9 and 6.10). These landforms increase in number along the mid- and upper reaches of the valley, likely due to a change of bedrock morphology in the adjacent mountain ranges and increase in tributary river size.

Figure 6.9  Alluvial fan deposits with various organic rich layers overlying charcoal-rich sand deposits [Norm Hageland, Mike Wilson and Iain McKechnie from left to right]

Photo by author
Another feature of the Upper Pitt River are the bedrock canyons in the lowest reaches of several large tributary creeks, such as Corbold and Boise creeks, at ca. 11 to 14 km upriver from the lake (Figure 6.11). Such erosional features are associated with hanging valleys and reflect the U-shaped characteristic of the Pitt Valley with truncated tributaries. Once the main valley-glacier retreated the base level of such tributaries changed dramatically and erosion commenced.

Just above these canyons between ca. 100 and 140 meters asl several glacifluvial deposits were observed. At Corbold Creek these deposits are of a nearly flat-topped, terrace-like form. Three exposures (Figures 6.12 and 6.13 a and b) of these sediments were examined closely and contained stratified bedding of cobbles, pebbles, and sands resembling delta deposits, although no typical foreset / topset bedding was observed (see Fig. 5.4).
If these tributary creek valleys became ice-free prior to the main valley, as was commonly the case on the Pacific Northwest coast, a significant quantity of externally derived water from rainfall and snowmelt would have been added to the glacial system of the Pitt Valley. A large amount of fluvial sands and gravels would have been carried onto the ice, possibly accumulating to form kame terraces in ice-marginal environments with stratified fluvioglacial sediments. In mountain valley locations they commonly result from deposition in meltwater streams, flowing adjacent to glacial ice along valley sides, creating flat-topped, steep-sided landforms. When glacial ice melted further, these deposits were left without support and frequently collapsed leaving behind irregular slumped bedding and a steep-sloped terrace margin. Alternatively, a kame
delta could have formed into a small lake created behind the marginal ice wall of the valley glacier and fed by the tributary stream.

**Figure 6.12** Foreset-bedded deltaic sediments on south side of Corbold Creek

![Photo by author](image)

The observed deposits are found on both the west and east sides of the tributary valley (Figure 6.16) at similar elevations indicating a delta formation, whereas kame terraces usually form a spillway on one side of a tributary valley, channelling water and sediments onto or along the glacial margin. These terraced landforms are also cut in some places by channels running in a south-westerly direction towards the main floodplain of the Pitt Valley and the sedimentology better resembles a fluvial kame delta than a kame terrace deposit (Figures 6.14 a and b).

In addition, such deltaic deposits could have formed into a marine arm extending up the Pitt Valley during ice retreat, therefore correlating to relative sea levels between 100 and 140 m above present, or alternatively into a larger glacial lake covering the main valley, blocked somewhere down-valley by an ice barrier. Thick deposits of clay in the central Upper Pitt Valley elevated between 2 and 10 m above
Figure 6.13 Exposure of foreset-bedded deltaic sediments on north side of Corbold Creek at [a] 140 m and [b] 120 m

Photos by author
Figure 6.14  [a] Detail of sediment bedding [see trowel for scale] and  
[b] Infilled channel in bedded glaciofluvial sediments  
located at exposure Figure 6.13 b

Photos by author
the current river channel and up to 6 m thick, also suggest a large body of water in which fine glacial outwash sediments settled. Whether this was a fresh or saltwater body, and its age, should be the topic of further research. Diatom analysis of the clay deposits would clarify if they were created in salt or fresh water and determine the nature of the water body present during the creation of the nearby deltaic landforms. If a larger glacial lake was present in the Pitt Valley during the late Pleistocene, we would have to assume that an ice dam existed somewhere down stream, due to the lack of any other landforms such as end moraines that could have restricted water drainage. Such an ice-dammed lake would of course be another source of a catastrophic flood, potentially obliterating parts of the early cultural record in the lower Pitt River valley and the Fraser River delta.

