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Architecture, Fire, and Storage: Cathlapotle and Meier Features

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Architecture, Fire, and Storage: Cathlapotle and Meier Features

Wapato Valley Archaeology Project
Report #9

Kenneth M. Ames and Katie Henry, Editors

with contributions by Stephanie Butler,
William Gardner-O'Kearney,
and Emily Shepard

2017

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Number 17

Portland State University

U. S. Department of the Interior
U. S. Fish & Wildlife Service
Region 1

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TABLE OF CONTENTS

PART I

PART II

PART III

PART IV

PART V

PART VI

LIST OF TABLES

PART I

Chinookan Households on the Lower Columbia River: Contact and Complexity by Kenneth M. Ames

PART II

Building and Maintaining Plankhouses at Two Villages on the Southern Northwest Coast of North America by Emily E. Shepard

PART III

Domestic Hearth Features at the Cathlapotle (45CL1) and Meier (35CO5) Sites in the Wapato Valley of Oregon and Washington by William C. Gardner-O'Kearny

PART IV

The Interpretation of Indoor Storage Facilities from Two Plankhouse Sites in the Greater Lower Columbia River Region by Stephanie T. Butler

PART V

Postscript to Architecture, Fire and Storage: Cathlapotle and Meier Features by Kenneth M. Ames

LIST OF FIGURES

PART I

Chinookan Households on the Lower Columbia River: Contact and Complexity by Kenneth M. Ames

PART II

Building and Maintaining Plankhouses at Two Villages on the Southern Northwest Coast of North America by Emily E. Shepard

PART III

Domestic Hearth Features at the Cathlapotle (45CL1) and Meier (35CO5) Sites in the Wapato Valley of Oregon and Washington by William C. Gardner-O'Kearny

PART IV

The Interpretation of Indoor Storage Facilities from Two Plankhouse Sites in the Greater Lower Columbia River Region by Stephanie T. Butler

PART V

Postscript to Architecture, Fire and Storage: Cathlapotle and Meier Features by Kenneth M. Ames

PART VI

Visuals Gallery

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PART I

CHINOOKAN HOUSEHOLDS ON THE LOWER COLUMBIA RIVER: CONTACT AND COMPLEXITY

Kenneth M. Ames

PREFACE

Kenneth M. Ames

CHINOOKAN HOUSEHOLDS ON THE LOWER COLUMBIA RIVER: CONTACT AND COMPLEXITY

Kenneth M. Ames

This report is one in a series on the archaeology of the Wapato Valley region of the Lower Columbia River (Figure 1.1). Most of the reports discuss aspects of the excavations and archaeology of two sites, the Meier site (35CO5) and Cathlapotle site (45CL1) for reasons detailed below. Other related topics are also treated. Most of the reports are revised and edited M.A. theses and Ph.D. dissertations but some contain previously unpublished/unavailable specialists' reports. The latter are generally descriptive with interpretation and discussion to follow later, but we wish to make the data available. These reports are the final versions of these documents, superseding any previous versions. Discussions and conclusions have been updated where appropriate. In some instances statistical analyses have been redone to accommodate new data or new understanding of the site. Where there are differences in artifact counts between the original document and this report, the counts in this report are final.

Each report has at least four sections; the first section, which you are currently reading, is an overall introduction to the series and project and is standard across all of the reports and is in essence "boilerplate", which provides a standard and consistent introduction to all the reports. It is intended to provide enough detail on the overall project and the excavations to understand the report, but lacks the detail of a final excavation report. The second section is an introduction to the particular volume itself, presenting background peculiar to the volume in hand. The third section is the report's actual contribution. This may include one or more theses or technical reports. The fourth section is essentially a postscript which explicitly links those contributions to the project's broader goals.

Regional Background

The Greater Lower Columbia River (GLCRR) encompasses the final 200 miles of the Columbia River and adjacent portions of the Pacific

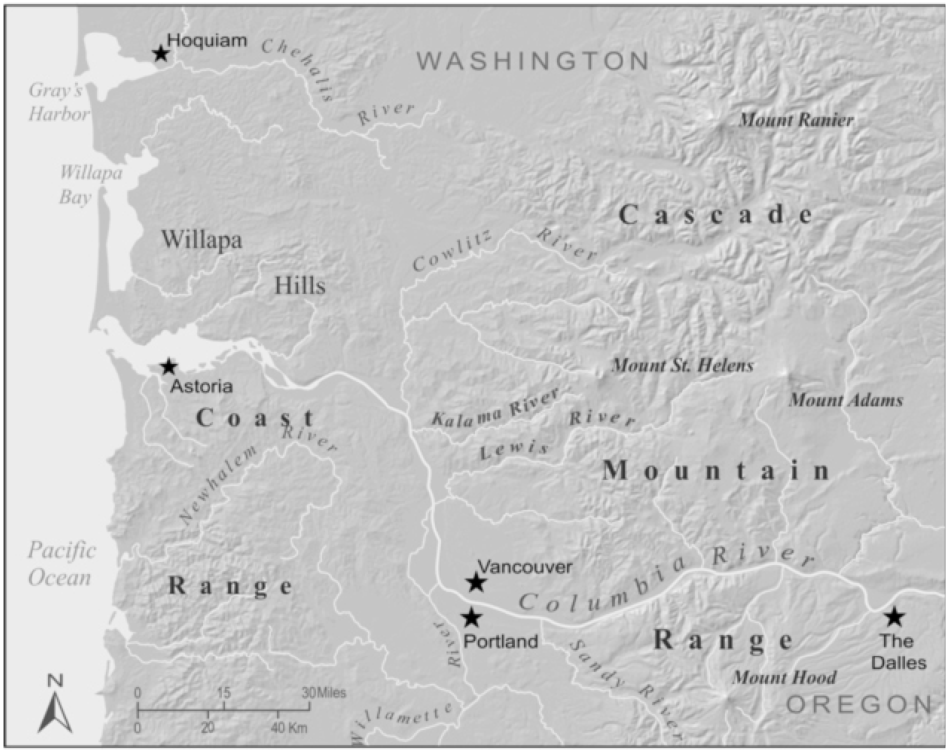

Figure 1.1. Shaded relief map of the Greater Lower Columbia River Region.

coastline (See Sobel et al. 2013 for a more detailed discussion). The region was one of several interaction spheres comprising the Northwest Coast culture area (Hajda 1984, Suttles, 1990, Ames and Maschner 1999). Hajda (1984) defined it using local and regional patterns of social and economic interaction. The documentary record is primarily the accounts of explorers such as Lewis and Clark, of individuals in the fur trade, and early settlers (e.g. Gairdner 1841, Simpson 1847, Coues 1897, Franchere 1967, Moulton 1990, see also Lang 2013). There is not the voluminous ethnographic record that exists for portions of the coast further north (e.g. Boas 1894, Ray 1938; see also Suttles and Lang 2013).

The area is topographically and ecologically diverse (Ellis 2013, Sobel et al. 2013). At its eastern edge, the Columbia Gorge breaches the Cascade Mountain range. West of the Gorge, the river passes through the Portland Basin, Lewis and Clark's Wapato Valley, the name used by this project. Here, the broad floodplain once contained extensive wetlands. Below the lowland, the river penetrates the Coast Range, a long, rugged chain of low, heavily forested mountains, enters its wide fjord-like estuary, and meets the Pacific Ocean. The climate west of the mountains is maritime, with heavy rains and moderate temperatures.

Several ethno-linguistic groups occupied the GLCRR at contact. Speakers of Chinookan languages were the most numerous (Hajda 1984, Silverstein 1990) with large comparatively dense populations. Boyd conservatively estimates precontact populations at 34,000 people (Boyd 1990, 1999a, 2013). Most were concentrated on the major rivers and tributaries, particularly in the Wapato Valley. Chinookan social organization and economy had much in common with other Northwest Coast societies (Hajda 1984, 2013;Silverstein 1990). The household was the basic socio-economic unit, and the village or town the maximal unit (Hajda, 2013, Ames and Sobel 2013). Households lived in large post and beam plankhouses of western red cedar (*Thuja plicata*). Society was divided into two broad classes, free and slave (Donald 1997, Hajda 2005). Free people were subdivided into a chiefly elite and commoners. Chiefly status was based on heredity, wealth, and widespread social and economic ties (Hajda 1984). The slave population in the late 18th and early 19th centuries may have been 25% of the total (Mitchell 1985, Ames 2008).

Contact began c. 1775, with the first documented exploratory voyages along the coast (Hajda 1984, Gibson 1992). Ongoing contact on the Columbia began in 1792 with the European discovery of its mouth (Vancouver 1926), and the start of the maritime fur trade. The fur trade brought the GLCRR into an "internationalized ocean basin" (Igler 2004) and mercantile and colonial systems spanning the world. Competition among Spain, Great Britain, and Russia (Cole and Darling 1990, Gibson 1992, Lightfoot 1997, Igler 2004) fueled exploration. By the 1790s the United States replaced Spain and competed directly with Britain in the GLCRR. Annually, an average of 12 vessels operated on the Northwest Coast between 1785 and 1841 (Gibson 1992) with at least one probably entering the Lower Columbia River annually (Robert Boyd pers. comm.). Vessels sailed from the GLCRR to Canton, South America, Hawaii, and elsewhere (Igler 2004). Before 1811, the fur trade was entirely maritime, with ships dependent on native people for furs and fresh provisions. The Lewis and Clark expedition spent the winter of 1805-1806 near the river's mouth. In 1811, Fort Astoria, the first permanent Euro-American base in the GLCRR (Franchere 1967, Jones 1999, Lang 2013), was established. The Hudson's Bay Company (HBC) in 1824 placed the headquarters for its entire Columbia Department at Ft Vancouver, in the Wapato Valley. The region became part of United States territory in 1848. By then, epidemics had decimated the GLCRR's original people. Contact-era epidemics were not everywhere as severe as even recently thought (e.g. papers in Larsen and Milner 1994, Baker and Kaelhofer 1996). However, they devastated the GLCRR (Boyd 1999, 2013). The effects differed within the region, with the Wapato Valley worst hit. Its population decline probably exceeded 90% between 1792 and 1832. The GLCRR's archaeological record is poorly known (Ames 1994a, Sobel et al. 2013). Limited evidence (e.g. Pettigrew 1981, Minor 1983, Losey 2002, Sobel et al. 2013) suggests cultural evolution in the GLCRR followed the broader trends of the Pacific Northwest (e.g. Ames 2000, Ames and Maschner 1999, Matson and Coupland 1995, Sobel et al. 2013). The Wapato Valley Archaeological Project (WVAP) was initiated to help fill that void.

Wapato Valley Archaeology Project

The Wapato Valley Archaeological Project (WVAP) was conceived in the late 1980s as a long term archaeological research project focusing primarily, although not exclusively, on the Columbia River flood plain between the mouth of the Sandy River on the east and the Cowlitz River to the north (Figure 1.1). The name "Wapato Valley" was taken from Lewis and Clark who used two names for the area: the Columbian Valley and the Wappato Valley. "Wapato Valley" was chosen to reflect the centrality of Wapato (*Sagitaria latifolia*) in local and regional Native economies. The project area is essentially coterminous with the Portland Basin and with the greater Portland/Vancouver metropolitan area. It was an umbrella project under which more specific projects could be undertaken as opportunities arose but which would focus on a common set of problems. At the time, the expectation was that there might be an array of projects including those arising from on-going field school excavations, and grant and contract-based projects through PSU's then Laboratory of Anthropology and Archaeology. The field school was central to this. WVAP's research program had two broad sets of research problems: the first and more fundamental was to refine and extend the area's cultural historical sequence; and the second was to investigate hunter-gatherer complexity in the project area.

There were two local cultural sequences for the Lower Columbia River at the time (Figure 1.2): Pettigrew's for the Portland Basin (Pettigrew 1981) and Minor's for the Columbia River Estuary (Minor 1983). Both were developed as part of dissertation projects at the University of Oregon. Both were preliminary and based on very limited data sets. Pettigrew tested seven sites and surface collected three more, coupling the results of this work with 25 radiocarbon dates to construct a cultural sequence for the Portland Basin floodplain that essentially remains intact in 2013. He excavated single 6m x 2m trenches in 1' arbitrary levels in each site. The work was done with volunteers. Pettigrew also examined extensive private collections made from sites in the Basin, including those produced by the Oregon Archaeological Society in the course of their sometimes enormous excavations. His sequence was temporarily short, spanning only the last 2600 years or so, although sites in surrounding uplands (e.g. Newman 1966; Woodward 1972; Daugherty et al. 1987a, 1987b) contained Early and Middle Holocene cultural deposits and, upstream, the Columbia River basin held late Pleistocene occupations on the Snake and Clearwater Rivers. Private collections made on Sauvie Island and in the near-by Scappoose, Oregon area also contained Early/Middle Holocene materials (e.g. Cascade points). Thus the medium/long term goal was to flesh out Pettigrew's sequence and extend it back in time. The areal focus would be Sauvie Island and environs. A key element to this program would be developing a Holocene alluvial chronology for the Portland Basin, or at least for the Sauvie Island area. None existed at the time (and still doesn't but see Minor and Peterson 2013, Peterson et al 2011, 2012, 2014 for recent work). The complexity of this task was significantly underestimated and remains undone as of this writing (2013).

Given the general paucity of archaeological data, the Lower Columbia River had played little or no role in research on Complex Hunter-Gatherers elsewhere along the Pacific coast although the documentary record showed very large aboriginal populations at contact and other characteristics then associated with hunter-gatherer complexity (e.g. Price 1981, Kelly 1995, Koyama and Thomas, 1981, Price and Brown 1985). The project's initial central focus again was chronological – to construct a sequence for the development of complexity in the Wapato Valley and to look at causal factors that might be accessible via the local archaeological record. Saleeby (1983) hypothesized that the ancient residents of the Wapato Valley had been fully sedentary. Her hypothesis was based on her analyses of the faunal assemblages from Pettigrew's excavations. Given the importance of sedentism in theories and models of social evolution generally (e.g. Testart 1982) and hunter-gatherers particularly (e.g. Kelly 1991) testing Saleeby's hypothesis with larger, better controlled samples was the first issue to be addressed by the field school excavations. Testing Saleeby's hypothesis meant simultaneously testing a model of local mobility patterns proposed by Dunnell et al. (1973) based on survey around Vancouver Lake.

Calendar Years Before Present	Region	Estuary	Wapato Valley
AD 1850	Early Modern	Early Modern	Early Modern
AD 1750			
500	Late Pacific	Ilwaco 1	Multnomah Phase
1000			
1500		Ilwaco2	
2000	Middle Pacific		Merrybell Phase
2500		Sea Island Phase	
3000			????
3500			
4000	Early Pacific		
4500			
5000			
5500			
6000			
6500	Archaic	????	
7000			
7500			
8000			
8500		Young's River Complex	????
9000			
9500			
10000			
10500			
11000		????	
11500			
12000			
12500		????	????
13000			
13500	Clovis/Stemmed Pts		
14000	Stemmed Pts?		
14500	Paisley Cave		

Figure 1.2. Lower Columbia River Archaeological Sequence. Modified from Sobel et al. 2014.

The original plan for the field school was to begin by returning to Pettigrew's sites and to more formally test each over one or two field seasons. This was planned for pragmatic and ethical reasons. The pragmatic reason was that Pettigrew's sites were known, at least in a preliminary way, based on his test excavations and, together, they formed the backbone of his chronology. The ethical reason was trying to operate within the concept of conservation archeology (Lipe 1974). Most, if not all, had suffered damage from development, ongoing use and/or looting, thus the field school would not be impacting intact sites but rather retrieving information from damaged or threatened sites on private land, i.e. sites not then protected by state or federal law or regulations.

The formal field school excavations commenced at the Meier site (35CO5) in 1987 and, for reasons developed below, the WVAP's focus quickly shifted to the excavation/analyses of two, large complex sites, Meier and Cathlapotle (45CL1l). The original goals and plans were rapidly modified. As a consequence, there has been no formal test or development of Pettigrew's original local sequence, although there has been ongoing CRM work in the area (Ames et al. 1994). The WVAP did conduct other projects besides the Meier and Cathlapotle excavations. These include:

- Excavations of the Early Holocene Burnett Site in Lake Oswego (Burnett 1991)

- Exploratory work at the Trojan Nuclear site in anticipate of a headquarters building that was never built (Burtchard 1989)

- Preparation of a Portland Basin Context Statement for Oregon SHPO (Ames et al. 1994)

- Preparation of a National Landmark nomination for the Sunken Village site (35MU4); (Newman 1991) and participation in testing of the site (Fagan 2004 Pettigrew and Lebow 1987)

- Survey and testing of portions of the Ridgefield National Wildlife Refuge (Daehnke 2007, Daehnke et al. 2010)

- Joint PSU/NPS excavations of the Middle Village site (45PC106) in the Columbia River Estuary (Wilson et al. 2009)

In addition, Sobel (2004) included Clahclellah in the Columbia Gorge in her dissertation (see below), thus extending the WVAP's data base east. Her analysis of Clahclellah is included in this report series.

Ongoing work:

Field work for the WVAP was suspended in 1996 because of the great volume of materials from Meier and Cathlapotle requiring analysis. Geoarchaeological field work was conducted at Cathlapotle in 1998 (Hodges 1999) and 2000 (Hodges 2002) and geophysical surveys in 1998 and 2000 (McDonald 2002). Laboratory analysis of some 25,000 tools and 150,000 plus other objects has been ongoing with work on both sites proceeding together and as of this writing (October 2013) is complete. The collections from both sites are curated at the federal curation facility at Ft. Vancouver National Historic Site.

Outreach:

In addition to the academic products, the project has been actively involved in community outreach, particularly with its Cathlapotle partners, the Chinook Tribe and the U.S. Fish and Wildlife Service. In 2002 the project received the Advisory Council for Historic Preservation's first Chairman's Award for Federal Achievement in Historic Preservation. Activities include teaching kit geared for 3 – 6th graders, workshops for teachers, innumerable public and school lectures, special events and a published booklet on the site for the general public (Daehnke 2002, 2005). Our principle outreach project is a 37' x 78' plankhouse on the Ridgefield NWR about a mile from Cathlapotle. This ongoing project involves the Chinook Tribe, the U.S. Fish and Wildlife Service, Portland State University and large numbers of community volunteers. Construction required over 3500 volunteer hours. The plankhouse opened March 29th 2005. Its construction was based in part on the excavated structures at Meier and Cathlapotle and combines authentic materials and techniques with accessible features for public safety. It is the focal point for most, but not all, of our public outreach and interpretation activities. These include on go-

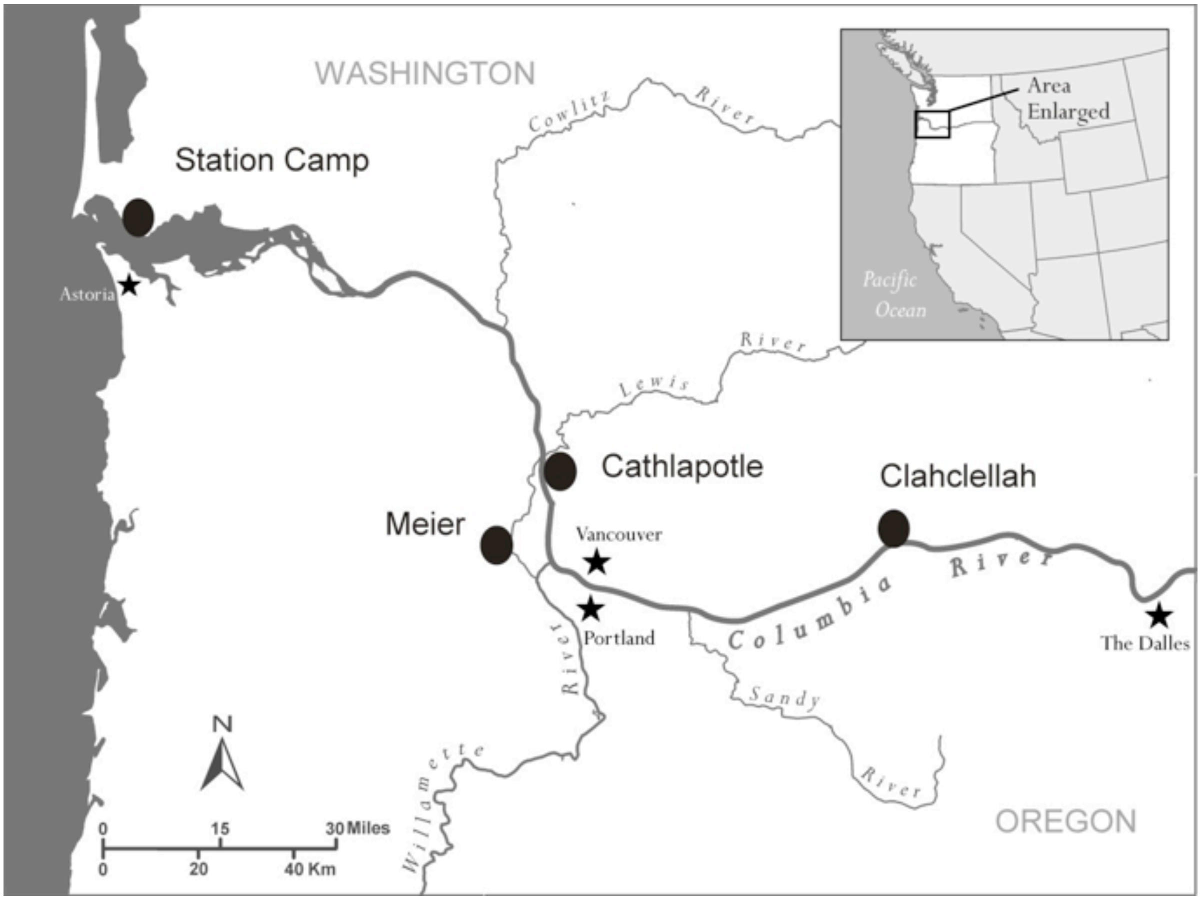

Figure 1.3. Locations of archaeological sites discussed in the text.

ing plankhouse construction and maintenance, tours given by volunteer docents, lecture series, and festivals. The plankhouse is also be used by the Chinook tribe for cultural events. Daehnke (2007) analyzes the issues of heritage and tribal sovereignty as they intersected at the Plankhouse. Project partners speak regularly to the public on various aspects of the project's results to community groups usually in the Portland-Vancouver Metropolitan area, but also as far away as Vancouver British Columbia and Fayetteville Arkansas.