One alternate cause of lake damming, however, exists. The clay deposits are found just upriver from the first canyon of the Upper Pitt River. If this canyon had only developed during the early Holocene then a body of standing water could have potentially existed behind a bedrock outcrop blocking the path of the river during the late-glacial period. Such a lake, in a glacially scoured depression, and fed by glacial meltwaters of a retreating valley glacier upriver, would be big enough to trap clay particles and have them settle out as lake bottom deposits. Glaciofluvial sediments 21 km upriver from Pitt Lake could also indicate remnants of a delta entering such a freshwater lake. If such a lake existed, then downriver portions of the watercourse may have presented a better habitat for various fish species at an earlier time, as silt and clay particles settled out in the lake.

A small kettle lake and associated mounds of fluvial sediments, at ca. 180 m asl at the southwest side of Corbold Creek, indicate that a kame and kettle terrace might have formed here along the valley glacier margin. Datable material recovered at such a kame terrace could indicate the height of the valley glacier when it formed. A lacustrine deposit composed of sand rhythmites, indicative of a small proglacial lake, was also found in close proximity at 200 m asl. Rippled bedforms indicating near-shore subaqueous flows, and sediment layer displacements and deformation, indicating slumping after supporting ice was removed, suggest that this was likely a ponded body of water associated with the kettle and kame terrace. Several occasional thin clay layers indicate a pause in sediment influx (Figure 6.15 a and b).
Figure 6.15  [a] Lacustrine sediments: Deformed sand and clay layers with [b] occasional ripple marks

Photos by author
The only landform on which previous research was conducted is the Olsen Creek Delta (Figures 5.6; 6.16; & 6.17), forming a flat-topped land surface at the head of a small tributary valley running almost parallel to the Pitt River valley, ca. 11 km

Figure 6.16   Location of Deltaic Sediments in Upper Pitt Valley

Map by author [Produced with BC TRIM Map Data]
Figure 6.17  [a] Western slope of Olsen Creek Delta and [b] Glaciofluvial sediments at Olsen delta with possible foreset / topset bedding

Photos by author
upstream from the lake. This landform lies between 200 and 130 m asl and consists of glaciofluvial gravels. It has been identified as a glacio-marginal delta partly because of foreset bedding observed along exposures at the edges (Agra Engineering 1999:4). A seismic refraction survey was conducted, confirming the glaciofluvial deposits as well as an underlying layer of dense, impermeable glacial till (Frontier Geoscience 1999). Behind the delta landform two shallow lakes named Cougar Lake 1 and Cougar Lake 2 are separated by a narrow bedrock ridge and together form a saddle across which the Boise valley is located (Figure 6.16 and 6.18).

The setting suggests that delta sediments were either derived from the Boise Valley, when the ice-free tributary stream was blocked by consistent ice in the Pitt River valley below, or by an ice-marginal stream flowing along the main valley glacier and spilling across this ridge into a proglacial lake that had formed in the Olsen Creek valley and possibly in the Pitt River valley below this point. The thickness of these deposits, warranting a proposed gravel mine operation, suggests large amounts of sediments possibly derived from both the Boise valley and glacio-marginal kame deposits. The elevations of these deltaic deposits indicate a different stage of development compared to the Corbold Creek deltaic sediments almost directly across the Pitt valley. However, the small kettle lake at 180 m asl along the down-valley side of Corbold Creek could be related to the Cougar Lakes at 190 and 200 m asl as both locations seem to indicate spillways along valley sides, with remnant ice melting in situ creating the lake basins (Figure 6.16). It seems likely that this delta is associated with an ice-marginal lake and not to the marine transgression at around 12,000 BP due to the high elevation of the deposits. However, it has been stated that marine transgression in the Fraser lowlands could have been as much as 200 m asl and, combined with the possibility of increased isostatic depression in a near-glacial and mountainous location, this possibility cannot be ruled out.

Again, a locality in north-eastern North America serves as example that such raised deltas and kame terrace features could have attracted early human populations. The Paleoindian fluted point sites at Munsungun Lake in Maine are located on kame terraces adjacent to glacial spillways. Research indicates that the sites were used while meltwater streams still drained nearby stagnant ice (Bonnichsen et al. 1991:10).
6.5.4 Summary

The lack of sufficient, reliable paleo-shoreline indicators, landforms and dates and the reconnaissance nature of fieldwork to date, preclude a definitive glacial or sea-level history in the Pitt Valley. Only general statements can be made.

Paleo-deltas and land surfaces of the late Pleistocene in the lower Pitt River valley are now buried under various thicknesses of sediments. Upland areas may have been stripped of cultural deposits by large, catastrophic floods from either the Pitt or Fraser Valleys. Other known, potentially older, raised landforms at higher elevations in the vicinity have largely been removed by economic development. In the upper Pitt River valley maximum marine incursion was likely constrained by remnant valley glaciation during the period of high sea level between 12,000 and 11,000 BP. Exposures of gravels and sands, of which four have been investigated, have all been interpreted as deltaic deposits. These raised delta landforms and thick clay deposits on the valley bottom could have resulted from the existence of one or several ice-dammed glacial lakes in the upper parts of the river, during a period when stagnant valley ice
started to break up. More likely, the raised deltas may have been built into ice-marginal lakes, while the clay layers were deposited in a lake constrained behind a bedrock ridge, sometime later. The conditions during the late Pleistocene in the Upper Pitt Valley might have been similar to those observed today in northern coastal mountain areas (Clague and Evans 1994). Further research is needed to examine the above presented observations and assumptions.

### 6.5.5 Cultural Remains

Summaries of known archaeological sites in the lower Pitt Valley are provided by Arcas Consulting (1995b), Driver and Spurgeon (1998); Golder Associates (1993:10 and 15) and Spurgeon (2001). Traditional place names in the Katzie territory are recorded in Suttles (1955:16-20). Of the 93 locations only one is recorded for the upper Pitt River area at the north end of Pitt Lake. This location, a summer village (Boas 1894), was not surveyed by the author. No cultural remains are known from the Upper Pitt River valley in Borden site designation grids DjRp and DkRg, likely due to limited survey activity. Only one site, a culturally modified tree, is known from the upper Pitt Lake area, also falling within DjRp (Pokotylo 1999:11). The lower Pitt Lake area, has 9 recorded pictograph sites, some with lithic flake debitage, as well as other isolated lithic and lithic scatter sites (Fig. 6.20 a and b) (Golder Associates 1993:15 and 19; Lundy 1974). Golder Associates also report unspecified traditional hunting activities in the upper Pitt River area. Oral histories by Katzie elders mention a route from the head of Pitt Lake to Harrison Lake, and state that people from Harrison used to leave canoes at Pitt Lake (Arcas Consulting 1995a:15).

Surveys in the upper Pitt River have concentrated on forested slopes that were to be logged (Pokotylo 1998, 1999, 2000) with the exception of one survey along the mouth of Boise and Corbold Creeks (Golder Associates 1998). Survey activity by the author concentrated largely on locating earlier raised landforms and largely neglected the flood plain. Two water-worn lithic specimens found at the foot of the large terrace below the second canyon in the Upper Pitt valley, described above, display multiple flakes, as well as apparent platforms (Fig. 6.19 a and b).
Figure 6.19 [a & b] Glacially modified lithics from base of outwash terrace

Photos by author [taken in field]
However, due to the location at the base of a glacial outwash terrace they cannot be positively identified as of cultural origin. Radiating lines as observed on the larger flake suggests impact percussion while flake scars on the smaller lithic suggests pressure flaking. Pressure flaked lithic geofacts are readily found in ice-contact sediments and percussion flaking can occur in high energy streams.

On the basis of these reports, especially the recorded oral histories of Katzie elders, archaeological sites can be expected to be found in the upper Pitt River Valley at the interface of the River with the Lake (campsite and summer village), the general flood plain area (hunting camps), and in the mountainous areas along trails and routes used in the past.

Figure 6.20 [a & b] Pictograph sites on Pitt Lake

Photos omitted in respect to Katzie Elders.

Photos by author
CHAPTER 7: DISCUSSION

Unequivocal archaeological data from the Pacific Northwest of North America to support the coastal migration hypothesis has yet to be located. While more early sites have been reported along the west coast in the last decade, none is of sufficient age to demonstrate such an association. This thesis emphasizes that other sites may be found along uplifted sections of the Pacific Coast that could provide the needed support. In order to understand why archaeologists, especially those interested in the late Pleistocene / early Holocene time period, need to focus increased attention on geomorphic processes and landforms we need to review the history and previous work done in this field. This helps to understand the challenges ahead in order to generate new, useful approaches to answering long-standing questions concerning late Pleistocene human movements.