The project has benefited greatly from its sustained relationships with the Chinook tribe and the Confederated Tribes of Grand Ronde. This is perhaps best exemplified in the recently published *Chinookan Peoples of the Lower Columbia* (Boyd et al. 2014). One of the co-editors and several authors are Chinookan peoples including Tony Johnson, one of the co-editors and a member of the Chinook Tribe and David Lewis, Chuck Williams and Eirik Thorsgard of the Grand Ronde Tribe.

Methodological and Theoretical Background to the WVAP excavations at Meier\Cathlapotle

The project's research used multiple and diverse lines of evidence at multiple spatial and temporal scales to investigate the political economies of households within these communities and within the broader region before and during the maritime fur trade (see Ames 2008). It is, at the same time, research into the political economy of complex hunter-gatherers. The research is conducted within the methodological framework of household archaeology.

Household Archaeology, Political Economy, and Household Production:

The project's methodology is framed by household archaeology (e.g. Blanton 1994, Deagan 2005, Hendon 1996, Rogers and Smith1995, Sobel, Gahr and Ames 2006, Wattenmaker 1998, Wilk and Rathje 1982), political economy (e.g. Netting 1993, Muller 1997), and household pro-

Table 1.1. Traits of Generalized and Complex Hunter-Gatherers (Kelly 1995).

	Generalized	Complex
Environment	Unpredictable or variable	Highly predictable or less variable
Diet	Terrestrial Game	Marine or plant foods
Settlement size	Small	Large
Residential Mobility	Medium to high	Low to none
Demography	Low population density relative to food resources	High population density relative to food resources
Food storage	Little to no dependence	Medium to high dependence
Social Organization	No corporate groups	Corporate descent groups (lineages)
Political organization	Egalitarian	Hierarchical, classes (ranks) based on wealth or descent
Occupational specialization	Only for older persons	Common
Territoriality	Social-boundary defense	Perimeter defense
Warfare	Rare	Common
Slavery	Absent	Frequent
Ethic of competition	Not tolerated	Encouraged
Resource ownership	Diffuse	Tightly controlled
Exchange	Generalized reciprocity	Wealth objects, competitive feasts

duction (Ames 2006, 2008). The household is the key methodological unit in fieldwork, hypothesis testing and interpretation. Our rationale for household studies is: “[T]he individual patterns of choice and strategic behavior can be placed within larger social structures and economic–ecological contexts. Societies adapt in only the most abstract sense of the word, but households adapt in concrete and observable ways (Wilk 1997; 31).” The larger social, economic and ecological contexts include the GLCRR and the fur trade era.

We build our approach to household production and economy on the work of several scholars who used documentary and archaeological sources in tandem (e.g. Gallant 1991, Muller 1997, Nevett 1999) and on certain key ethnographies (e.g. Suttles 1951, Oberg 1973, Fricke 1986, Netting 1993, Wilk 1997, see also Ames 2006) and Flannery’s The Mesoamerican Village (Flannery 1976) with its clear, scalar archaeological methodology. In many ways, it has not been superseded. Our approach is exemplified by Sobel, Gahr and Ames (2006).

Household archaeology begins with the household’s economic and ecological context, including the habitats used, the array of resources (number and relative proportions) harvested, the distributions in productive activities in time and space, and the relative costs and risk[1] of production (Ames 2006, Muller 1997: 225). The next level is production, consumption and distribution (e.g. Muller 1997, Costin 2001) within households, including task organization (Ames and Maschner

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[1] Risk in this context refers to the potential for failure – it is, in a sense, a measure of environmental variability and the effectiveness of subsistence techniques. It does not refer to danger (Ames 2006).

1999), the division of labor, and possible forms (e.g. Brumfield and Earle 1987, Ames 1995) and degrees (Cobb, 1996, Costin 1991, Spielman 2002) of specialization. This involves reconstructing production chains (e.g. Smith 2004, 2008), the spatial distribution of production (Smith 2008), fabrication of utilitarian and prestige items (Hayden 1998), and the relationship among specialization, elite status (e.g. Ames 1995, Spielman 2002) and patterns of consumption. These analyses are expanded to interhousehold level, then the community (sensu Varien 1999) level, and then between communities, including production differences related to local environmental differences and those that are not. Investigating distribution and exchange at all these levels has been central to the project since its inception (e.g. Hamilton 1994; Sobel 2004, 2006, 2011).

Hajda's (1984) definition of the GLCRR is based on local and regional patterns of exchange and distribution that link different areas and levels of organization (e.g. Crumley 1995). She postulates two separate networks, one for processed resources (e.g. dried salmon) and a second, separate system for prestige goods. Studies of the distribution of prestige goods must rely both on ethnographic (e.g. Hayden and Schulting 1997) and archaeological data (e.g. Sobel 2004, 2006). For the latter, differences and similarities in artifact styles are crucial. Sobel (2004) also provides a rich ethnohistorical ethnoarchaeology of Chinookan plankhouse based on the documentary record, which is extremely useful.

Complex Hunter-Gatherers:

The existence of complex hunter-gatherer societies in different times and places is a major archaeological discovery of the past 30 years (e.g. Ames 1985, 1994b; Arnold 1996, 2001; Chapman 2003; Fitzhugh 2003; Hayden 1995, Hayden and Cannon 1982, Koyama and Thomas 1981, Lightfoot 1995, Maschner 1992; Price 1981; Price and Brown 1985; Sassaman 2004). Table 1.1 summarizes a recent definition of "complexity" among hunter-gatherers. This research is significant in a number of ways: "[R]ecent research on complex hunter-gatherers has not only expanded the empirical record of sociocultural formations once deemed anomalous and/or derivative of European contact but also has contributed to the ongoing process of clarifying concepts of cultural complexity and how this process ultimately restructures Anthropological Theory. (Sassaman 2004: 227)". Corporate households, such as those in the GLCRR, were central actors in the development of permanent elites among hunter-gatherers (e.g. Arnold 2001; Ames 1985, 1994; Coupland 1985a, 1985b, 1996; Hayden and Cannon 1982, Kuijt 2000, Pauketat 1996).

Most research is geared toward explaining the origins and development of complexity and inequality. In contrast, this project is based on the premise that a detailed understanding of the economics and organization of these households is essential to any consideration of origins and development. A single case study cannot explain the evolution of inequality in human societies, but it can be a crucial test of theoretically derived expectations. The project defines complexity broadly, and includes high population densities, sedentism, and so on (Table 1.1).

Most archaeological research on complex hunter-gatherers relies heavily on analogies drawn from the Northwest Coast's voluminous ethnographic record. Most ethnographically-described complex hunter-gatherer societies lived either along the Northwest Coast or in California (e.g. Binford 2001). One goal of this project since its inception has been to test generalizations based on that record against the archaeological record, both in terms of using multiple lines of evidence and by testing them against each other (e.g. Sobel 2004, Ames 2008, Ames and Martindale 2014) as recommended by Leone and Potter (1984), Lightfoot (1995) and Rubertone (2000). The signs of social inequality in small-scale societies can be ambiguous (e.g. Feinman and Nietzel 1984). It is in part because of this ambiguity that we rely on multiple lines of evidence (e.g. Sobel 2004, Smith 2006).

The Fur Trade and Contact[2] on the Northwest Coast and GLCRR:

There is a vast literature on Contact in

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[2] Silliman (2005b) has critiqued the term "Contact" arguing that it should be reconceived as Colonialism. However, the term "contact" is embedded in the literature (e.g. Gosden 2004, papers in Cusick 1998, Murray 2004) and so is used here.

the Pacific Northwest in Anthropology, History and Geography among other disciplines. This literature is so large it is impossible to summarize (See Suttles and Lang 2013). However, anthropological (including ethnohistory and archaeology) studies of the fur trade era share many of the goals, issues, and problems with contact studies elsewhere in North America (e.g. Silliman 2005a). Much of it is framed by the Direct Historical Approach; intended to bridge an archaeological past and an ethnographic present and to write ethnography using ethnohistory (e.g. Hajda 1984, Boyd 1996) and, to a much lesser extent, archaeology.

The consensus among anthropologists is that the fur trade actually had little impact on native societies (e.g. Cole and Darling 1990, Acheson and Delgado 2004) beyond the exchange of goods and an intensification of trends already present (e.g. increasing social differentiation, heightened levels of warfare) despite the devastating effects of epidemics. Precontact patterns are thought to have continued well into the contact period when they were recorded by ethnographers (Cole and Darling 1990). A minority view, primarily held by some archaeologists, is that depopulation was so devastating that pre- and post-contact cultures were very different (e.g. Dobyns 1983, 1991; Dunnell 1991).

Most of the region's fur trade archaeology focuses on fur trade forts such as Fort Vancouver (e.g. Carley 1982, Chance and Chance 1976, Ross 1976, Thomas 1987, Thomas and Hibbs 1984), Fort Spokane (e.g. Combs 1964) Fort Langley (none published yet) – all Hudson's Bay Company posts - and Fort Ross (Lightfoot et al. 1991, 1997, 1998), the Russian fur-trading post in northern California. There are important exceptions focusing on native responses to the fur trade (Fladmark 1973; Marshall 1993: MacDonald 1989; Martindale 1999, 2005; Prince 1998; Rahn 2002) that use archaeological data such as changing settlement, subsistence and food patterns (Graesch et al. 2010). There is also a lengthy tradition of excavating contact era native sites to supplement ethnographies (de Laguna 1960). Thirty years ago, Fladmark argued archaeology should be used to test rather than supplement the ethnographic record (Fladmark, 1973). While this is now increasingly being pursued (e.g. Martindale 1999), archaeology has had little impact on fur trade scholarship in the Northwest beyond the trading posts (see Klimko 2004).

This circumstance mirrors broader, even

Table 1.2. Sites Used in This Study.

	Middle Village	**Meier**	**Cathlapotle**	**Clahclellah**
Smithsonian #	**45PC106**	**35CO5**	**45CL1**	**45SA11**
Excavations	**2004-2005**	**1987 – 1991**	**1991- 1996**	**1977 – 1979**
Age	**AD 1792 AD 1820**	**AD 1400 – c. AD 1810-1820**	**AD 1450 – c AD 1832**	**AD 1700 – AD 1855**
Site Area		**60 x 30 m**	**300 x 60 m**	**170 x 40 m.**
Mean Depth	**0.7 m**	**1.5 m**	**2 m**	**2 m**
Number of Houses	**NA**	**1**	**6**	**7**
Mean House Size±σ	**NA**	**420 m^2**	**413 ± 187 m^2**	**76 ± 23 m^2**
Excavated	**78 + m^2**	**154.6 m^2**	**309 m^2**	**50%**
% of Total Site Volume Sampled	**1.7**	**5.7**	**1.1**	**NA**
Shaped artifacts	**2000+**	**12825**	**10047**	**100,000 +**

global, problems in contact-era archaeology. These include how best to conceptualize the period and its issues (e.g. Paynter 2000a, 2000b, Silliman 2004, 2005a, 2005b; Book); the extent to which contact era studies should focus on the local and particular and to generalizing and theory building; what, beyond description, are the research goals (e.g. Lightfoot and Martinez 1995); what is archaeology’s role in researching a period with rich documentary records; what is the relationship between the archaeological and historical records (broadly defined – to include oral traditions) and how can each be most fruitfully used (e.g. Ames 2010;Cusick 1998; Wylie 1999, 2000).

As the WVAP project evolved, it followed an emerging consensus on some of these questions (e.g. Sobel 2011). It is essential for research to tack between the particular of local case studies and broader issues. Archaeology is not a “handmaiden,” supplementing and filling gaps in an inherently superior written record. These two are each the products of very different creative dynamics that may overlap, but may not (e.g. Ames 2008, Silliman 2004, Wylie 1999). Rather than a weakness this is a methodological opportunity. Leone and Potter (1988) outline a methodology based on Binford’s version of middle range theory (see Wylie 1989, 2000). We updated that using his concept of “frames of reference (Binford 2001)”. The different kinds of data - historical, archaeological, environmental - that the project employs are frames of reference projected against each other to identify contradictions and ambiguities (Binford 2001). These become targets of productive future research. Archaeology provides the long-term frameworks essential to investigating Contact. The temporal scale appropriate for studying the Contact era is necessarily larger than that era itself (Lightfoot 1995) because “[t]he study of long-term change in both prehistoric and historic contexts is necessary to evaluate the full implications of Columbian consequences (epidemics, novel trade items, alien fauna and flora) (Lightfoot 1995: 210 – 211).” Relevant archaeological data is often rare (Fitzhugh 1985; Chilton 2001). Contact-era research must be multidisciplinary (Chilton 2001; Lightfoot 1995; Murray 2004; Rubertone 2000; Silliman 2005a, 2005b; Wesson and Rees 1997; Williamson 2004). It requires multiple lines of evidence (or frames of reference or “cables of inference (Wylie 1989)) from many disciplines and from different research areas within archaeology itself, drawing upon the integration of, for example, environmental archaeology (e.g. Deagan 1996), lithic analyses (e.g. Cobb 2003a, 2003b; Silliman 2004), discard behavior (e.g. Lightfoot et al. 1998), and household archaeology (e.g. Deagan 2005) among others.

The Archaeological Sites

Meier (35CO5) (Table 1.2, Figures 1.3 and 1.4):

The Meier site is on the western edge of the Wapato Valley. It was the focus of major excavations between 1987 and 1991. The excavations exposed a large plankhouse, exterior midden deposits, and activity areas (Ames et al. 1992, Smith 1996, 2005). Accessible by boat via small channels, it is about 5 km from the Columbia and 1.3 km miles from the nearest major waterway. It contains fur trade era European goods (Banach 2002, Kaehler 2002) but no Euroamerican accounts

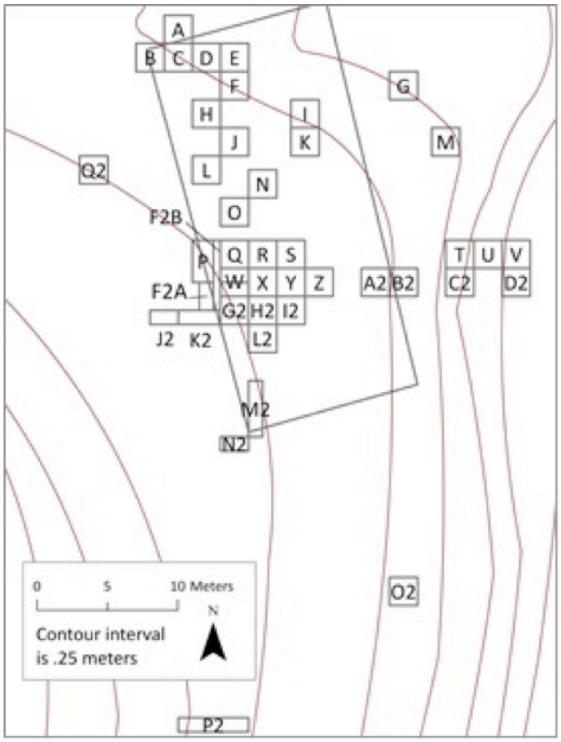

Figure 1.4. Meier excavations. Rectangle indicates approximate position and size of the house. Lettered squares are excavation units. Meier units had both standard grid addresses (i.e N0-2/W24-26) and an alphabetic code. The letters in the units are its alphabetic code. Map by Emily Shepard.

mention the site. Late Pacific – Early Modern period Native residential sites at or near the downstream end of Sauvie Island. Prior to our excavations, the site was well known in professional and amateur archaeological circles as a very rich site and was suffering (and still suffers) from looting. Portions of it were also being damaged by farm related activities and it was threatened, and continues to be, by near-by gravel quarrying. These are among the reasons it was selected for field school excavations: it was well known, was threatened and had already suffered damage.

The site had also witnessed a variety of excavations. Pettigrew excavated his 6x2 m trench in 1973 (Pettigrew 1977) as part of his dissertation research. For her dissertation, Saleeby (1983) analyzed the faunal remains recovered by Pettigrew at six of the tested sites, including Meier. In the early 1970s, Dennis Torresdahl conducted excavations at the Meier site with his Scappoose Middle School science class. Finally, Willamette Associates, a Cultural Resources Management firm, tested the site in 1984. Our excavations were not going to impact a pristine site. Additionally, the landowner was willing. Ellis had held field school excavations at the Briar Site (35CO35) in 1986. The Briar site is on the Meier property about 1 km from Meier. There has been no work at the site since 1991 and the end the PSU excavations. The site has been monitored for looting, which continues at a small scale and for potential industrial damage from the adjacent quarrying.

Meier was also central to Saleeby's sedentism hypothesis; faunal preservation was good so one to two seasons excavation's was thought to be sufficient to produce a faunal sample adequate to test her hypothesis. As it turned out, we worked at the Meier site until 1991. By the end of the first summer, it was clear that the midden deposits, expected to be the source of the zooarchaeological assemblage, were severally damaged by looting. However, intact deposits were encountered east of the midden, which required exploring. It became clear by the end of 1988 that we were excavating a large plankhouse and that became of the focus of the work. Work ceased 1991 not because the information potential was exhausted but because the site is so rich the analytical load of each additional unit was too great. Approximately 160 m^3 were excavated. The house proved to be approximately 30m x 14m, dating between ca. AD 1400 and 1820 or so.

Cathlapotle (45CL1) (Table 1.2, Figures 1.3, 1.5, and 1.6):

Cathlapotle is on the U.S. Fish and Wildlife's Ridgefield Wildlife Refuge (Ames et al. 1999). It was one of the Wapato Valley's major Chinookan towns with estimated populations as high as 900 (Boyd and Hajda 1987); Ames estimates a population between 700 and 800 (Ames 2008). Cathlapotle, which is spelled variously in the ethnohistoric record, was visited by Lewis and Clark on March 29th, 1806 and described in detail in their journal accounts for that day. They describe a town of 14 wooden houses. It appears frequently in other Euroamerican accounts from 1792 on (Sobel 2004). Ames was approached by Anan Raymond, Archaeologist for the Fish and Wildlife Service, in the winter of 1990-1991 about initiating field work on the Ridgefield Wildlife Refuge near Vancouver, WA to locate the Cathlapotle Town site and conduct excavations to evaluate the site and provide USFWS with data with which to manage it. The proximity of the site to metropolitan Vancouver WA and Portland OR was seen as providing a potential for public education about Native cultures in the area, its archaeology and the mission of the USFWS. The town's location had been an issue and a topic of controversy since 1948. The first task was to locate it. Work began in December 1991, proceeding with augering and test excavations through 1993. Major field school excavations were conducted 1994-1996. Excavations were originally planned to continue for 10 years, through 2004. It was clear by 1995 that we lacked the fiscal and logistical capacity to sustain that plan. The sampling strategy was consequently scaled back. It was intended to wrap up excavations in 1997, however, the threat of flooding and the absence of funding precluded field work; a lab field school was conducted in 1997.