Evidence from geomorphological and palynological studies indicates that the late Pleistocene paleogeography and paleoenvironment of the south-west British Columbia coast were clearly suitable for habitation by early maritime/estuarine adapted populations. The overall pattern that emerges is that between 14,000 BP and 9000 BP conditions were less hostile than previously thought. While such paleoenvironmental evidence alone does not demonstrate that humans inhabited the coast of B.C. before 10,500 BP, it tends to favour that possibility. The distribution of unifacial and mixed unifacial and bifacial cobble tool sites and leaf-shaped projectile points also suggests widespread use of the region by at least early Holocene times. Why then have no sites been discovered that have equally early dates as those in central and eastern portions of this continent, or even older sites to account for a coastal immigration into the Americas?

One of the greatest problems facing late Pleistocene archaeology in this region is the limited data. There is not much funding available to conduct the archaeological and geological research needed to build a more precise chronology for the early period of human occupation. Thus, a lack of systematic surveys of late glacial landforms along the British Columbia coast and the adjacent Coast Mountains might be the main reason for the absence of known late Pleistocene sites. Earlier sites were also likely
simpler and smaller, and thus harder to find, compared to more recent ones. Simple lithic technology consisting of expedient tools such as cobble choppers and unifacial flakes also might be invisible to the untrained eye, so many early sites may have been disturbed but not recognized. Furthermore, faunal assemblages from inland / non-shell midden sites are rare and what is recovered are mostly calcined bone fragments. Evidence for boat, or wood and bone technology would also be biased by poor preservation factors.

If we accept the logical assumption that the first inhabitants or people migrating along the Pacific coast of the Americas had a maritime adaptation then we would expect most of their habitation sites to be located along Late Pleistocene shorelines. As elaborated above this could have taken place in various locations, either on glacial refugia or on terrain deglaciated on the outer coast as early as 14,500 BP. This would lead to the conclusion that due to the glacio-eustatic and glacio-isostatic effects affecting the outer islands on the margins of the Cordilleran Ice Sheet, most potential sites are now inundated by the ocean at various depths. Only small temporary hunting or perhaps lithic procurement sites can be expected in what originally were inland portions of these outer coastal areas. If, however, these populations had a riverine or mixed riverine/estuary adaptation, then sites could be located some distance inland and above today's coastline. However, since most river systems of any significant size were located on the continental mainland, the antiquity of such sites is limited by the timing of the end of major valley glaciation and would hence be several hundreds or perhaps thousands of years too late to correlate with pre-Clovis candidates. Many low-lying coastal estuary or river delta localities, such as those that were exposed on the continental shelf by low relative sea levels, have also subsequently been inundated by the eustatic sea level rise at the end of the last glaciation.

My research has led me to believe that some of the most promising areas, that were both ice-free before 12,000 BP, with paleo-landforms and shorelines elevated above today's sea level due to sufficient isostatic rebound, and in proximity of major streams or coastal estuaries and marshes, include areas of Vancouver Island, the Gulf Islands and Sunshine Coast in British Columbia, as well as the islands in Puget Sound and some portions of mainland western Washington in the United States. Potentially promising areas to find archaeological sites could be where elevated landforms have been identified and dated (directly or indirectly) to the late Pleistocene, or near shell-
bearing deposits found at locations above modern sea level dating to at least 10,000 years ago. A good example would be the wave-cut terraces in glacial and deltaic sediments in the Mill Bay area and on Saanich Peninsula in south-eastern Vancouver Island that occur at about 5, 20, 40 and 80 m asl. Such features likely represent post-glacial times when glacio-isostatic rebound and eustatic sea-level rise were nearly equal.

Other sites could be located in other less obvious locations. Many new river drainages with associated deltas as well as lake and marsh areas were created immediately after deglaciation, and would have presented preferred places of occupation to the first inhabitants. However, frequently changing patterns of drainage during glacial retreat, rapid shifts in climate and precipitation, and occasional catastrophic floods and paraglacial, tectonic or volcanic activity may have altered many local river courses, deltas and other post glacial landforms. Many sites may have been washed away or covered deeply by sediments. It seems likely that the sudden appearance of the Pacific coastal archaeological record at the Pleistocene-Holocene divide is caused by a stabilizing landscape and not so much by the fact that this was the time when people first appeared in the region.

In order to find more archaeological sites dating to the late Pleistocene epoch, again, increased attention needs to be given to older landforms and to the possibility of deeper and older cultural deposits. However, even if archaeologists and geologists pay more attention to such locations, what are the chances of actually finding early sites in southwestern British Columbia? They presumably were few in number, with only “thin” cultural signatures. In addition, late Pleistocene sites without diagnostic projectile points may have gone un-identified or, when discovered, understudied. According to Fiedel (2000) one of the most profound implications of Monte Verde is the fact that if the organic materials and handful of well-made bifaces had not turned up, the lithic assemblage alone would not have met the established criteria for recognition of a human presence. If artifacts consist of only expedient tools, accidental discovery, as is often the case with Paleoindian sites containing elaborate spear points and other superbly crafted artifacts, is not likely to occur. Construction crews working in housing developments, public infrastructure, and gravel extraction businesses would not be likely to identify basic flake and core tools, or assign any importance to such simple stone implements. In addition, current government policy and public opinion does not
encourage the reporting of archaeological sites, if recognized. Hundreds of potential early sites also could be missed because they contain simple tool assemblages largely indistinguishable from other naturally rounded and broken pebbles and cobbles. The education of operators of excavation equipment would be helpful, but is not likely to be implemented. Some control and inspection by an archaeologist, employed directly by government or hired by construction companies, on the other hand, would not be too difficult considering that many inspections already take place during the construction of any type of structure, road or buried pipeline. Simply educating building inspectors in short courses about basic geological and archaeological identification of sediments and artifacts might help to avoid loss of invaluable cultural information buried in late Pleistocene landforms.

The logging industry fares no better. Although pre-logging impact assessment and mitigation surveys are conducted, these are unlikely to find deeply buried material, due not to the competence of consultant crews, but to the logistical and cost constraints of such work. Most of the rivers of coastal British Columbia are constrained in glacial valleys of the Coast Mountains with narrow floodplains and a large sediment supply, which tends to not only produce deep alluvial deposits potentially conducive to archaeological stratigraphy and preservation, but also to the deep and inaccessible burial of cultural deposits. In addition, where rivers emerge on broad coastal plains, greater lateral channel migration occurs and archaeological deposits may be hidden in marginal locations away from current streams or locations normally viewed as associated with archaeological sites. Goodyear (1999), for example, reports that an early Holocene site was discovered on the surface of a moderately elevated, alluvial feature within a back-swamp of the Oconee River, after the ground had been disturbed by clear-cutting machinery.

While such sites are not likely to be discovered by the usual pre-logging survey, they could potentially be uncovered by subsequent logging activity, which often includes the removal of gravel from fluvial or glacial landforms for the levelling and maintenance of logging roads, loading zones, etc. While education of machine operators again could help identify potential archaeological sites, current regulations do not encourage such a development. Another possibility would be to conduct a post-logging survey, which could be fairly brief, inspecting only areas that exhibit significant alteration of pre-logging surfaces. As an extension, such monitoring could also include
new sewer, water, and oil and gas pipeline trenching (Wilson and Burns 1999:235), as well as occasional gravel pit inspections.

In the author’s opinion, a database should be created that includes all known late Pleistocene / early Holocene landforms, rockshelters, raised shell beds or buried peat deposits. Development applications could then be cross-checked and locations monitored during soil excavation. Failure to consider these geomorphic processes and landforms could lead to the development of distorted or incomplete predictive models in future research designs.
CHAPTER 8: CONCLUSIONS

With geological and paleoenvironmental data now demonstrating that most northern Pacific outer coastal regions were deglaciated between 14,000 and 12,000 BP, a potential coastal migration into the New World seems clearly viable. It is also possible that such a migration could have had a rather limited impact on the interior of North America, as people who came from coastal Asia via that route may have continued down the coast to South America, by-passing much of the northern continent. Earthquakes and volcanoes changing the course of rivers and altering landforms, but in particular raising relative sea levels, also might have had far-reaching effects on localized coastal areas, submerging much of the evidence left behind by these first immigrants in those areas.