Cathlapotle has six large house depressions on its surface (Figure 1.5), marking the locations of plankhouses, four of which were divided into compartments. We mapped 14 – 16 compartments, matching or exceeding Lewis and Clark's count. We excavated 240 m^3 of deposit focusing on the largest house (House 1) and one of the smallest (House 4). House 1 is 69 x 15m and House 2

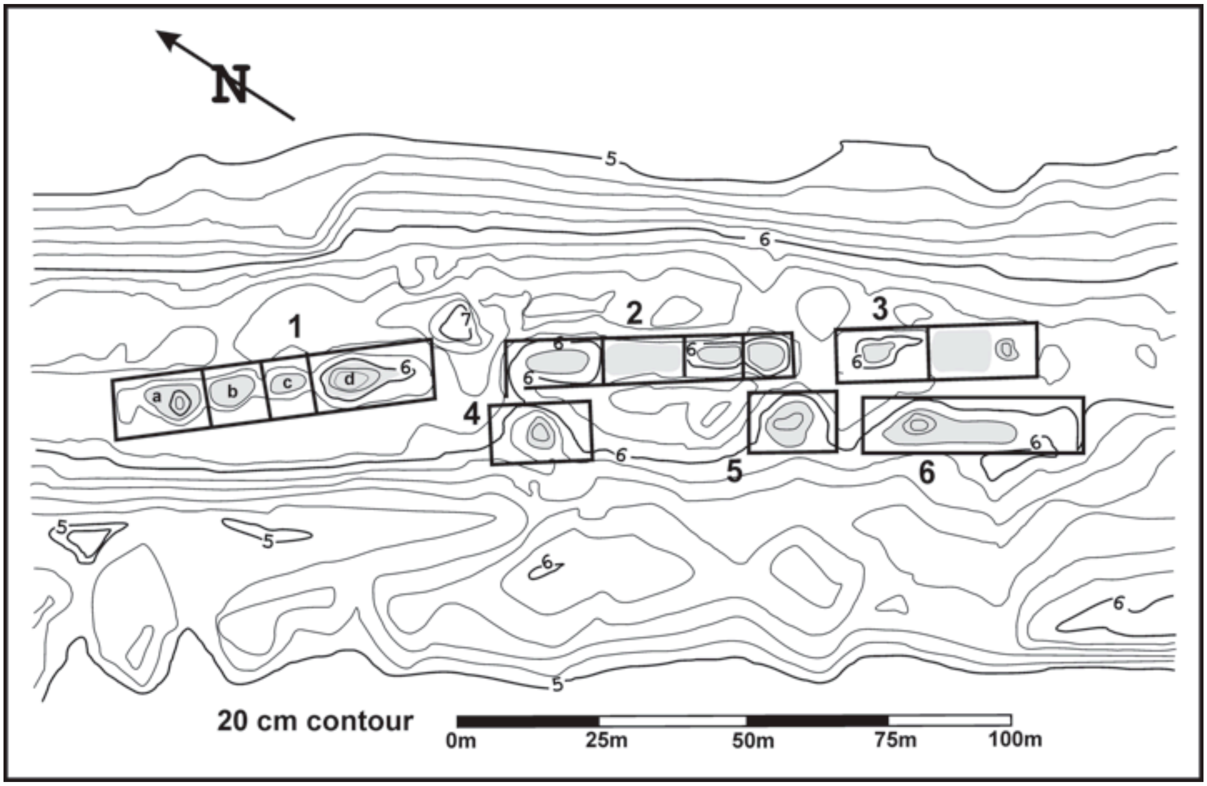

Figure 1.5. Topographic map of Cathlapotle showing inferred positions of houses. Dark areas are lowest areas in the house depressions. Letters in the House 1 segments designate the segment: e.g. House 1D.

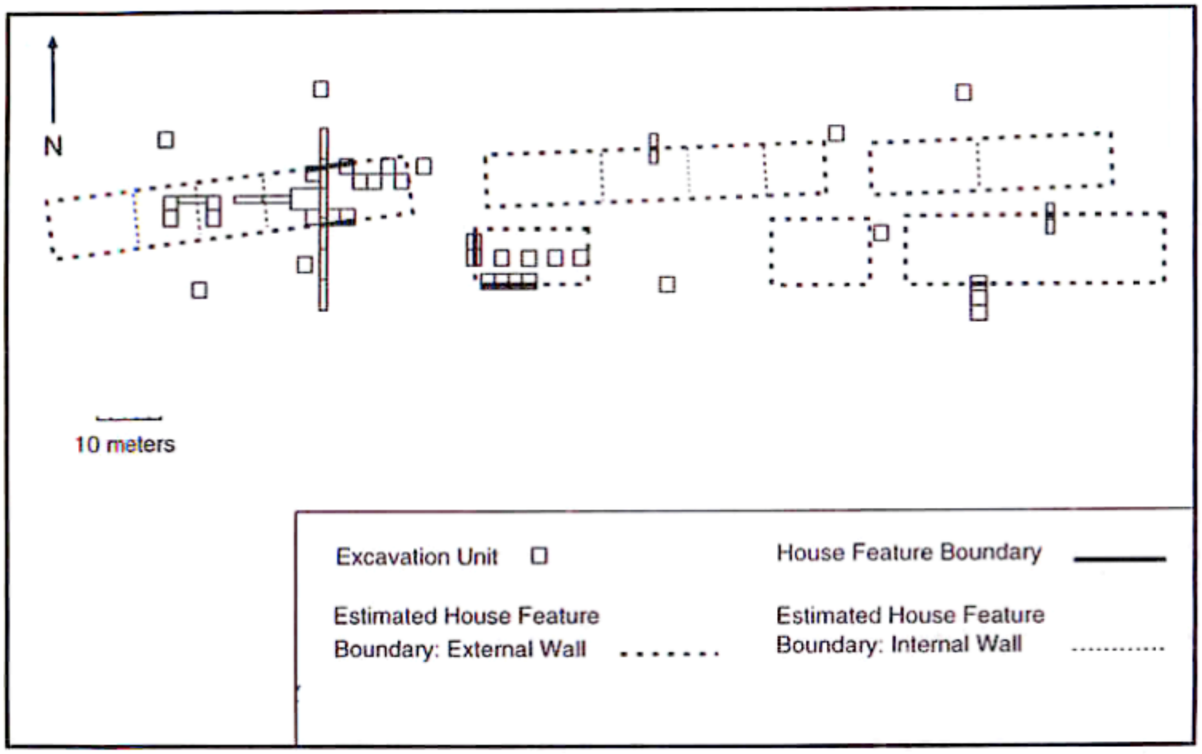

Figure 1.6. Location of Cathlapotle excavations relative to the houses. From Sobel 2004.

is 20 x 10m (Figure 1.6). The village was established in its current position ca. AD 1450 and it was abandoned sometime after 1830. It is notable for the clarity of contact in its deposits. The initiation of the fur trade at the site is archaeologically distinct (Figure 1.7). Trade goods appear abruptly about 70 cm. below surface in deposits 2 m deep. The excavations were preliminarily reported in 1999 (Ames et al. 1999).

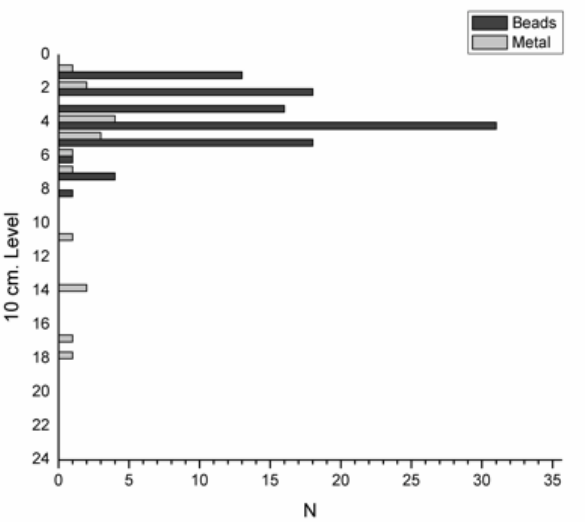

Figure 1.7. Typical sequence of historic trade goods at Cathlapotle. The metal at levels 18 and 17 dates to ca. AD 1450.

Clahclellah (45SA11) (Table 1.2, Figures 1.3 and 1.8):

Clahclellah is in the Columbia River Gorge (Figure 1.2). It was excavated as a data recovery project (Minor, Toepel and Beckham 1989, Sobel 2004). Sobel (2004) incorporated it into the larger WVAP project, analyzing samples of artifacts from each its seven houses to compare Cathlapotle. It did not have multiple linkages to the fur trade although it is mentioned by Lewis and Clark (Moulton 1990). The site was probably occupied for two centuries (Sobel 2004).

Middle Village (45PC106) (Table 1.2, Figure 1.3) (Wilson et al. 2009):

Middle Village, formerly McGowan/Station Camp, is on the Columbia's north bank at Baker Bay, a major fur trade anchorage across the river from Fort Astoria. The site was the subject of a joint data recovery project between the National Park Service and Portland State University. The artifact assemblage is important for comparisons and will be used for that purpose. The site is at or near Lewis and Clark's Station Camp where they spent November 15 – 24th, 1805 (Moulton 1990) and an historic Chinook summer village (Silverstein 1990: 534). It is neither of those. It contains evidence of temporary structures and a remarkable Native American fur trade era artifact assemblage (Wilson and Cromwell 2005, Ames 2005b). It appears to date between ca. 1790 – 1820/1830. The site may represent a Chinookan trading locality.

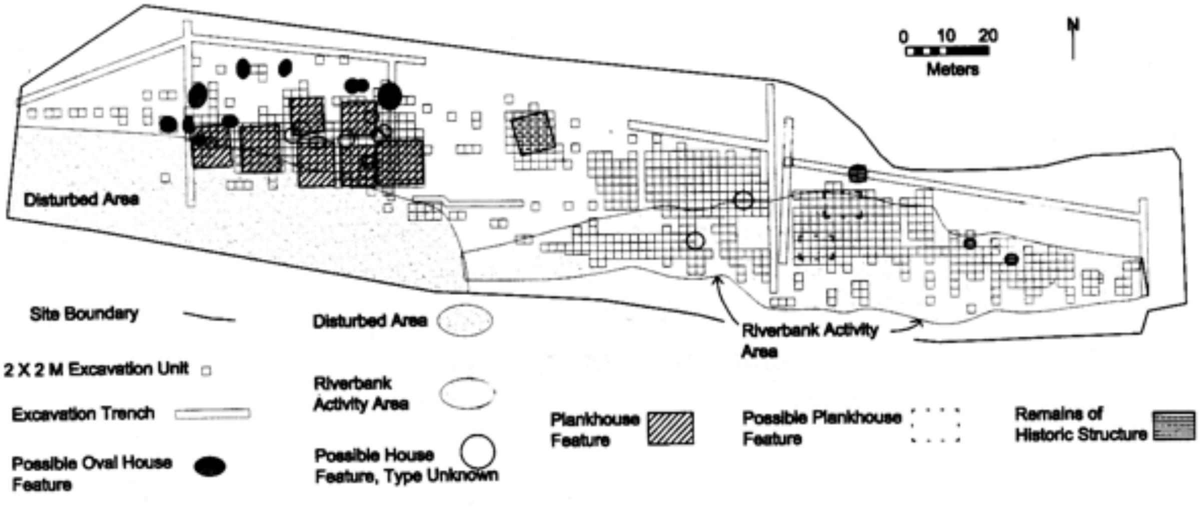

Figure 1.8. Excavations and houses at Clahclellah. At Clahclellah, the analytical units were samples within the houses (Sobel 2004).

Structure of the Meier and Cathlapotle Data Sets

Sampling and Excavation Methodology

The Meier excavations were originally intended to sample the site's midden (Figure 1.4, units C2, T, U, V and D2) to acquire a zooarchaeological assemblage. However, as noted above, the damage sustained by that portion of the midden from looting and the discovery of the house required a shift in excavation tactics to sampling along the house's long axis to acquire samples relevant to the issue discussed above. Sampling outside the structure was limited by the extent of looting although intact midden and non-midden exterior deposits were found and sampled.

Investigations at Cathlapotle (Figures 1.4 and 1.5) were intended to 1) locate the site of the town visited by Lewis and Clark, 2) test the site and 3) conduct excavations to investigate a range of research questions (Ames 1993). The goal of the Cathlapotle sampling design was to: 1) Establish whether large depressions visible on the site's surface were house structures. Four of the five were tested to accomplish this; 2) produce a stratigraphic profile across the site to link interior and exterior deposits. We could not do this at Meier. A trench was hand-dug across the site that spanned the non-cultural deposits at the rear (away from water) to the non-cultural deposits at its front (towards water) and linked interior and exterior deposits in a single continuous profile (Figure 1.9); 3) Sample two houses (Figure 1.6). The intrahouse sampling design was geared to producing data sets comparable to those from Meier to address the same range of questions, and 4) Sample precontact and fur-trade era deposits.

At both sites excavation was done by closely supervised field school students using trowels, brushes, etc. The students worked in 1 x 4m and 2x2 m excavation units with 1 m^2 blocks the basic horizontal recording and collecting units. All artifacts (including ecofacts) without point provenience were collected within their respective 1 m^2 unit, and, within that, their associated feature if present, and excavation level/stratum. Units were excavated in 10cm levels unless natural or cultural stratigraphy intervened. Sometimes, when it was necessary to accelerate excavation, 15 cm units were used. Screening was through 1/4 and 1/8th inch mesh. At both sites constant volume (cv) bulk samples for water screening were collected from all features (hearths, storage pits, post holes etc). Increment cv samples were also collected from the northwest quadrant of each excavation unit from each excavation level/stratum. At Meier, two liter samples were collected, at Cathlapotle, 10 liter samples. Over 1700 samples were collected at Meier; over 700 at Cathlapotle. The samples were water screened through nested screens with meshes of 4 mm, 2mm, 1mm and 0.5mm and sorted in the lab. Organic preservation is generally excellent. Charred plant tissues preserve reasonably well and the sites contain microscopic plant tissues. Bone preservation is excellent. All profiles were drawn and sampled. Geoarchaeological work at Cathlapotle continued after excavations ceased

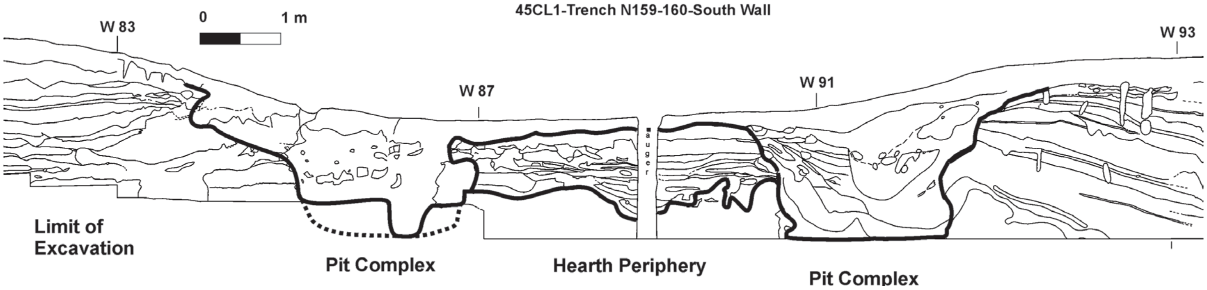

Figure 1.9. Cross-section of Cathlapotle through House 1 showing complex interbedding in the trench complexes in profile. The top and bottom of the central hearth periphery are indicated, showing the accumulation of hearths and floor laminae.

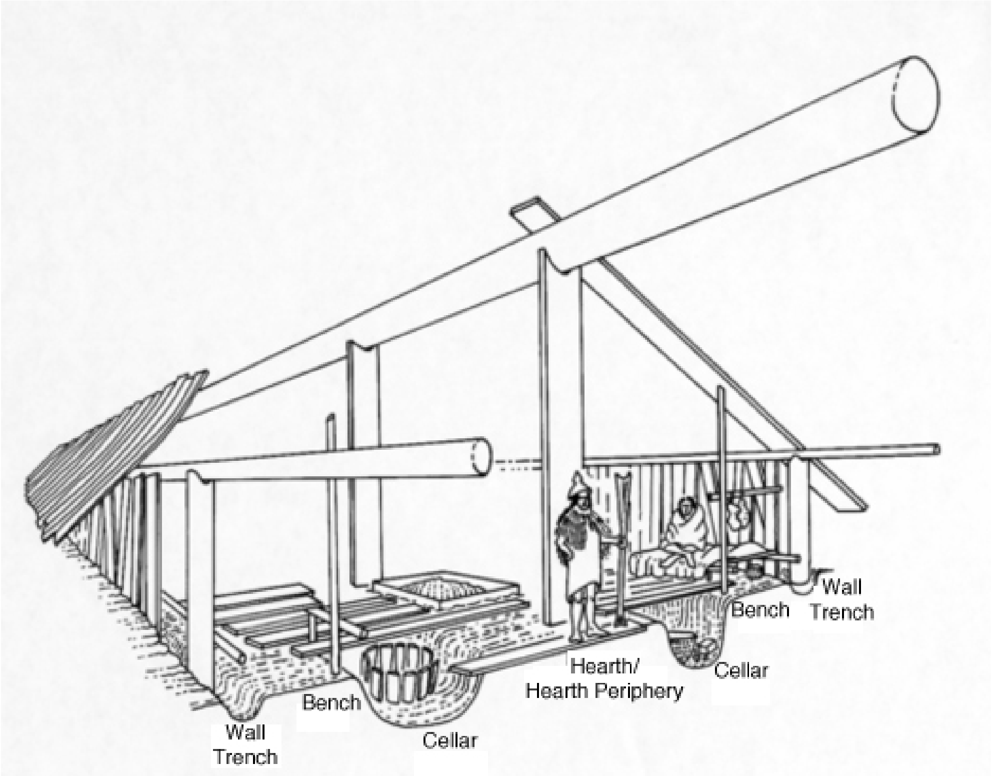

Figure 1.10. Interior contexts in excavated houses. Note: the storage pits are too shallow in this drawing.

(e.g. Hodges 2000, Hodges and Smith 2002).

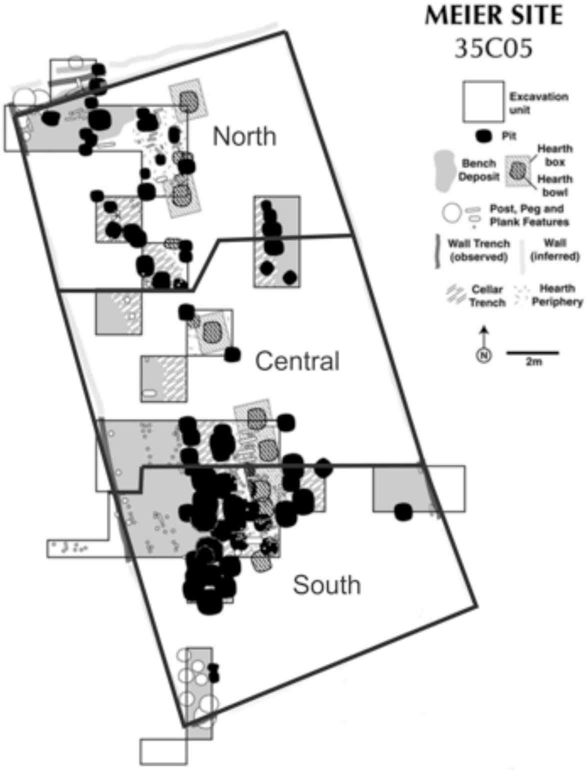

Figure 1.11. Meier house analytical units or segments.

At both sites, sampling of structures used a model of the archaeological features of Northwest Coast house interiors based on the Ozette excavations (e.g. Samuels 1983, 1991, 2005; Mauger 1991) modified to fit the details of Chinookan houses (Ames et al. 1992). Those details came primarily from the excavations at Clahclellah and the ethnographic and ethnohistoric records (e.g. Vastokas 1966). This model was refined in the course of the Meier (Ames et al 1992) and Cathlapotle excavations. The model divides the interior into archaeologically recognizable zones and architectural features (Figure 1.10). When possible, the houses are also divided into segments. Following standard Northwest Coast practice, these segments are based on the position of hearths (Figure 1.11) or interior walls (Figure 1.5 and 1.6). At Clahclellah, the houses are small enough not to be segmented (Figure 1.8). It is assumed these segments represent subdivisions of the household although there is debate within the research team as to whether the physical segments are separate households (Smith 2004, Sobel 2004) or household subdivisions. Exterior deposits are distinguished by their relationship to the houses (e.g. toft, yard), their formation processes, and form (e.g. midden [Beck and Hill 2004], sheet midden (Wilson 1994). These latter categories are not mutually exclusive (yards, sheet midden).

From the project's beginning, the sampling methodology was designed to measure artifact variation in space and time. "Artifact" is broadly defined and includes shaped tools, debris and waste, animal and plant remains, etc. To control for space, artifacts are assigned to first to unit and stratum or level, then to feature (post hole, pit, etc) if possible, then to analytical units (AUs, e.g. Smith 2004, Sobel 2004, Ames 2005c) that are organized hierarchically from very fine scale, (individual feature or stratum) to less fine scale (e.g. house wall, northern house segment, Meier, post-contact) (Figure 1.12) to medium scale (Cathlapotle, house 1) to coarser scale (Cathlapotle) to coarsest comparative scale (GLCRR) (Figure 1.12). Temporal control is provided by dating the analytical units using radiocarbon dates and time-sensitive artifacts (e.g. trade beads, projectile point styles). Thus, for example, at Meier and Cathlapotle, all materials recovered only from house walls can be compared; all precontact midden deposits can be compared or treated as an analytical unit separately from all post-contact midden deposits. High and lower status house segments can be compared, or houses can be treated as analytical and comparative units. This also permits comparisons among AUs using all of the AUs' contents (e.g. artifacts, animal remains, plant remains).

Depositional/Architectural AUs

- Interior: contexts within houses (Figures 1.10, 1.12, and 1.14-1.15)

  - Bench (Figure 1.12): Meier: deposits beneath sleeping platforms

  - Pit/Cellar (Figures 1.12 and 1.14): Meier: deposits within massive trench-like pit complexes extending the length of the houses between bench and central hearth row. These features were 1-2 meters deep. Bench/Cellar: Cathlapotle: At Cathlapotle, the pit complexes were beneath the sleeping platforms so the site lacks separate Bench deposits. Hearth/Periphery: Meier and Cathlapotle, deposits in and around the

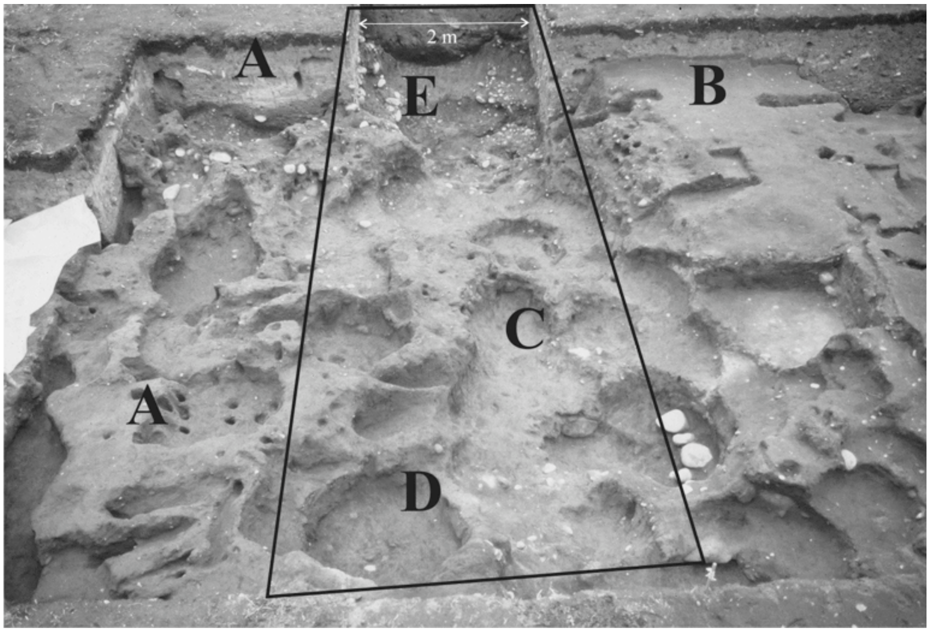

Figure 1.12. Block excavation of the southern section of the Meier house looking south showing facilities: A) hearth periphery with storage pits and plank-molds beneath where central hearth boxes had been located; B) Bench or area beneath sleeping platform; C) pathway under the Meier floor in the cellar (large rectangle); D) Pit rim constructed from mix of pitfill and silt clay loam substrate; E) pit rims constructed of planks as in drawing (Figure 1.10).

central hearths, not in pits. This AU is subdivided by individual hearth.

- Wall (Figure 1.15): Meier and Cathlapotle: deposits within trenches for exterior house wall.

• Exterior: contexts outside houses (Figure 1.17)

- Midden and midden lobes: Meier and Cathlapotle (Figure 1.18): refuse and artifact rich dumps (secondary refuse aggregates [Wilson 1994]), secondary deposits, high organic content, lenses of mollusk shells. They are the product of “deliberate and sequential accumulation of refuse at one location (Needham and Spence 1997: 80).” At Cathlapotle midden accumulated in deposits between structures and formed deep lobes extended in front of them and sometimes burying portions of older houses. At both sites, midden also accumulated on stream banks in front of the community.

- Sheet midden: Cathlapotle: wide thin lenses rich in charcoal, organics, artifacts, hearths, etc (identical in color etc to midden) interbedded with culturally sterile overbank (flood) sediments in front of Cathlapotle houses. These contained many small hearths, earth ovens and isolated

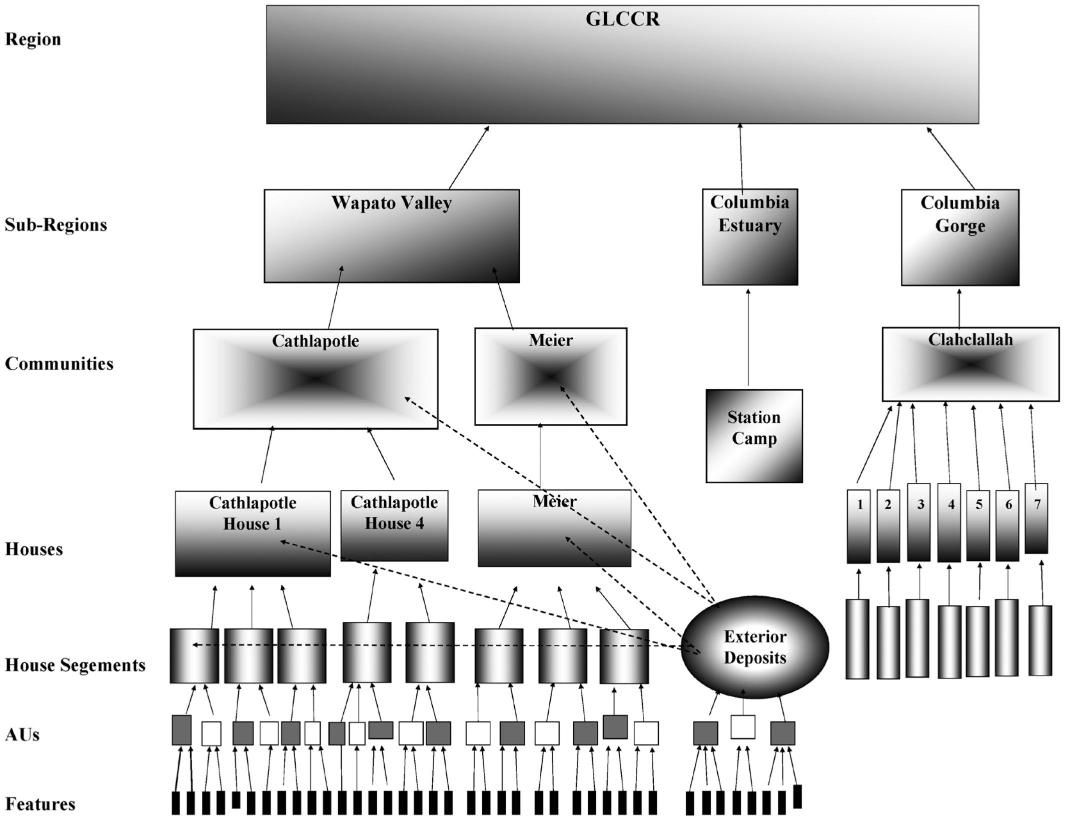

Figure 1.13. The scalar relationships among the data sets employed in the project. The analytical units at each level are comparable (features with features, site with sites). The alternating colors of the AUs indicates pre and post contact age. The small houses at Clahclellah have been compared with house segments at Cathlapotle but can also be compared with the complete houses; the position of Station Camp is ambiguous in terms of this diagram since it does not appear to represent house or village deposits but a specialized trading locality. The diagram does not fully separate all exterior deposits. Exterior deposits can be linked to specific structures; however, at Cathlapotle, not all those structures were excavated. These will be analyzed separately to understand intrasite variation and change across the site and aggregated to make comparisons at the community level.. That linkage can be made for Cathlapotle houses 1 and 4 and for Meier.

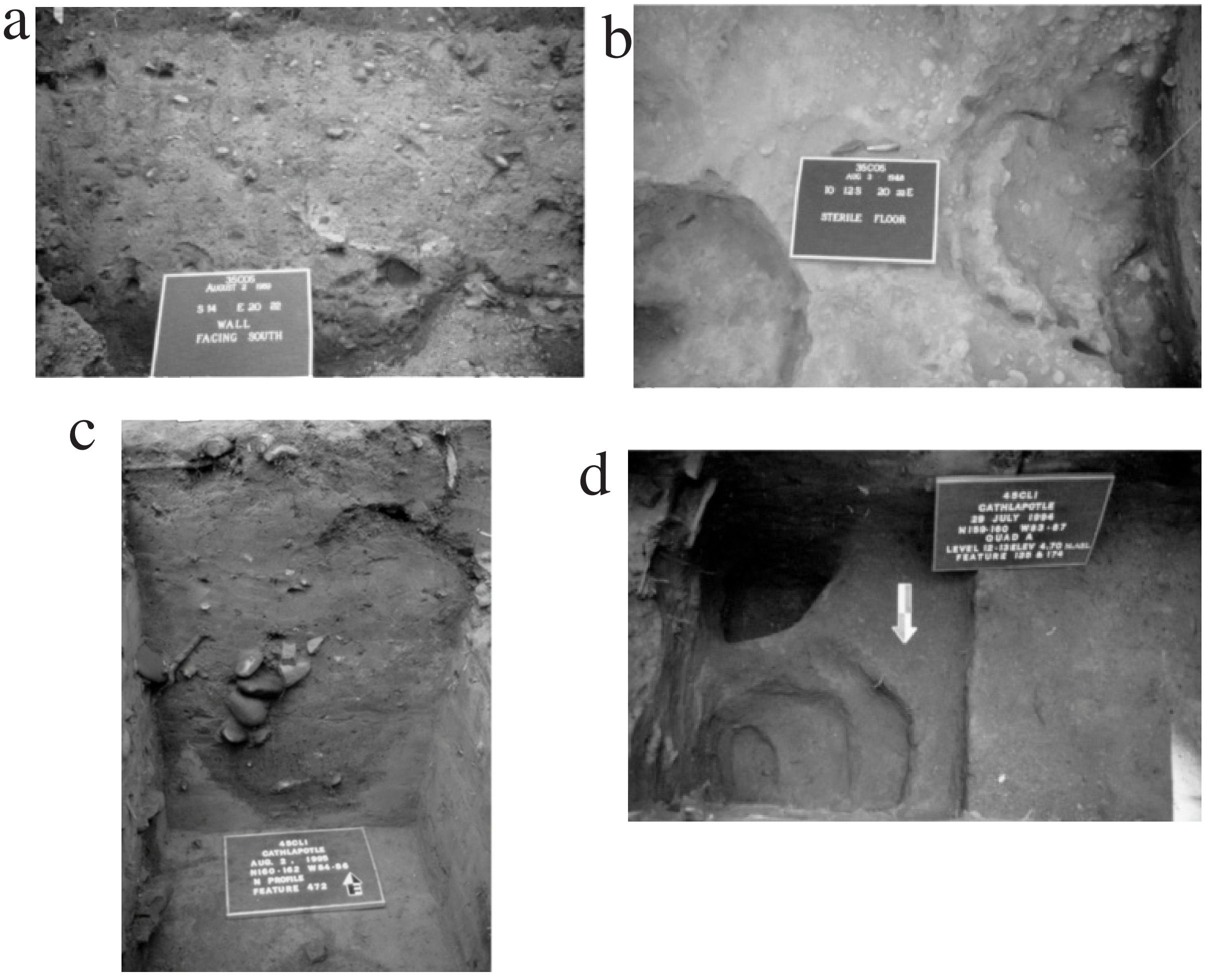

Figure 1.14. Meier and Cathlapotle Pit/Cellar features: a) Meier pit fill, b) planked pit rims on the floor of the Meier cellar; c) Cathlapotle pits becoming visible; d) excavated pit bottoms, note multiple intersecting pits.

structural features (postholes, plank molds, etc.). This class is similar to Wilson's "sheet trash (Wilson 1994: 43 – 44)." The layers merge with midden deposits. It is possible to subdivide this AU stratigraphically and temporally. The apparent absence of sheet midden at Meier may be a consequence of sampling or the effects of looting.

- "Yards": Exterior, non-midden cultural deposits at Meier. Artifact bearing but very low in organic content; lack the hearths and ovens found at Cathlapotle.

- Toft: Exterior deposits resting against the house walls and presumably beneath the overhanging eves of the houses (e.g. Hayden and Cannon 1983). Toft deposits are present at Meier and Cathlapotle.

Midden and sheet middens at both Meier and Cathlapotle can be stratigraphically associated with particular houses and house segments (e.g. Beck and Hill 2005). Meier contained only one house, so all exterior deposits are linked to that house. At Cathlapotle, sheet midden can be stratigraphically directly linked to House 1. The midden lobe associated with house 1 is between House 1 and 2 and so was probably produced by occupants of both houses. Part of this lobe buries an early portion of House 4.

House Segments

The houses are subdivided into analytical segments based on Northwest Coast archaeological practice and architectural evidence. These seg-

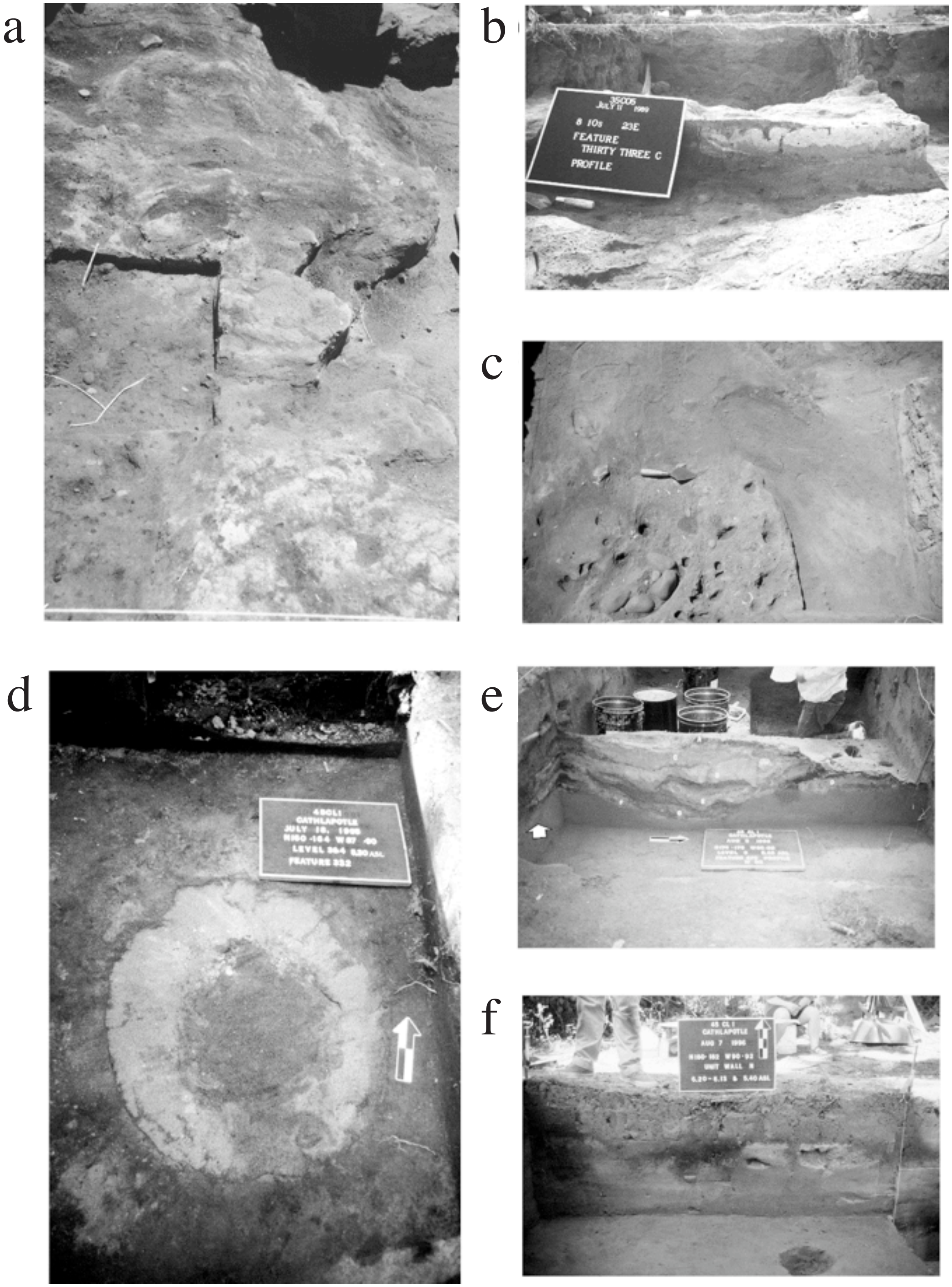

Figure 1.15. Hearths and hearth peripheries. a) Excavation of bottom of hearth box at south end of Meier house; b) Bisected hearth bowl and indurated ash, Meier; c) Hearth periphery with multiple post or peg holes, Meier; d) A central hearth showing lahar lining, House 1d, Cathlapotle; e) Hearth box, House 1c, Cathlapotle; f) Hearth on floor of House 1b, with lahar lining, Cathlapotle.

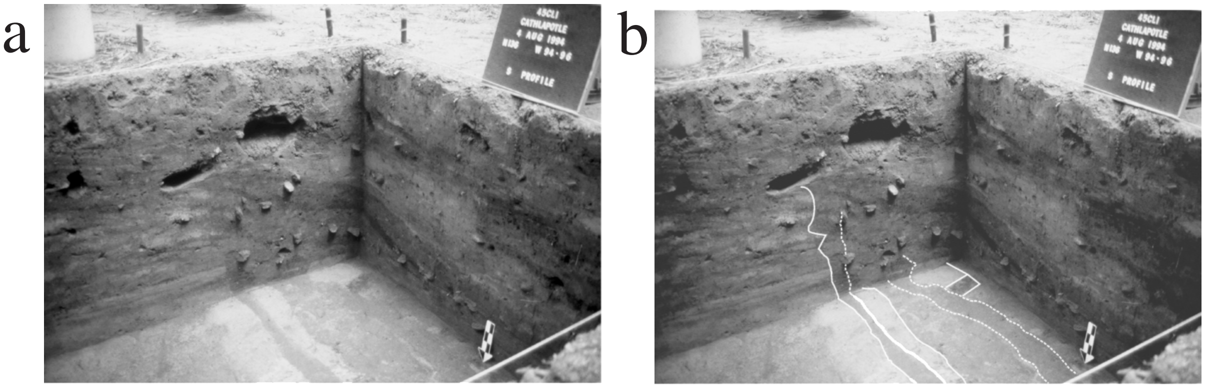

Figure 1.16. Cathlapotle wall trench, north wall House 4. a) original image; b) wall trench settings and resetting marked in white lines and white dashed lines which indicate less certainty in placement. The wall trench transects sheet midden visible at image right.