A human population migrating along the B.C. coast in the late Pleistocene would have likely taken the route along the sheltered so-called “Inside Passage” between the outer islands and the mainland, just as most boat traffic does today. The inside passage was ice-free in parts starting at 16,000 BP (Ager 1999; Barrie et al. 2005; Blaise et al. 1990; Clague et al. 2004; Hetherington et al. 2003, 2004a; Mann and Peteet 1994). A logical extension of such a migration would be along the east coast of Vancouver Island, which again would have been far more sheltered than the west coast. Even with the presence of some tidewater glaciers, the calm bays and island topography would have been more welcoming than the windswept open Pacific Ocean. However, after the Port Moody Intermestade ended at ca. 17,000 BP this route was likely blocked until at least 12,500 BP. Alternatively, the west coast of Vancouver Island would have been passable until 16,000 BP and again after 13,000 BP. The time period of 16,000 BP is of particular interest as both the northern Northwest coast and Vancouver Island’s outer coast were at least partially ice-free and vegetated. Al-Suwaidi et al. (2006) suggest that there was...

.......the possibility for a brief window of opportunity for migration along a relatively ice-free Northwest coast just before this time. [Al-Suwaidi et al. 2006:327]
Such a suggested boat-using population, whether arriving at 16,000 or 13,000 BP, staying close to shore, could have followed the coastline to the southern tip of Vancouver Island, from where they would have likely traversed the Gulf / Juan de Fuca Islands to the mainland coast or into Puget Sound. The general area of southwestern B.C. and northwestern Washington State may indeed have been the first place attractive enough to stay for a while after a long and dangerous journey along a glaciated coast, before moving on around the Olympic Peninsula and further to the south.

Some small groups may have moved up into mainland valleys, perhaps on hunting, gathering or lithic raw material procurement excursions at first, and later to settle permanently. Such different purposes for movement and migrations could explain differences in technologies and potential size and pattern of habitation sites. It seems clear, therefore, that we need to search available inland late Pleistocene raised landforms in order to add new evidence for a coastal migration. In addition, we need to be aware that such early assemblages are likely small, perhaps one-time use sites, containing materials widely different from sites of permanent settlers.

A review, in this thesis, of early sites along the Pacific coast of America shows the presence of a variety of stone, wood, and bone tools that could have been used to process a wide range of plant and animal resources. At Monte Verde, in Chile and other coastal sites ranging from Peru to Haida Gwaii, there is good evidence of a generalized diet focused on a mix of estuarine, riverine and terrestrial resources, or marine and terrestrial resources, depending on the local topography and environment. In order to locate similar sites along British Columbia’s southwestern coastline this thesis reviewed a variety of landforms in the hope of developing criteria to aid in recognizing late Pleistocene and early Holocene cultural deposits. A review of such sites elsewhere along the Pacific as well as Atlantic seaboard has demonstrated a high potential for deep alluvial burial of early sites in river floodplains, or on more localized raised late Pleistocene landforms. Identification of deposits that promise to be of sufficient age to contain late Pleistocene cultural material and with adequate integrity to preserve such data, would be critical to the dating of assemblages. Based on my literature review and fieldwork I conclude that outwash plains and raised landforms of sufficient age do exist and offer the greatest potential for early cultural deposition in southwestern B.C.
Again, a combination of large-scale fluvial aggradation burying some archaeological sites, catastrophic flooding eroding others, and sea-level change stranding landforms on mountain slopes, combined with a low-visibility lithic culture, have combined to hide evidence for early postglacial occupations of the southwestern coastal areas of British Columbia as well as neighbouring Washington State. Teams of paleoecologists, earth scientists, and archaeologists need to integrate their research into a regional overview, identifying locations of high potential for containing late Pleistocene deposits linked to the first human occupations of this area. This also will require increased methodological and theoretical sophistication in the design of suitable survey and excavation strategies, explicitly to locate early sites. Again, such surveys must be sensitive to the potential importance of late Pleistocene landforms and cognizant of the geological contexts in which early sites may occur. Archaeologists also will need increased public or private funding to conduct deep excavations, or use new technological applications. Examples of such interdisciplinary studies conducted elsewhere include work in Alaska (Crowell and Mann 1996), the Rocky Mountains (Fedje et al. 1995), the Oregon coast (Hall 2003), and Haida Gwaii (Fedje et al. 2005; Hetherington et al. 2003).