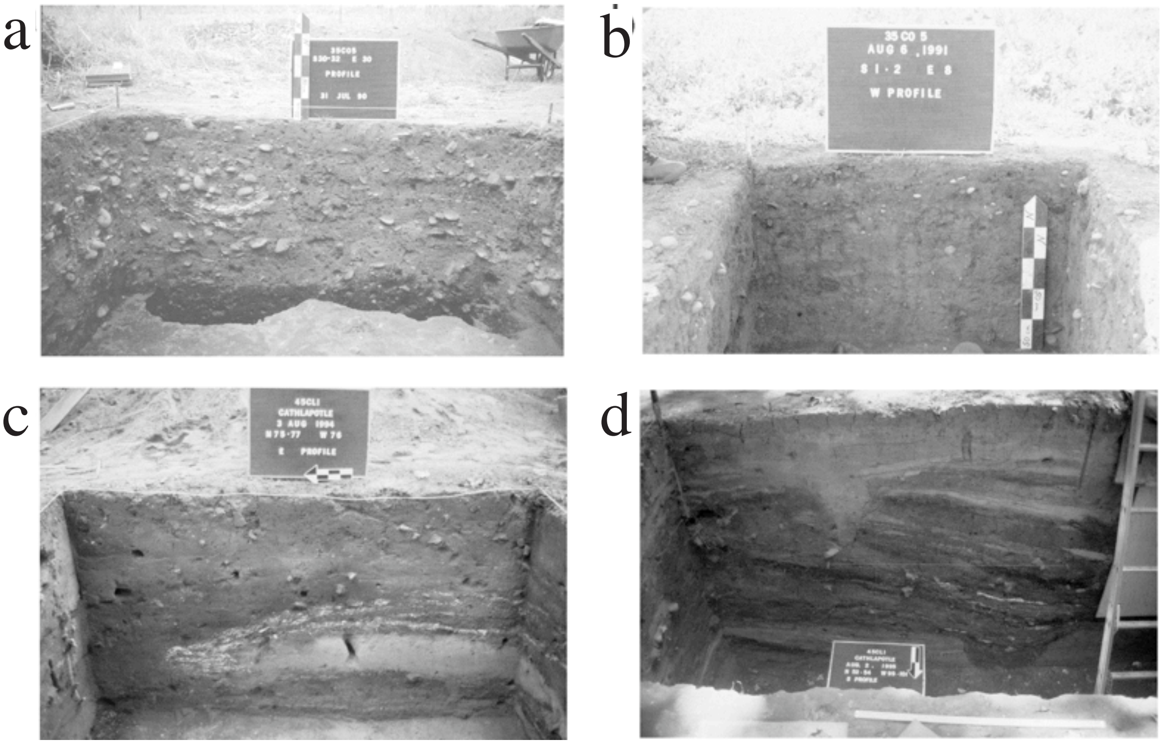

Figure 1.17. Meier and Cathlapotle midden and yard deposits. a) Meier midden southwest of the house, b) Meier exterior deposits, note the contrast between a and b in relative stoniness, c) Cathlapotle Midden Lobe B, with shell lenses and truncated overbank deposits, d) sheet midden west of House 6, House 6 wall trench is visible near the top of the profile.

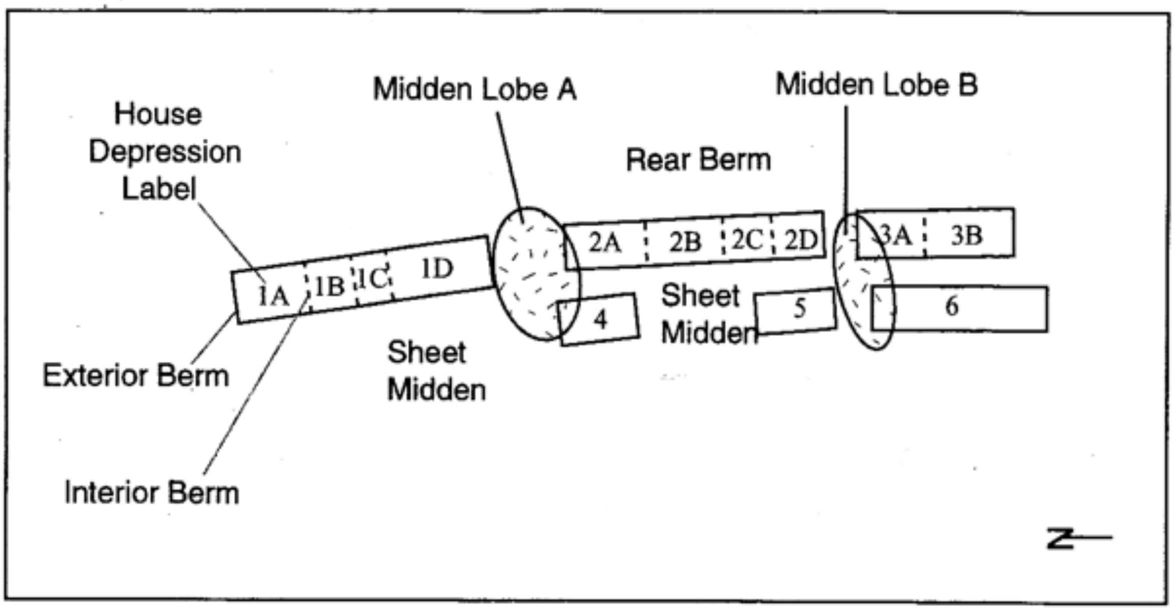

Figure 1.18. Cathlapotle schematic indicating major topographic/depositional units and house segment labels.

ments are have been used to investigate social and economic differentiation within the houses. At Meier, the segments are based on hearths (Figure 1.11). These are somewhat arbitrary but follow wide spread practice on the coast. Ethnographic evidence indicates that members of extended families shared a hearth (Sobel 2004). Cathlapotle House 4 is also analytically segmented this way. Cathlapotle House 1 was comprised of four compartments, each separated from the other by a wall (Figure 1.5). Three of these compartments were sampled (Figure 1.6). Based on its size and contents, segment 1D was the high status portion of House 1 (Sobel 2004). At Meier, we believe the northern most segment was the high status end of the house (Smith 2004). All AUs are identified by house segment.

The Clahclellah houses each contain a single hearth (Figure 1.8), and Sobel (2004) treated each separately. In her analysis she compared the Clahclellah houses with the house segments at Cathlapotle. Smith compared the house segments at Meier with the house segments at Cathlapotle. The Clahclellah house contents can also be compared with the full house contents for Meier and Cathlapotle (i.e. the combined contents of all segments).

Chronology

Analytical units are dated with radiocarbon dates, the presence/absence of trade goods and stratigraphic position. Cathlapotle has 52 radiocarbon dates (Ames and Sobel 2009); Meier 19. In many contexts at Cathlapotle, glass trade beads appear abruptly in the deposits 70 cm below the modern surface (Figure 1.7). This is particularly so in the sheet midden. It is therefore often possible at Cathlapotle to possible to separate the deposits into three chronological blocks stratigraphically: No trade goods, only metal, metal and glass beads. This sequence matches the popularity trends of European trade goods (Gibson). Effectively, however, the deposits are divided into pre and post-contact deposits. The upper 70cm of deposits can also be arbitrarily divided. At Meier, while there is less clarity in the deposition of trade goods, it is similarly possible to identify pre and post-contact deposits.

Ames and Sobel (2009) date the initial occupation of Cathlapotle to ca AD 1450, although there are earlier radiocarbon dates. Trade goods suggest a terminal date ca. mid 1830s which is line with the town being abandoned as a consequence of the malaria epidemics of the early 1830s. The Meier house was build ca AD 1400-1450. An analysis of the ceramics at both sites (Cromwell 2010) shows they were both occupied

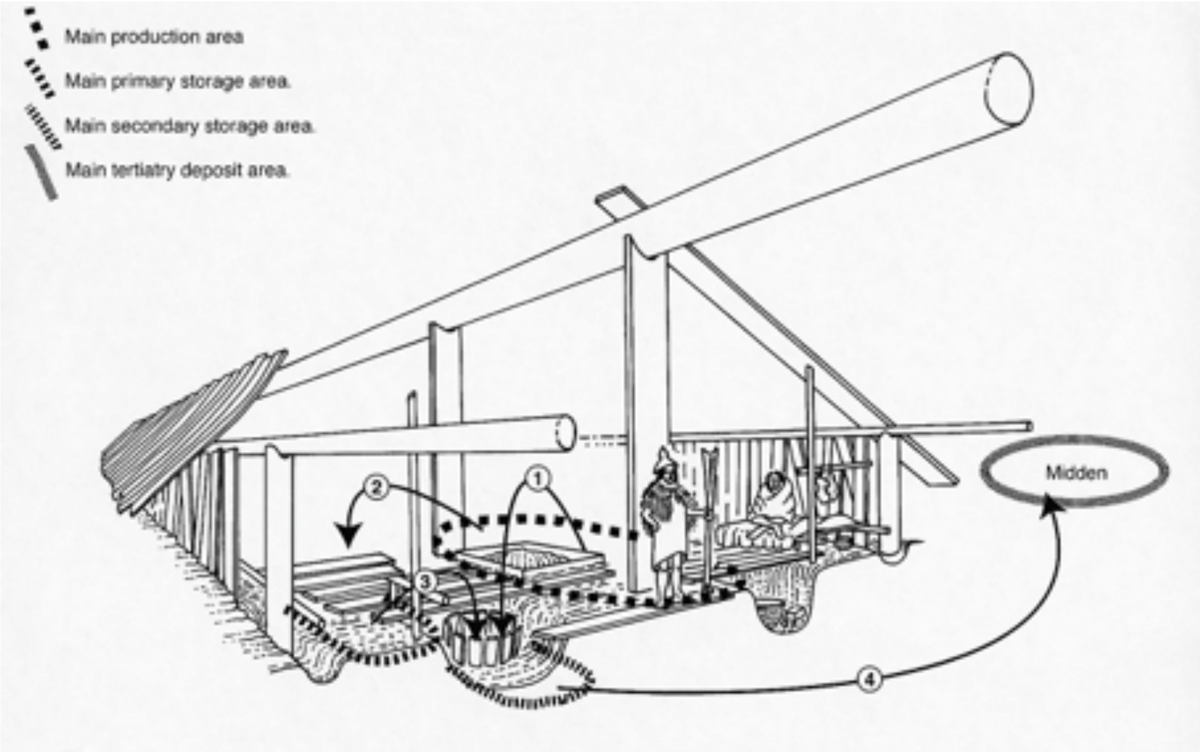

Figure 1.19. Model of debris flows through the Meier/Cathlapotle plankhouses.

during the early years of the fur trade and there is evidence suggesting people at Meier responded to the fur trade in interesting ways (Fuld 2011). On the other hand, the site has a relatively small number of trade goods when compared to Cathlapotle and Middle Village leading to the inference it was abandoned sometime earlier than Cathlapotle, perhaps ca. 1820 – 1830.

Site Formation Processes

A central methodological issue has been understanding site formation processes at Meier and Cathlapotle (e.g. Ames 2008, Hodges and Smith 2002, Smith 2006). The large pit complex/cellar features have been a particular concern since they appear to be unique (Ames et al. 2008) and functioned both as storage facilities and as artifact, food, food waste and debris traps. We developed a model of debris flows through the houses (Figure 1.9) and hypothesized that the pit features served in part as staging areas for trash etc. prior to its moving to exterior dumps. Smith (2006) evaluates a range of taphonomic processes that might have affected the in-house deposits.

To better understand the formation processes at work in and outside these structures, sediment samples from both sites were processed (White 2010). The parent material for both sites is alluvial silty sand, which accumulated slowly. The key difference between the two sites is that Meier sediments contain about twice the organic matter as Cathlapotle. Organic matter is rather uniformly distributed at both sites (across the cellars, middens, and sheet middens). Deposits with very high organic content occur both in the cellars and in the middens at both sites, but overall, levels of organic matter and other constituents are homogeneous across each site.

We also looked at how different artifact classes were deposited. We learned that different classes of material and artifacts followed different pathways. Some generally stayed in the houses (e.g. complete projectile points); others (e.g. thermally altered rock) moved from the hearths ultimately out to the middens (Ames 2008). We also discovered that functionally related tool categories (cores, hammerstones) did not follow similar pathways. Thus our model was broadly correct, but the reality was much more complicated.

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PREFACE

Kenneth M. Ames

The reports in this volume are analyses of the three major classes of archaeological features at Meier and Cathlapotle; Shepard on architectural features (post holes, plank molds etc.); Gardner-O'Kearny on fire-related features (hearths and ovens) and Butler on the storage pit complexes/ cellars at each site. Both sites are extremely rich in features. They are central to the household archaeology research questions animating the excavations so their recovery was a major focus of the excavation effort. Additionally, we wanted to go beyond the standard reporting of features, where there might only be a table of features with basic information such as size but not always much else.

Household archaeology has become a consistently important form of "middle ranging" theory (Trigger 2006) in archaeology. Trigger uses the phrase "middle ranging" since Binford had claimed "Middle Range theory." At its broadest and simplest, middle ranging theory is "all approaches used to infer behavior or beliefs from archaeological data (Trigger 2006: 508)." Household archaeology is a loosely structured set of inferential theories rooted in ethnography, ethnoarchaeology and social sciences more broadly combined with evolving archaeological field and analytical techniques. Anthropologists have long been interested in houses, households and domestic production. (e.g. Morgan 1881, Rapoport 1969, Sahlins 1974, Flannery 1976). Another side of that interest derives from Levi-Strauss' (1983) concept of société à maison (House societies) (e.g. Carsten and Hugh-Jones 1995). Much of current household archaeology grows out of seminal volumes and papers published in 1982 and 1984 (Wilk and Rathje, 1982; Netting, Wilk and Arnoud 1982) by Robert McC. Netting, Richard Wilk, William Rathje and others.

Following Wilk and Rathje (1982) households have three elements: they contain a social unit of some sort; they are materially manifested by dwellings, activities areas and possessions; and they have functions they perform, they do things. These functions (Wilk and Netting 1984) include production, distribution, transmission (or inheritance), reproduction (both biological and cultural, which includes cultural transmission) and coresidence. Wilk and Rathje's notions of reproduction and transmission need to be updated in light of recent theoretical developments in cultural transmission (e.g. Richerson and Boyd 2005), but that task is outside the scope of this essay. A strength of this approach is making it possible to investigate households as a basic unit of human social and economic organization without necessarily having to solve the archaeologically (and even ethnographically) difficult issue of how the household was organized (but see Hendon 1996). Douglass and Gonlin (2012) have usefully described several interacting dimensions of household archaeology and five major current research issues which encapsulate the WVAP's household approach. The dimensions are household form, function, domestic architecture and economic organization. The research issues they identify are what they term households as portals into societal trends, engendered households, households as primary producers, household inequality and differentiation, and households as craft producers. I would add a sixth issue, which is houses and households as taphonomic or site formation agents in archaeological sites. At their simplest, the issues addressed by the three reports here are architectural form (Shepard); household form (Shepard and Gardner-O'Kearny), production (all three). However, they touch on virtually all of the dimensions and issues. They do this using features.

Features are challenging aspects of the archaeological record. They are artifacts that exist post-excavation solely in the excavation records and post-excavation analysis is entirely dependent on the quality of those records. Unlike a chipped stone tool, features cannot be bagged, numbered and stored in a drawer for future study, although durable parts can be, such as wooden stakes, fcr, bone and ash. Their boundaries, shape and contents are consequences of in-field decisions and the skills of the excavators as much as they are of some objective reality. At what point does the scatter of fire cracked rock become an fcr concentration? Where are the edges of the pit? Is the "feature" anthropogenic or a consequence of bioturbation, depositional processes and so forth? Features are at the heart of the archaeological concept of context; objects that exist only in the spatial relationships among other objects. Pits are even more difficult; they are voids that may or may not have been filled in.

Cathlapotle and Meier have abundant features. Their recognition, excavation and recording were among the principle challenges to the field school students. One pair of students spent an entire seven weeks excavating the center of the massive hearth feature at the south end of the Meier house, struggling through indurated ash and multiple baked hearth bowls stacked one on the other. Other students coped with overlapping post molds that appeared in the damp morning soil, only to fade rapidly as the dirt dried out while yet other students dissected intersecting and overlapping storage pits, all filled with the same mix of organics, ash and fcr.

The features also presented fundamental methodological challenges in excavation design. Excavation unit size, distribution and shape materially affects the feature record. Features are essentially spatial relationships; a single post hole is far less informative than a row of them. They are subject to edge effects – is the little blob on the corner a small feature or the tip of an iceberg. Increasing numbers of edges increases the numbers of features. They are three-dimensional objects which we intersect using two-dimensional planes thus the shape of the feature as exposed may not be the shape of the feature-as-object. If the reader wants to explore this, take a large zucchini and slice it in various ways and look only at the resulting surfaces to reconstruct the original form, then do the same with a block of cheese. Features of differing sizes raise significant sampling issues.

Archaeological data are multiscalar, ranging for microscopic (e.g. pollen) to macroscopic (e.g. the Great Pyramid). Sampling must therefore also be multiscalar. Inevitably some data and scales of data will be privileged over others. Decisions about which scales to privilege should have three bases: 1) the purpose of the data retrieval, 2) scientific questions being asked and 3) the archaeologist's obligation to retrieve and report a basic set of archaeological data that are useful to her colleagues. We were conducting research into the functioning of large households; therefore we had to sample at the household level while retrieving artifacts ranging in size from plant macrofossils to houses.

We eventually solved the sampling issues by increment sampling. As noted in Section 1, the basic excavation unit at both sites use a 2x2m unit. In 1987 and 1988 at Meier, this was also the basic record keeping unit. In 1989, the basic record keeping unit was a 1x1 (which was always part of a 1x4 or 2x2). The 2x2 is a reasonable compromise among a number of demands, including exposing features. We screened all sediments through ¼" mesh, with one quadrat (1x1) of each unit screened through 1/8th" mesh. That proved to be so slow with field school students that it was abandoned. We were also collecting 5L bulk samples for water screening from the same quadrat we were 1/8th" screening and that was accelerated. We ended up taking close to 1700 bulk samples from Meier from levels and features. We tried the experiment with 1/8th" mesh again at Cathlapotle, coupled with bulk sampling and abandoned 1/8th" mesh entirely after the first season, moving the system of 10L bulk samples water screened through nested screened described in Section 1. The decision to stop using 1/8th" mesh may have been controversial beyond the project, since at least one archaeologist accused us to our faces of being unprofessional for not using 1/8th" mesh. For that reason, and since it is directly relevant to the topic of mutliscalar sampling, it is worth explaining that decision a little more detail.

There were two primary reasons for the decision: time and precision. Field school students sort 1/8th" mesh spoils very slowly with no apparent increase in precision; especially under variable light conditions (sunlight, shade) and moisture (dry, damp, pouring rain). These houses are both large in area and deep. Excavating large-scale entities such as houses requires large areal exposures. They are stratigraphically complex, necessitating lengthy stratigraphic profiles. Accomplishing this necessitates moving dirt. Screening through 1/8th" mesh essentially privileged small scale data, e.g. smelt bones, over large scale data; e.g. identifying activity zones within the houses. The increment sampling allowed us to do both: collect small-scale data and across large areas and permitting us to retrieve large samples of the features discussed in this volume.

A considerable amount of field time was devoted to features: recognizing, defining, pursuing, and recording them. Basic terminology and definitions were based on Fladmark's 1978 guide to field procedures and the British Columbia Heritage guide to recording archaeological data (Loy and Thomas 1977), both modified to meet our needs. Our recognition of plank house architectural features was heavily reliant on feature data from Ozette, especially Mauger's (1978) data on the size and shape of the structural elements of the Ozette houses. Ozette generally was important for understanding plank houses as deposits (Ames 2006). We were also guided by the plan views of the Clahclellah houses in Minor et al. 1989. Ames et al. (1992) presents the state of our knowledge at the end of the Meier excavations of the house features. In a sense, we were building Middle Range theory about recognizing plank house features based on Ozette's extraordinary preservation. Cathlapotle introduced us to the variability in layout among houses, but the basic structural features remained the same.

In contrast, Cathlapotle presented us with far greater diversity among fire features. At Meier, we dealt with hearths and hearth fragments but we did not encounter earth ovens, for example. At Cathlapotle, there was greater variability among hearths and new features, including ovens. New feature classes or subclasses were defined as necessary in the field. The concept of "hearth" became particularly problematic at Cathlapotle which contains massive prepared hearths in houses, fires built on house floors, as well as small temporary fires outdoors. This variability however fell within the range of variation archaeologists in the Northwest normally encounter across a range of sites.

The storage pit and storage pit complexes described by Butler in this volume were, on the other hand, unique in our experience.

All features were classified, if possible, given a feature number and recorded in a feature catalog with basic data (number, date, provenience, size measurements, recorder), on a feature sheet (on which they were mapped), on level forms and in the excavator's note books. Feature sheet data included feature contents, all measurements, associations (other features), detailed provenience data, Munsell colors, all photo numbers, and samples taken (including sample numbers). The feature sheet was maintained while the feature was present and closed when the feature ended. At that point, it was attached to the level form for the excavation level in which the feature first appeared and its number assigned.

After excavation, the feature forms were reviewed at least twice and some features decataloged based on information in the forms, note books, or level forms. Descriptions were reviewed and classifications changed if needed. Feature forms and level forms were separated and filed separately. The paper feature catalogs were transcribed into Excel files.

The three broad categories of features described in these reports are the most common we encountered and the most important in the field and subsequently for developing working hypotheses for the layouts of the houses, their internal organization and how that organization may have changed through time. Shepard's analysis of architectural features: post holes and post molds, plank molds, wall trenches, etc. was initiated as a test of the models we had developed during excavation of the sizes and interior layouts of the Meier and Cathlapotle structures (e.g. Ames et al. 1992, 1999). There had been no formal analyses of these features. Sobel (2014) digitized and reproduced the feature maps for the units she sampled for her artifact study, but she did not investigate or test the house form model for Cathlapotle, and Meier was not in her sample. Shepard took the data she developed to extend the project's long-term interest in the labor costs (as represented by the volume of wood) of these houses (Ames 1996, Gahr 2006, Ames et al. 1992). She has taken the issue well beyond its original conception in political ecology as the reader will see.

Gardner-O'Kearny's study of fire features began as an effort to go beyond a listing of hearths and their provenience, which led him to a consideration of such things as the edge effect in shaping our understanding of the numbers and forms of features. His study includes not only fire features, such as hearths and ovens, but also mammalian remains associated with interior or household fires in order to say something about the behavior around the fires. The study does not include artifacts since, at the time of his work, all of the lithic artifacts were being reanalyzed and reclassified and adding them would have turned what was a thick MA thesis into something on the scale of a large dissertation. The implications of his work, as with the other reports, will be considered in the postscript to this volume. However, his analysis of changing hearth sizes and number pre and post-contact has significant implications for our knowledge of the effects of contact in the region.

The storage pits/cellars (Ames et al. 2008) analyzed by Butler are probably the most significant empirical discovery of the project. Archaeologists have found storage pits associated with houses throughout North America, and many so-called rubbish pits were probably originally storage pits. Houses in the Southwest had rooms devoted to storage, but subfloor storage at the scale of these seems rare. Storage in Northwest Coast houses was usually in the form of food hung from the rafters and in boxes and baskets set on the sleeping platforms ringing the house. The questions arising here are why subfloor storage at all – especially in an area subject to annual flooding – and why so much. I will return to these and other issues in the postscript. Butler includes the artifacts recovered in the pits in her study. That portion may be subject to revision since the artifact classes she used were provisional and they have been reanalyzed and classified.

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PART II

BUILDING AND MAINTAINING PLANKHOUSES AT TWO VILLAGES ON THE SOUTHERN NORTHWEST COAST OF NORTH AMERICA

Emily E. Shepard

ABSTRACT

Plankhouses were functionally and symbolically integral to Northwest Coast societies, as much of economic and social life was predicated on these dwellings. This report investigates plankhouse architecture, and also examines how actions entailed in production of these dwellings articulated with household economy and continuity. Studying plankhouse construction and maintenance provides information regarding everyday labor, landscape use outside of villages, organization of complex tasks, and resource management.

This report investigates three plankhouse structures at two sites, Meier and Cathlapotle, in the Lower Columbia River Region of the southern Northwest Coast of North America. Methods consisted of digitizing over 1,100 architectural features, creating detailed maps of architectural features, and conducting statistical and spatial analysis of these features. I use ethnographies, historical documents, experimental archaeology, and ecological studies to characterize the processes of plankhouse production. This information is combined with excavation data from Cathapotle and Meier to calculate estimates of material and labor required for plankhouse-related activities.

Results of this study support previous inferences regarding house architecture, construction and maintenance at the two sites. Structural elements were frequently replaced, yet house appearance changed little over time. Results hint at possible, but unconfirmed, changes in house orientation over time at Meier. Some differences in structural element use and size are noted between the two sites, suggesting that slightly different building techniques may have been employed at the two villages.

Although approximate, calculations of raw materials and person days required for various building tasks provide a glimpse of the massive undertaking entailed in constructing and maintaining plankhouses. These data suggest that an enormous amount of trees were required for construction and maintenance over house occupation, approximately 700-1,200 trees at Meier, 900-2,000 trees at Cathlapotle House 1, and 150-400 trees at Cathlapotle House 4. Estimates of minimum person days for initial construction range from 1,400-2,800 at Meier, to 2,100-4,500 at Cathlapotle House 1, to 350-700 at Cathlapotle House 4. In highlighting the articulation of plankhouse labor with household reproduction, this report demonstrates the important interplay between material outputs, everyday action, and sociopolitical aspects of Northwest Coast society.

ACKNOWLEDGEMENTS

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CHAPTER 1
INTRODUCTION

Plankhouses were at the heart of political, social and economic life for people of the Northwest Coast. Each structure was home to a household group with a distinct identity and traditions. Large cedar plankhouses were not only dwellings, but served a myriad of functions including storage facilities, ceremonial stages and centers of production. Construction and maintenance of plankhouses, which could stand for hundreds of years and house dozens of generations, entailed major investments of raw material, human effort and social capital. Although the importance of plankhouses on the Northwest Coast is well known, only a few studies have been able to use archaeological data to investigate their architecture or to examine labor involved in building and maintaining these structures over their long use lives.

In this report, I argue that in addition to the cultural importance of plankhouses within Northwest Coast societies as ‘finished products’, the actual process of plankhouse production was significant, and can inform our understandings of these groups in various ways. The massive input of labor to construct the dwellings embodied the house founders’ economic, social and political power. Hence, sustained labor investment in houses affirmed commitment to the household and displayed the group’s continued economic prosperity. Labor activities involved in building and maintaining plankhouses constituted a major ongoing task for household members and so can give us a better understanding of everyday work activities and organization. Harvest of cedar for housing occurred in forests, and so provides an opportunity to investigate activities that transpired outside of villages. Understanding how Indigenous peoples extracted cedar from the landscape can also increase knowledge of resource management practices. Furthermore, archaeologically visible signatures of plankhouse labor can be used to characterize the organization of other communal work endeavors that are harder to detect from material remains, such as fish, tuber and berry processing.

This report focuses on two plankhouse village sites in the Lower Columbia River Region (LCRR) of the southern Northwest Coast, Meier and Cathlapotle. Although structures at the villages are long gone, evidence of materials utilized and house design are found in architectural features recorded during archaeological excavations. I use GIS maps and statistical tests to examine morphological attributes of structural elements and to test prior models of house architecture, repair activities, and physical continuity. I apply these data to develop estimates for the amount of labor involved in constructing and maintaining plankhouses at Meier and Cathlapotle. This includes quantifying materials and time, as well as characterizing the skills and knowledge workers needed for house construction. Throughout this report, I address the role of plankhouse architecture in LCRR groups using the framework of household archaeology. I also employ ideas from political economy to consider the broader implications of plankhouse production.

I begin with a description of Meier and Cathlapotle and briefly summarize prior relevant research at these sites (Chapter 2). Chapter 3 discusses political economy and household archaeology and their significance to this project. In Chapter 4, I discuss research questions, expectations and methods. Subsequently, I present results associated with seven questions designed to investigate plankhouse structural features and architecture at Meier and Cathlapotle (Chapter 5). I then briefly digress from results to review Northwest Coast plankhouse building and repair processes (Chapter 6), drawing from other archaeological studies, historical documents and ethnographies. I also outline pertinent information concerning western redcedar ecology, distribution and characteristics. Information from this chapter is then applied to data from Cathlapotle and Meier to quantify and characterize labor tasks associated with household construction and maintenance (Chapter 7). In Chapter 8, I consider plankhouse architecture in relation to LCRR households and situate plankhouse production within socioeconomic aspects of these groups, and also discuss potential directions for future research. In Chapter 9, I conclude by arguing that labor involved in the production of plankhouses is deeply intertwined with socioeconomic aspects and continuity of LCRR households. Two appendices are included: Appendix A, which details architectural features in the Meier and Cathlapotle databases, and Appendix

B, which provides further information regarding calculations of raw materials used in plankhouse construction.

CHAPTER 2
MEIER AND CATHLAPOTLE

Site Contexts and Excavation Backgrounds

Meier (35CO5) and Cathlapotle (45CL1) are located in what has been termed the Wapato Valley, an area of the LCRR (Figure 2.1) that was densely inhabited by around 8,000 people when Europeans first arrived in the early nineteenth century (Ames et al. 1999). Groups in this region lived in winter villages and traveled further afield in the summers for resource collection. Food was obtained by fishing, collecting plants, and hunting. Plants were also important for a variety of technologies.

Cathlapotle is located directly east of the Columbia River on what is now the Ridgefield National Wildlife Refuge. Cathlapotle was a large, multi-house site with an estimated population of 700 to 800 people (Ames 2008) (Figure 2.2). The village was occupied by Chinookan speakers and may have periodically increased in population with influxes of people from neighboring communities (Boyd 2011:177). Lewis and Clark, who visited the site in the fall of 1805 and again in the spring of 1806, describe Cathlapotle as a busy trading village containing 14 houses (Moulton 1990). Several historical accounts document the village during the protocontact era, where many changes in village demography and subsistence practices occurred (Boyd 2011).

Surveying, auguring and test excavations occurred at Cathlapotle from 1991-1993, and more extensive excavations were conducted by Portland State University field schools from 1994-1996 (Ames et al. 1999:23-34). Radiocarbon dating and historical documents demonstrate that occupation at Cathlapotle extended from approximately A.D. 1400 to 1832 (Ames and Sobel 2009). Approximately 240 m^3 of the site has been excavated. Excavation focused on two houses at the site: House 1, which measured 65.8 by 10 meters, and House 4, which measured 13.2 by 10 m.

Meier is situated near the town of Scappoose, Oregon. The single-house site lies two meters above a creek on a gravel terrace approximately two kilometers west of the Columbia Riv-

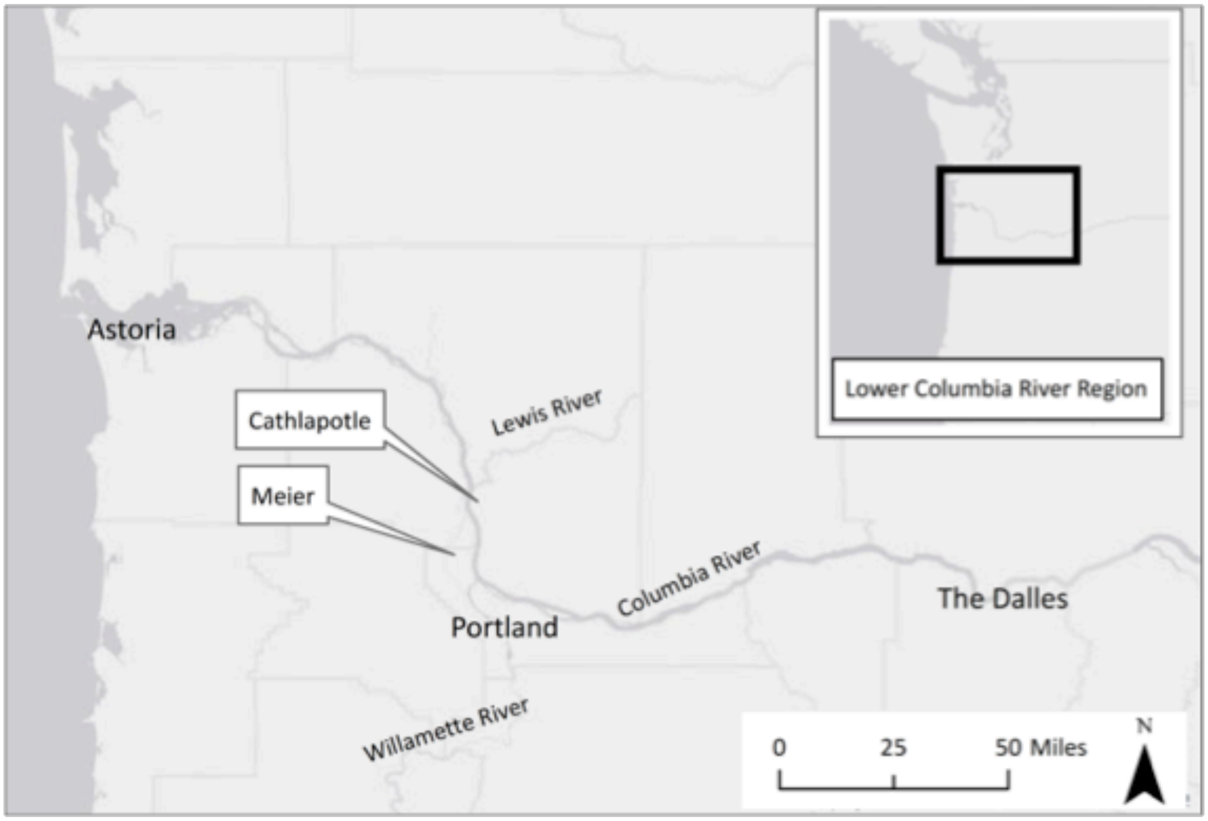

Figure 2.1. Lower Columbia River Region with Meier and Cathlapotle locations.

Figure 2.2. Cathlapotle house outlines with excavation units.

er (Ames et al. 1992). Unlike Cathlapotle, Meier was not recorded by early explorers. Meier was likely less of a trading hub in precontact times because of its positioning further from important rivers, although involvement may have increased during the postcontact fur trade (Fuld 2012). The first small-scale archaeological investigations at Meier were conducted by Pettigrew (1981) and Ellis (n.d). The site was more intensively excavated from 1987-1991 by Portland State University (Ames et al. 1992) (Figure 2.3). Radiocarbon dating places occupation of Meier from around A.D. 1400 to 1820 (Ames 1996). Approximately 160 m of the site has been excavated, mostly on the west side of the house. The Meier house was approximately 30 by 14 m.

Houses at each site are divided into facilities that served as analytic units, which are outlined in Table 1 (Smith 2006). These facilities are the same at both sites with two exceptions: bench and cellar facilities were combined at Cathlapotle and the berm facility was not used at Meier (this facility was either always absent or destroyed by plowing).

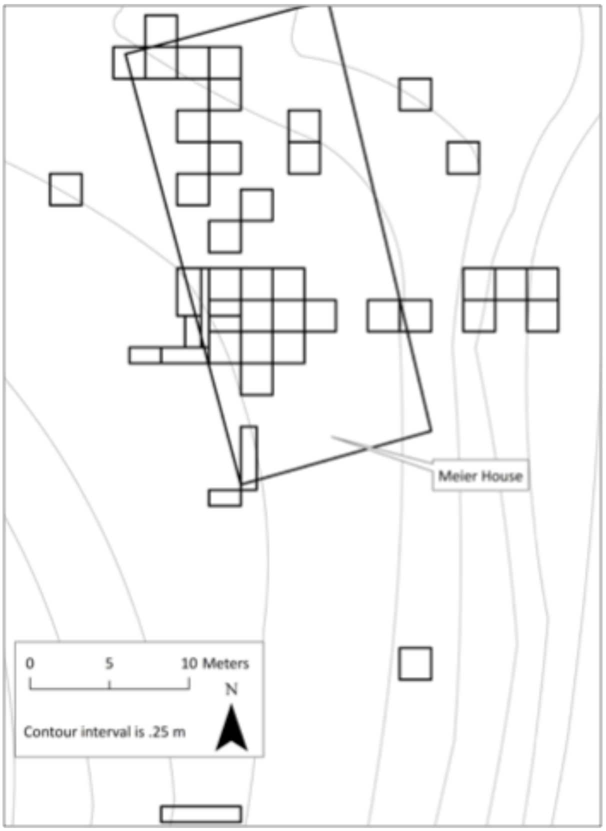

Figure 2.3. Meier house outline with excavation units.

Site Formation Processes

Numerous processes contributed to site formation at Meier and Cathlapotle. Schiffer (1972) draws a distinction between activities that occur during site occupation (systemic context) and after site occupation (archaeological context). Smith (2008) investigates both systematic and archaeological site formation processes at Meier and Cathlapotle, concluding that ongoing cleaning and maintenance by house occupants was a major systemic site formation process. Continuous occupation at the sites for 400 years necessitated replacement of posts and planks, as well as reexcavation, filling and cleaning of subterranean storage features. This resulted in complex stratigraphy, with intrusive younger features often obliterating sections of older features (Figure 2.4).

Site formation processes in the archaeological context that affect architectural features include rot and decay, lumber scavenging, bioturbation and plowing. Looting also occurred at both sites, although impact at Cathlapotle was

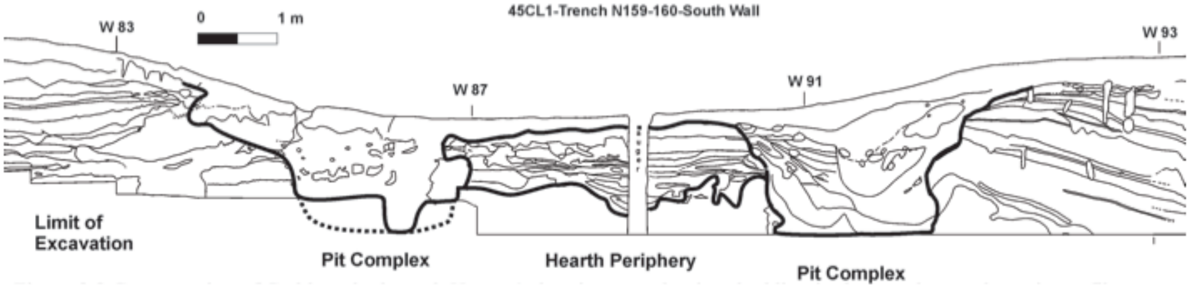

Figure 2.4. Profile of trench intersecting Cathlapotle House 1 (N159-160/W83-93) illustrating complex stratigraphy of house floors, hearths, walls and pits (figure based on Ames et al. 1999, Figure 11).

Table 2.1. Facilities at Meier and Cathlapotle.