In this thesis I hypothesized that the descendants of these first migrants could have settled along some of the larger lakes and rivers of this region, perhaps as early as 12,000 BP, and that the area was populated continuously since the late Pleistocene. Surface artifact distributions suggest that their sites could have been located along major lake and river systems, but marine and migratory bird resources found near shallow bays, estuaries and river deltas are also believed to have been an important attraction. In light of past and current research I conclude that the rapid burial of potential archaeological evidence and the poor visibility of an expedient cobble tool technology, combined with insufficient dedicated research efforts, account for the lack of known late Pleistocene sites and the rarity of early Holocene archaeological sites.

The goal of this thesis was to re-evaluate existing evidence and to propose new directions in the study of Late Pleistocene cultural manifestations on the southwestern coast of British Columbia. It included a review of relevant archaeological and paleoenvironmental literature and an analysis of previously proposed models and assumptions, and resulted in a summary of the present state of archaeological and geological information. Furthermore, several questions related to this problematic
period in the early archaeological record were addressed. According to the data presented here, there is no reason why the southern coast of British Columbia could not have been inhabited during the late Pleistocene and early Holocene.

Future Research:

I strongly believe that if we are ever hope to find traces of the earliest inhabitants of this area, or learn about their hypothetical relationship to the first migrants into the Americas, fieldwork needs to be concentrated on identifying and archaeologically examine suitable late Pleistocene depositional environments and raised landforms. Only then can we be able to study appropriate archaeological contexts for this time period. Potential locations have been identified by various archaeological or geological research projects, for example, as noted previously, raised beach-ridges have been reported at the Tsawwassen /Point Roberts Peninsula and Vancouver Island's Saanich Peninsula and Mill Bay (Brolly et al. 1999; Huntley et al. 2001).

The wealth of research into late Pleistocene paleoenvironments and archaeology in northern coastal British Columbia, especially that resulting from the Haida Gwaii / Parks Canada Archaeology Project, forms the model for suggested future research strategies. Attempts to find sites of this age in southwestern British Columbia should include a broad regional analysis of late Quaternary geomorphology, and geological fieldwork should be oriented toward identifying and mapping late Pleistocene and Holocene sediments and landforms conductive to archaeological site preservation. Such research would include a map and aerial photograph analysis of the terrain, detailing drainage patterns, late glacial landforms, and surficial deposits. Drainage patterns, for example, can tell us whether local river channels have remained in their present position since the beginning of the post-glacial time period or have shifted considerably. Stable rivers with regular sediment aggradation, could have served to preserve well-stratified sites, such as those found on the Atlantic coast of North America and coastal sites on the Pacific coast of South America. Other sites could be preserved along old river channels and oxbow lakes in marginal areas of the present floodplains. Furthermore, remote-sensing methodologies could be used to locate and investigate high potential areas for late Pleistocene sites. Deep column sampling could then be used to test locations that display potential, to indicate if the
location had aggrading sediments of an early age, and may even provide cultural
evidence.

Detailed description and analysis of the sedimentology of promising landforms
will be necessary to really understand the formation and depositional histories of these
landforms. Archaeologists untrained in geomorphology need to be capable of giving
useful descriptions of sediments which, in combination with good photographs, could
be used by earth scientists or geoarchaeologists to interpret their mode of formation
and depositional environments. It is hoped that more archaeologists interested in late
Pleistocene human populations will become familiar with geological terminology and
able to conduct basic identification of sediments and landforms. This will be necessary
for them to make informed decisions on the potential of finding deeply buried cultural
remains of the first people who sett foot on the pristine landscape emerging after the
end of the Fraser Glaciation.

On a provincial regulatory level, post-logging surveys, gravel pit inspections,
and monitoring of development excavations into potential late Pleistocene raised
landforms should complement the present emphasis on pre-impact assessment and
mitigation. The fact that many late glacial landforms have already been destroyed in
the lower Fraser River mainland should cause the archaeological community to regard
the remaining as a rare and endangered habitat. Late Pleistocene landforms need to
be prioritized for both preservation and research before they are totally removed from
scientific scrutiny.
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