Facility	Description	Location	Associated Elements	Feature Correlates
Wall	Walls of house comprised of vertical planks	Surrounding dwelling	Wall planks, ridge beam support posts, corner posts, rocks	Wall trenches, plankmolds, postmolds, postholes
Bench	Sleeping and storage of personal items	Ringing interior of house	Post and plank bench structures	Small plankmolds, postholes and postmolds
Hearth	Cooking fires, space for household activities	Center of house, parallel to long axis	Hearth boxes made of planks, drying racks	Ash lenses, plankmolds, small postholes and postmolds
Cellar	Excavated pits for storage	Cathlapotle: under benches. Meier: between hearths and benches	Storage pits, sometimes lined with clay or planks	Pits, small plankmolds
Yard	House exteriors, used for activities such as food processing	Outside house	Drying racks, earth ovens	Small plankmolds, postholes, postmolds and earth ovens
Toft	Areas of debris build up immediately outside the house	Outside walls under eaves, on top of berms	Rubbish	Debris concentrations
Berm	Ridges created by disposal of house fill and excavation spoils during construction and maintenance	Surrounding depressions	Rubbish, spoil soil	Debris concentrations
Sheet Midden	Rubbish disposal, sometimes processing activities	Outlying house exterior	Rubbish and accumulated yard debris from exterior activities	Small postmolds and plankmolds; thin, flat sediment strata and lenses.
Midden	Rubbish disposal	Outlying house exterior	Rubbish deposits	Deep debris mounds

minimal. At Meier, the eastern portion of the site was heavily looted. In addition to modern looting, architectural elements may have been scavenged and removed from the sites by early settlers. Other significant impacts to sites that likely occurred in the archaeological context resulted from natural forces, including trampling, decay, decomposition, bioturbation, and floods.

During excavation, variation in color between features and the surrounding soil matrix resulted in relatively easy detection of architectural features (see Figure 2.5 and Figure 2.6). Investigations at Cathlapotle benefit from exceptional feature preservation and stratigraphic integrity, partially resulting from repeated rapid alluvial deposition (Ames et al. 1999:81; Hodges and Smith 2002). At Meier, plowing obscured many remnants of shallow architectural features (Ames et al. 1992), consequently most features are related to the more-deeply buried house frame.

House depressions were affected by numerous systemic and archaeological formation processes. Villagers used natural topographic features formed by the meandering river as the basis of depressions, which were further excavated with the spoils added to natural crests. Depressions were accentuated by debris accumulation at the sides of houses during occupation, resulting in a sharper difference between excavated interiors and exteriors. At Cathlapotle, the west and east sides of houses are distinguished by berms composed of especially pronounced accumulations of house fill and debris, heightened by the accumulation of sediments from numerous minor flood events (Hodges and Smith 2002). Cathlapotle depressions 1, 2, 3 and likely 6 were divided by low

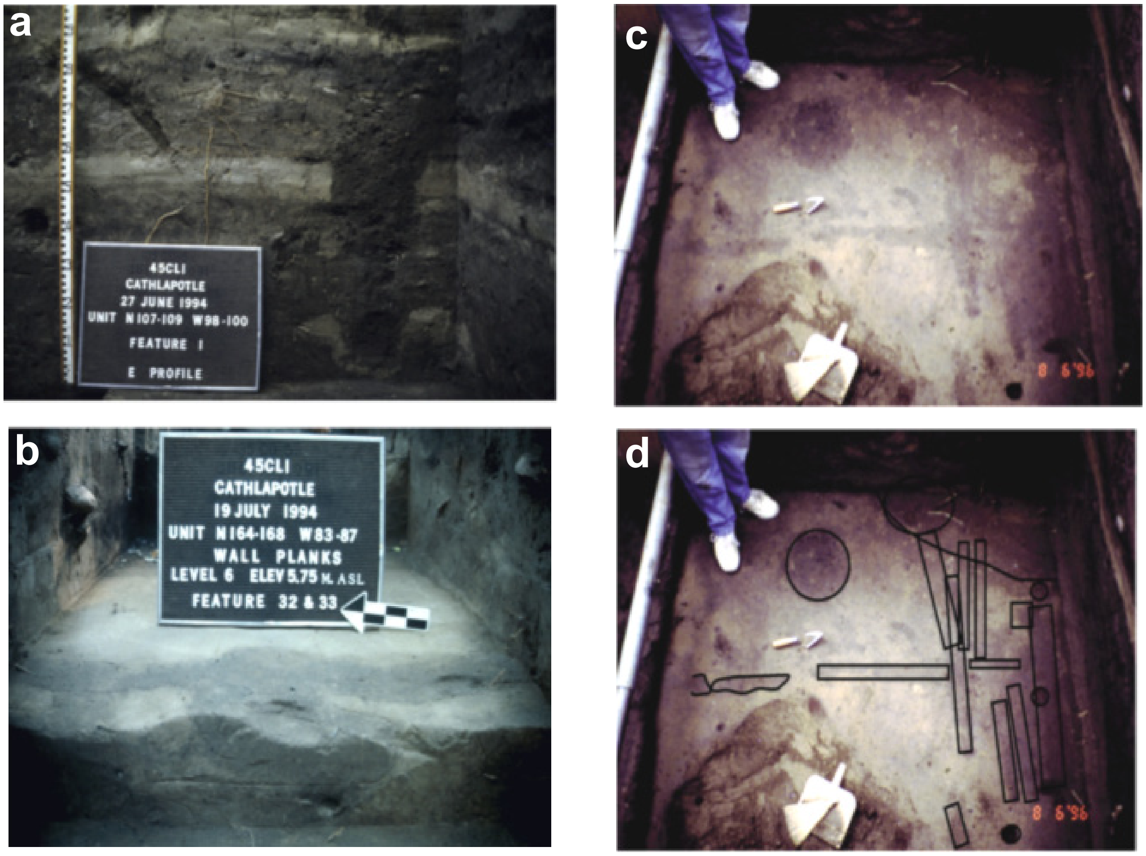

Figure 2.5. Examples of architectural features: (a) postmold in profile (b) wall plankmold in plan and profile (c) plankmolds and postmolds visible on the unit floor (d) plankmolds and post features outlined (figure drafted by Kenneth Ames).

ridges perpendicular to their long axis. Excavation revealed that these ridges contained plankmolds, indicating that houses were subdivided into separate compartments (Ames et al. 1999:37). Ridges in Depression 1 (the correlate of House 1) were separated by compartments labeled A-D (Figure 2.2).

Prior House and Household Research

Ethnographies and historical documents provide valuable information concerning LCRR houses. Although plankhouses throughout the Northwest Coast shared many similarities, elements of structures such as roof style and interior layout varied (Gahr et al. 2006; Suttles 1992; Vastokas 1966). Hajda's (1994) compilation of ethnohistoric sources in the LCRR demonstrates variability in village layout and house size, but similar building styles. Large, semi-subterranean, post-and-beam plankhouses were constructed from western redcedar (*Thuja plicata*), had gabled roofs and had vertical plank walls. Multiple large hearths were located in the central area of the houses, walls were lined with benches for sleeping and storage, and an oval hole served as the house entrance. Interiors were segmented by partitions according to rank, with the portion of the interior near the door often occupied by slaves or low status peoples.

Excavations at Meier and Cathlapotle confirm much of this ethnographic information and allow for elaboration. The floor of Meier was covered with planks for at least some of its existence (Ames et al. 1992). The discovery of high status goods in the south of Cathlapotle House 1 (Compartment D) and the northern section of the Meier house indicate that these areas were inhabited by elites (Ames 2008).

Spatial patterns of artifacts from Meier and Cathlapotle inform understandings of households in the LCRR. By analyzing distribution of

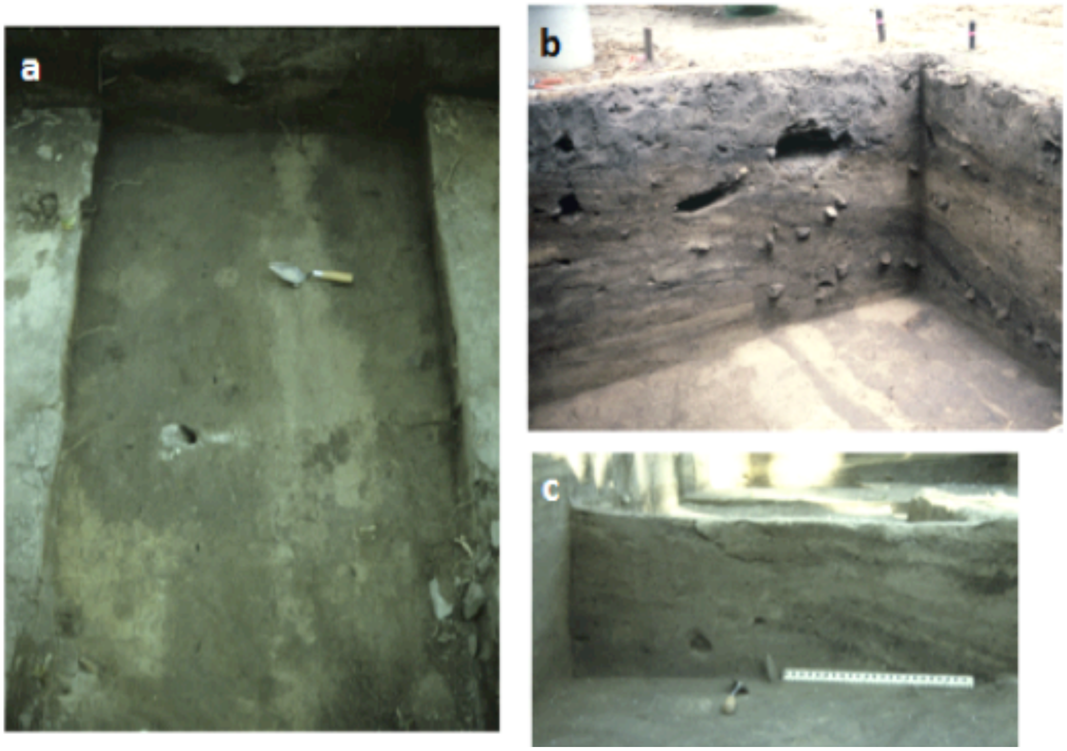

Figure 2.6. Examples of wall trenches in Cathlapotle House 4: (a) West wall beginning to emerge, wall trench is the dark stain to the left of the trowel. (b) Wall trench of the north wall in plan and profile. One trench is a plank wide and to its right is a larger trench. The fill in the trench is visible above it and it merges into the storage pits. (c) West wall in profile with sand floors terminating against the wall (figure drafted by Ken Ames).

the prestige good of obsidian within households, Sobel (2004) demonstrates that subtle status differences existed between houses in the LCRR. Using distribution of artifacts types and use wear within the Meier and Cathlapotle houses, Smith (2006) shows that social rank influenced degree of participation in various economic activities. Higher ranked households or elites within houses were more likely to engage in tasks such as stone tool manufacture, while lower ranked people were more likely to engage in large-scale fishing and hide scraping. These studies provide evidence of differential access to materials and specialization both within and between LCRR households.

Hearth and pit features at Meier and Cathlapotle are well understood. Large, central hearths and massive complexes of storage pits were noted at each site (Ames et al. 2008; Bulter 2007; Gardner-O'Kearney 2010). At Meier, pits were located in the central area of the house, while at Cathlapotle pits lined house interiors. There are interesting differences between storage pits at Meier and Cathlapotle, with pits at Meier significantly larger and more varied in form (Butler 2007:67, 143). Research into hearths indicates that at Meier, these features differed in morphology and content between status areas of the house, a pattern followed to a lesser degree at Cathlapotle (Gardner-O'Kearny 2010). Hearths differed in function according to socio-economic status at other sites on the Northwest Coast (Dolan 2009:116).These studies suggest possible differences between interior use at each site, and between people of different ranks within households.

Several studies explore costs of building the Meier and Cathlapotle houses in terms of materials and labor. At Meier, construction and maintenance required a tremendous amount of raw material (Ames et al. 1992). Significant effort was also expended on building repair, many elements show evidence of replacement a minimum of five times (Ames et al. 1992). Labor expenditures to construct houses were enormous, Gahr (2006) calculates that 20-50 times the population of the Meier community was required for house raisings. These studies provide an excellent basis for further exploration of plankhouse architecture, materials and labor at the two sites.

Architectural features have been used to infer sociopolitical aspects of the communities. Ames (1996) outlines the significance of architecture in cultural reproduction and transmission at Meier. Similarly, Smith (2006) connects high levels of structural stability at Meier over the house's 400 year uselife with continuity in social structure. However, the Meier house may have shifted slightly approximately midway through house occupation (evidenced by a 10-15 degree change in orientations of ridge beam supports), the house may have once been entirely rebuilt, and the north wall of the house may have been moved south (Ames et al. 1992; Smith 2006:241). Other indications of changes in interior architecture are evident from plankmolds noted under hearths (Gardner-O'Kearny 2010).

CHAPTER 3
THEORETICAL ORIENTATION

Political Economy

Contemporary political economy is highly influenced by the writings of Karl Marx, who in his famous critique of previous economic theory argued that economies should not be analyzed in isolation, but must be considered within a broader context of social relations (Giddens 1973:10). Marx also stressed that capitalism and private property was only one of many possible economic formations. Although political economy has developed greatly in the past 150 years, these two overarching points are still salient. Among the many current definitions of political economy, the one I find most useful is Saitta's (2012): "the various and complex ways that humans produce and distribute social labor in specific historical circumstances, and negotiate the cultural conditions that sustain such relationships." In this section, I tease this statement apart to discuss how political economy informs this project. I focus on three aspects of this definition: production, social labor, and "cultural conditions that sustain relationships".

Following from its Marxist roots, emphasis on production is one of the defining factors of archaeological studies of political economy (Robotham 2012, Trigger 1993). Questions addressed by these studies include: Who is doing the producing? Who is organizing or controlling production? Who owns the goods that are produced? Importantly, contemporary political economy diverges from traditional Marxism in that mode of production is not used to group societies into static evolutionary categories. Instead, relations of production are examined to understand the contingent cultural development of each group.

Closely aligned with production is the concept of social labor. Labor is seen not merely as work, but also as connections and relationships among people (Cobb 1993). This social definition of labor highlights that economic, social and political aspects of society are deeply interconnected. One of Marx's most enduring arguments is that economics cannot be considered without regard to sociopolitical aspects (Giddens 1971:10). This point has been employed to link labor and production with aspects of society traditionally not viewed as economic, such as ideology (Wolf 1999), gender (Cobb 1993) and knowledge (Williams 1977).

Saitta's definition of political economy also emphasizes the "cultural conditions that sustain such relationships". In contrast to some other theories, political economy emphasizes that conditions within societies are not self-sustaining, but are constantly being maintained, reproduced, renewed and changed. Material culture is active and often plays a role in this process, not only because it "physically organizes space and action", but also because objects take on social meaning as they are created by people through labor (McGuire 1992:103). Thus, archaeological studies focusing on political economy often examine how social conditions are maintained or changed within specific societies through material culture.

These three elements of political economy – production, social labor, and active sustaining of conditions – inform this project. Architecture is an extremely important aspect of material culture in shaping and reproducing social elements for two reasons. First, buildings are highly visible and permanent compared to other aspects of material culture (Nielson 1995:55), and embody cultural or symbolic capital in materials used for construction and decoration, and in the labor expended on the structure. Second, buildings are part of the day-to-day, domestic life of all people within a society, "as non-discursive phenomenon, architecture is crucial to the reproduction of social practice because it provides part of the mundane, everyday reality" (McGuire 1992:203).

Importantly, relations of labor involved in constructing and maintaining plankhouses were qualitatively different than the alienated labor involved in capitalism critiqued by Marx and other political economists. The sociopolitical importance of collective production of dwellings is emphasized in Rapoport's comprehensive study of worldwide structural forms (1969:107), where house building is characterized as a "complex, multiple activity… with collective work as its essence." Unlike in capitalist societies, labor involved in plankhouses was not hidden and mystified, but was overt and emphasized in the product of the labor. Plankhouses embodied not only the social capital of the household and its leaders, but just as importantly, served as a reminder of corporate identity present throughout continuing generations. The transparent social quality of the labor is important, as plankhouses served as constant reminders of this expenditure.

Household Archaeology

Broadly speaking, households are defined as co-residential groups that form the basic economic, social and political unit of community life (Wilk and Rathje 1982). Archaeologists employ data gathered from excavations, ethnoarchaeology, and ethnography to study households (Steadman 1996). Although archaeological house remains should not be studied as the simple material correlates of households, the history of household archaeology demonstrates that analysis of house structures can provide valuable insight into households.

Household archaeology coalesced as a subdiscipline in the 1980s. Initially, much household research focused on the adaptive function of households. In classic papers, Wilk and Rathje (1982) argue that households increase efficiency by enabling collective engagement in production and distribution, while Hayden and Cannon (1982) postulate that corporate groups allow community stability. A major goal during this time was general theory building to enable information about households to be extrapolated from material remains of houses. For example, McGuire and Schiffer (1983) explore symbolic and utilitarian elements of architectural design, asserting that house structure is a product of both environmental and social constraints. Rathje and McGuire (1982) examine how domestic architecture can be correlated with degree of access to basic resources among Maya households.

Early household studies concentrated not only on characterizing individual households, but also on variability among household groups both within and between settlements. Stanish (1989) classifies characteristics of exterior house architecture as a method of differentiating ethnicities in precontact villages in the Central Andes. Bawden (1982) examines room size of houses in four different areas of a Moche village to tease apart socioeconomic variability of households. In a study of a late neolithic site in northeastern Yugoslavia, Tringham (1991) researches how decisions made within households can be reflected in small scale architectural changes that differ between communities. Studies such as these enable comparisons between household groups.

Ethnoarchaeology is important in building theory and methodology to interpret architecture and household artifacts. By observing contemporary cultures, researchers can detect relationships between social structure and architecture that can be applied to archaeological data. Using examples from ethnographies and ethnoarchaeology fieldwork, Kent (1990) argues that sociopolitical complexity is marked by increasing spatial segmentation within houses. Other researchers use ethnographic data to assert that higher quality construction is associated with household permanence (McGuire and Schiffer 1983), and that larger house size is linked with wealth (Netting 1982). However, assumptions cannot be generalized to all cultures (Arnold and Ford 1980). In fact, ethnographies demonstrate the complexity of relating households to larger communities or economies (Nash 2009:221).

Archaeologists also study ancient households by investigating labor involved in building activities. Abrams (1994) presents a comprehensive analysis of work involved in house construction at the Maya site of Copan. Carmean (1991) quantifies labor investment in house structures to study the development of land ownership patterns on the Yucatan Peninsula. Other researchers study labor and materials involved in household rebuilding and repairs, linking continued investment in maintaining house appearances to social reproduction and stability (Hally 2008:308; van Gijseghem 2001:268).

Contemporary household archaeologists are much less concerned with functionalist approaches than in the beginning of the subdiscipline. Instead, researchers are largely interested in two different (although not incommensurable) research focuses: individuals and broad processes. Many archaeologists emphasize the capacity of domestic structures to provide information concerning commoners in complex societies where much research often centers on monumental architecture and rituals related to elites (Fleisher and LaViolette 1999; van Gijseghem 2001; Wendt 2005). Other studies explore inequality and use house architecture to investigate lives of low status people, women or slaves (Hagstrum 2001; Hendon 1996; Pauketat and Alt 2005). This research also reminds us that households are not cohesive wholes, but are comprised of individuals with different goals according to age, gender and class (Barlett 1989).

Other archaeologists focus on the role of households in large societal changes, using developments in house form or household activities to study sociopolitical shifts. For example, Kolb (1997) charts differences in labor required for structures built over an 800 year period in a Hawaiian community to explore changes in social organization, while Saitta (1997) uses data on labor involved in Chacoan architecture to examine sociopolitical change. The combination of these two focuses – individuals in households, and the role of households in large changes – allow archaeologists to develop ways of examining developments on both fine and coarse scales.

Household archeology provides the theoretical underpinning of this study, which examines architecture of dwellings and characterizes household labor in production of plankhouses. The household is the basic unit of analysis for this project, and the fundamental assumption of household archaeology – that material house remains can be used to study households – is elemental in the research design. Household archaeology provides methods of using archaeological data to make inferences about household groups on the LCRR.

Household Archaeology in Northwest Coast

Plankhouses and the household groups they sheltered have been important elements of Northwest Coast groups since at least 3000 B.P. (Coupland 1985; Hayden 1997), and perhaps much earlier (Martindale et al. 2009). Development of the household social group is linked to the evolution of key elements of Northwest Coast societies including resource intensification, storage and inequality (Ames 2003).

Although approximately twenty plankhouse village sites in the LCRR are reported in the ethnohistoric literature, only three sites other than Meier and Cathlapotle have undergone extensive excavation (Ames and Sobel 2013). The Middle Village site, located at the mouth of the Columbia, contains the remains of at least five approximately 8 x 10 m plankhouses (Wilson et al. 2009). Similarly to houses at Meier and Cathlapotle, these were post and beam structures with vertical wall planks and interiors segmented into hearth and bench areas. This protocontact site likely represents a summer settlement focused on trade. Broken Tops, another probable summer settlement located around the confluence of the Sandy and Columbia Rivers, contains the remains of several smaller (9 x 8 m), less permanent dwellings (Ellis 2006). The other plankhouse village in the LCRR subject to intensive excavation is Clahclellah, which was roughly contemporaneous with Meier and Cathlapotle but was located approximately 70 km upstream (Sobel 2004). The eight or more plankhouses at this village were gable-roofed with vertical wall planks, central hearths and, similarly to Meier, had planked floors. This information mirrors Hajda's (1994) characterization of LCRR plankhouse architecture based on ethnohistoric documents.

Intensive excavation of plankhouses has enabled researchers to make use of archaeological data to examine sociopolitical aspects of households on the Northwest Coast. In coastal British Columbia, Lepofsky et al. (2000) use archaeological data on shifts and stasis in house form and village layout as proxies for social identity. Other researchers have employed spatial data from plankhouse interior organization to investigate communal activities within household groups (e.g. Coupland et al. 2009; Hoffman 1999) or to link household size with status (e.g. Coupland 1985).

Other studies focus on production of subsistence and technological goods to consider the social implications of household economies. Ames (1995, 2008) considers how specialization, resource control and social organization influence the productive capacity of households. Similar to Smith's (2006) findings in the LCRR, Grier (2001) demonstrates that rank influenced degree of participation in different production activities at a village on the central coast. These studies demonstrate that archaeological information regarding house form can provide valuable information regarding dynamics of Northwest Coast households.

CHAPTER 4
RESEARCH DESIGN

Stemming from the overarching goal of examining production and labor investment in plankhouses, this report uses architectural features at Meier and Cathlapotle to explore two main research aims. The first aim is to examine the construction and maintenance history of plankhouses at the two sites. The second aim is to apply information from construction history to characterize and quantify labor and materials involved in building and maintaining plankhouses.

Research Questions and Hypotheses

Plankhouse Construction and Maintenance History

I use information from architectural features to reconstruct plankhouses from initial building to repairs over subsequent generations, and to test previously proposed models concerning plankhouse structure and continuity at each site. Seven research questions were operationalized with hypotheses and archaeological expectations to address the first aim of this project.

1. *The Cathlapotle House 1 interior was compartmentalized, House 4 and the Meier House were not*. Previous field models posit that Cathlapotle House 1 was compartmented while the Meier House and Cathlapotle House 4 had open interiors (Ames et al. 1992; Ames et al. 1999:46). If so, I would expect large and medium postholes, postmolds and plankmolds to be located in parallel lines bisecting the house interior at Cathlapotle House 1, but not at the Meier House or Cathlapotle House 4.

2. *Substantial structures were located outside houses*. Some significant architectural features were reported exterior to houses at Cathlapotle (Ames et al. 1999:42, 49) and Meier (Ames et al. 1991). Historical documents on the Northwest Coast sometimes note that ephemeral structures were located outside houses (see Stewart 1984:73-75). If substantial structures were located outside of houses, clusters of patterned architectural features outside of house depressions would be expected.

3. *Placement of structural elements was consistent through time*. Structural elements replaced in similar locations over time would indicate continuity in plankhouse appearance. Models developed during excavations posit that replacement of architectural features was common, but that house layout remained stable over time (Smith 2006). If structural element replacement was frequent and consistent, I would expect to see vertically and horizontally clustered similar features, as these elements would overlap if they were in place at the same time.

4. *Plankhouse orientation was consistent through time*. As discussed above, house appearance at both sites is thought to be relatively steady through time. Stability in house orientation is an indication of structural continuity over time. Orientation of plankmolds can be used as a proxy for house orientation. If house orientation was stable over time, I would expect to see no major correlations between plank orientation and depth. Vertical groupings of planks with orientations deviating from the norm would indicate a broad shift in plankhouse orientation.

5. *Similar structural elements were used in Cathlapotle House 1 and 4, and in Compartments B-D of House 1*. Although the two Cathlapotle houses vary in size and status, field observations indicate they are architecturally similar (Sobel 2004:567). If structural elements are similar between houses and compartments, I would expect to see no significant differences in maximum length or width when feature classes are compared between the two sites.

6. *Structural elements differ between facilities*. Previous models divided houses into architectural facilities reflecting spatial function (see Table 2.1). Differences in architectural features between facilities would indicate these designations reflecting interior house use are quantifiably distinct. If structural elements differ between sites, I would expect to see size differences in feature size and distribution between facilities.

7. *Similar structural elements were used at Mei-*

er and Cathlapotle. Architectural information can increase understanding of differences and similarities between the villages. Although plankhouse architecture at the two sites seems comparable, there are intriguing differences between the two sites (e.g. Davis 2012; Fuld 2012) despite their contemporaneousness and close proximity. If architecture was similar at the two sites, I would expect features to be similarly sized and for feature distribution to be alike.

Plankhouse Construction and Repair Costs

An important goal of this study is to articulate how individual actions of house building and upkeep contributed to households being sustained over many generations. Calculations of labor involved in house raisings by Gahr (2006) demonstrate that many person days were required for this aspect of house construction. I continue assessments of labor involved in plankhouses by characterizing and quantifying tasks involved in procuring materials for houses, preparing for building, construction and maintenance. I do so by addressing several questions:

- *How many trees were required for house construction and repair?* Prior work at Meier and Cathlapotle show that a large amount of lumber was used in these building and maintaining these structures (see Ames et al. 1992; Ames 1996). I expand and refine estimates of wood required for houses by using precise estimates of house surface area and structural element size derived from architectural data.

Table 2.2. Attribute Data Included in the Meier and Cathapotle Architectural Features GIS.

Attribute	Description
Associated Features	As noted during excavation, any associated features.
Associated Specimens	Specimens collected from the feature during excavation.
Beginning Elevation*	Depth where the feature was first noted.
Beginning Elevation from Datum*	Depth where feature was first noted, with any site datum corrections.
Comments	Additional comments made in the field or noted while imputing the feature into GIS.
Complete	Whether the feature was complete, or was truncated by another feature or unit boundary.
Date	Date the feature was excavated.
Ending Elevation*	Depth where feature was last noted.
Ending Elevation from Datum*	Depth where feature was last noted, with any site datum corrections.
Feature Class	Classification of feature (plankmold, posthole, etc.).
Feature Number	Feature number assigned during excavation.
Fill	Color and texture of feature matrix.
Horizontal Location	Horizontal provenience.
Level	Excavation level where the feature began.
Maximum Length	Maximum horizontal length of feature in cm.
Maximum Width	Maximum horizontal width of feature in cm.
Object ID	Unique identification number in the GIS.
Other Level	Any levels where the feature was present beyond the beginning level.
Photos	Photo numbers associated with the feature.
Preservation	State of feature preservation (excellent, good, fair or poor).
Shape Area	Feature area, as determined by the GIS.
Shape Length	Feature circumference, as determined by the GIS.
Square	Unit address.
Thickness	Vertical depth from the beginning to the end of the feature in cm.
Unit	Unit name where the feature occurred.

* At Meier, depth was calculated in centimeters below ground surface. At Cathlapotle, depth was calculated in meters above sea level.

- *What tasks were associated with plankhouse construction and repair, and how many person days did this work entail?* Using information from ethnographies and historical accounts, I develop a production sequence for plankhouse construction in the LCRR that attempts to consider all aspects of preparation, construction, and maintenance within a social context. Although some processes of plankhouse construction and repair are unquantifiable, it is important to acknowledge all possible aspects of these activities.

- *How often would structural elements need to be replaced?* Replacement rates of structural elements allow estimates of total wood needed for house maintenance and assessments for required labor to procure these trees.

Methods

Initial work for this report consisted of digitizing architectural features recorded during excavation in ESRI ArcMap10. Each feature form from the two sites was examined. If the feature was architectural, it was digitized in the greatest detail possible. Detail in feature digitization was dependent on the scale of the original map and completeness of notes. GIS databases were checked against feature catalogs to ensure that each architectural feature was included. Numerous attribute fields were populated, data were extrapolated directly from feature forms when possible (Table 2.2). When information was clearly incorrect (e.g. horizontal measurements outside of the unit address), a note was made on the digital catalog describing the nature of the error and the changes were made in the GIS. When attribute data were missing from the feature form, an effort was made to locate the information in level forms or field notebooks. Files associated with this project were maintained in a manner that will maximize ease of use for future studies.

Each level form was also examined for structural features. Fairly often, floor maps included drawings of 'possible' or 'probable' features. In these cases, I assigned the feature in question a possible feature number and recorded it in a separate database in the GIS with all relevant attribute data and comments. This information was not included in analysis, but was appended in the GIS in case it had any bearing on broad patterns.

No features from Meier had previously been digitally mapped. At Cathlapotle, features from all but ten excavation units were previously mapped using computer assisted drafting (CAD) (see Sobel 2004). These CAD files were converted to shapefiles compatible with ArcGIS by personnel at Maul, Foster and Alongi, Inc. However, because of CAD software capabilities, only feature class and elevation were included in the CAD files. Therefore, architectural features were redigitized based on Sobel's CAD files and feature forms, enabling additional attribute data to be attached and available for querying related to spatial analysis.

After GIS databases were completed, descriptive statistics were calculated for the entire dataset and for subsets of data. The most common statistically examined measurements are maximum feature length and width. Length refers to the greatest horizontal dimension of the feature and width refers to the measurement perpendicular to length. To test for normal distribution of the data, the Shapiro-Wilk test was run for each feature type at each site. Separate tests were run for all features and for only features with complete horizontal measurements.

Plankhouse Construction and Maintenance History

Seven specific questions were formulated to address house construction and repair history. Questions 1, 2 and 3 query the spatial arrangement of architectural features at the two sites by testing aspects of models proposed by previous researchers. For these questions, a series of GIS maps detail the layout of plank and post features, allowing inferences regarding architectural layout to be drawn. These maps group features and display data by a variety of attributes. Questions 4, 5 and 6 are concerned with intrasite spatial patterning of architectural features, while Question 7 compares the two sites. These four questions were investigated by a combination of inferences from maps, spatial analysis, and statistical tests. The following discussion details specific methods.

1. The Cathlapotle House 1 interior was compartmentalized, House 4 and the Meier House were not. To address this question, GIS maps were generated of postmolds, plankmolds and

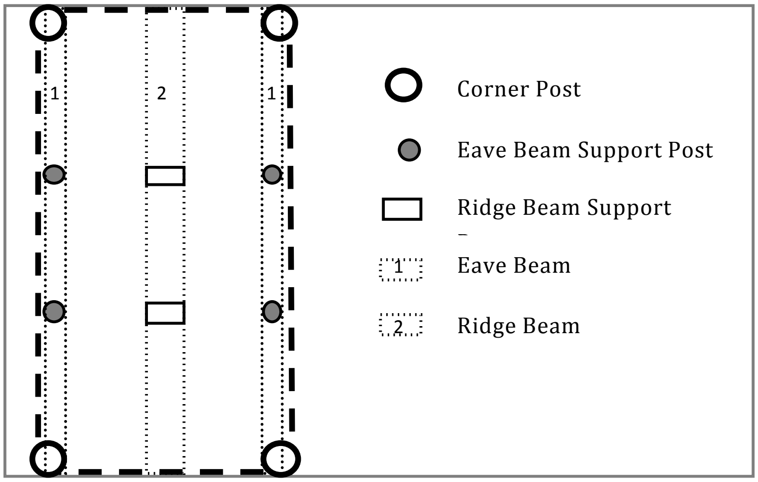

Figure 2.7. Idealized plankhouse with architectural elements labeled.

postholes at each site. These maps enabled features potentially used to compartmentalize the houses to be examined in detail.

2. Substantial structures were located outside houses. GIS maps of units outside the house were created and examined to study exterior features on a fine scale.

3. Placement of structural elements was consistent through time. Maps were created to examine where multiple features are 'stacked' around each other using upper elevations (from site datum). Elevations were divided very finely into 22 groups using equal intervals of 10 cm at Cathlapotle and 8.3 cm at Meier, so that small differences between nearby features could be detected. Upper elevations were used for several reasons. First, this measurement was more likely to be documented in field notes than lower elevation. Also, lower elevations are influenced by feature size (larger features will be buried deeper) rather than reflective of building events through time. Upper elevation cannot be compared throughout the site as a whole, as this measurement is affected by difference in natural topography and placement in the house. Hence, elevations were compared between neighboring units to reduce these influences. Plankmold elevation was generally assumed to be connected with occupational period, that is, plankmolds with higher elevations were assumed to be from later occupations. It should be noted, however, that complex site stratification renders a simple correlation problematic.

4. Plankhouse orientation was consistent through time. Plank features were split into groups based on their direction (north-south or east-west) or their location in the house (wall or central). Plankmold orientation was determined in the GIS. Changes of house orientation over time were examined using three methods. First, the Spearman's Rank Order Correlation was run between upper elevation and orientation to test for either positive or negative correlation between plank orientation and depth. The Spearman's Rank Order Correlation is a statistic used to test for the presence of positive or negative correlation between two ordinal datasets (Shennan 1997). Second, Linear Directional Mean (LDM) analysis was used to compare orientation of planks of different elevation groups. LDM is a spatial analysis tool that measures the average angle for a group of lines. For this test, plankmolds were split into three groups based on upper elevation using the natural breaks method and these plankmold groups were examined for trends between LDM and depth. Third, maps of plankmolds grouped by elevation were drafted and examined for each house.

5. Similar structural elements were used in Cathlapotle House 1 and 4, and in Compartments B-D of House 1. Architectural element sizes were compared using the Mann-Whitney test between House 1 and House 4, and

Table 2.3. Methods of Determining Structural Element Metrics.

	Diameter	Reference	Height	Reference
Wall plank	.4x.1 m	Excavations, see Tables A-9 and A-10	1.5-2.4 m	Hajda 1994
Corner post	1 m	Excavations, see Tables A-9 and A-10	1.5-2.4 m	Hajda 1994
Ridge beam support	.5 m	Excavations, see Tables A-9 and A-10	4-6.1 m	Hajda 1994
Eave beam support	.3 m	Excavations, see Tables A-9 and A-10	1.5-2.4 m	Hajda 1994
Ridge and eave beam	.3-1 m	Mauger 1978, Stewart 1984	House Length	Excavations

also House 1 Compartments B-D.

6. Structural elements differ between facilities. Statistical analysis consisted of comparing sizes of feature classes between facilities using the Mann-Whitney U test and the Kruskal-Wallis H test, which are designed to test for differences in ordinal scale variables for one-to-one and more than two categories, respectively (Shennan 1997). One-to-one tests were run for all feature categories in all facilities, but for simplification, only significant results are reported. The chi square test was performed to examine if architectural feature classes were distributed differently between facilities, using both complete and incomplete features. The chi square test is used to compare population proportions between samples (Drennan 2004:183).

7. Similar structural elements were used at Meier and Cathlapotle. The Mann-Whitney test was performed for length and width of structural features at the two sites, both for the total sample and between facilities. In this analysis, I used only complete features and eliminated the post features smaller than 7 cm in maximum length (to make sites comparable and so that result reflect the features used in architecture rather than household furnishings). As an additional method of comparing architectural feature size between the two sites, the chi square test was performed to assess differences in distribution of size classes at each site for both posts and plank features. Features were divided into size classes using the natural breaks method and were grouped into five classes based on the maximum length measurement. These classes consisted of Class 1: 7 cm or smaller, Class 2: 7.1-20 cm, Class 3: 20.1-40 cm, Class 4: 40.1-70 cm, Class 5:70.1 cm or larger. Distribution of planks and combined posts (postmolds and postholes) was compared at Meier and Cathlapotle between three facilities. To increase comparability between facilities at the two sites, berm units at Cathlapotle were merged with midden units, and floor units were combined with hearth units.

Plankhouse Construction and Repair Costs

The second main aim of this project was to use architectural feature data to quantify labor required to construct and maintain plankhouses in the LCRR. The first step of this process was to quantify how much raw material was involved in building and repairing houses, which was calculated using size and counts for each structural element (see Figure 2.7). Diameter of structural features was estimated using metric data from excavations (Table 2.3, Appendix A). Since complete, large features were rare, incomplete features were 'completed' when possible.[1]

Estimating height of elements and morphological attributes of beam elements was more difficult, as these elements left no archaeological correlate at Meier and Cathlapotle. Height of structural elements was determined from historical documents, and other archaeological sites.

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[1] A similar method as described in Gardner-O'Kearney (2010:58) was employed to estimate size of incomplete features. Incomplete circular features were completed based on approximations from the known section. Although completing features is necessary to increase sample size, there are some issues with this technique. It is possible that not all post features were completely circular, some may have been elliptical. Also, it was difficult to complete measurements for plankmolds, resulting in a low sample size for planks.

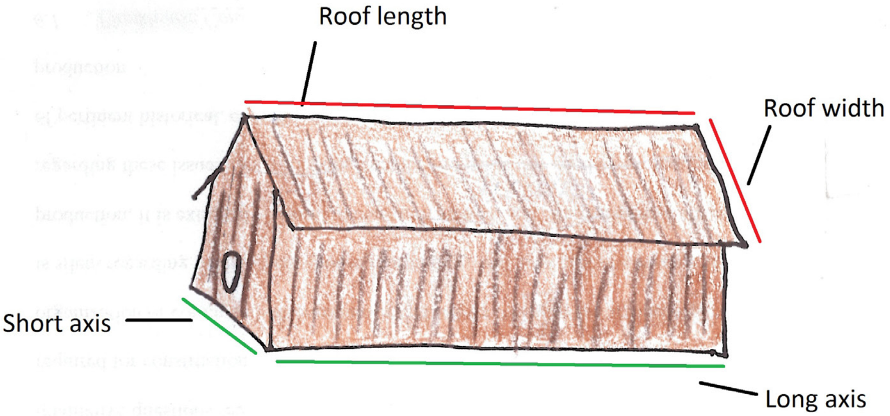

Figure 2.8. Plankhouse long axis and short axis, and roof width and length.

Counts of structural elements for each house were also derived from historical sources and other archaeological data pertaining to spacing of elements. Appendix B details these metric and element spacing estimates.

Surface area of siding, roofing and flooring were calculated to determine the area that would need to be covered with planks. Details of all calculations are presented in Appendix B. Roof width was multiplied by roof length to determine the surface area of the roof (Figure 2.8). Surface area of siding was estimated by adding surface area of the long axis of the house by its short axis. Surface area of the long axis was determined by multiplying the length of the houses by the height, using both the small and large range for wall height. Surface area of the short axis was calculated similarly, but took into account the triangular pitch of the roof. At Meier, surface area of the wood floor planking was determined by multiplying the house length by width.

Surface area calculations were applied to board feet calculations to estimate trees needed for planking used in siding, roofing and flooring (at Meier). Board foot log rules are used to determine how many board feet can be cut from round, tapered logs. These calculations include several assumptions, including that logs contain no defects, and that some wood is lost to sawdust at the mill. Of course, modern milling equipment was not used by LCRR residents, but wood was finished with adzing, which would result in some wood loss. Board feet were calculated using the Scribner's Log Rule, which states that a log that is 36 inches in diameter at breast height (approximately one meter) and 20 feet tall has 1150 board feet, one board foot is 12x12x1 inch (Countryman and Kemperman 2000). Since plank width was larger than one inch at the study sites (see Table 2.5 and 2.6) raw board feet calculations were multiplied by a factor of three.

Meters of logs needed for post and beam elements were also calculated. Element quantities used at each house were combined with estimates of element size to produce a range of meters of logs (see Appendix B). This calculation was combined with board feet estimates to produce an approximation of number of trees required to build and maintain houses. For posts and beam elements, a tree measurement of 6.1 usable meters of wood was employed. This number was used because I wanted to maintain compatibility with board feet calculations, which were based on 20 ft (6.1 m) logs.[2]

The second step to quantifying labor was identifying steps involved in building and repairing dwellings. The amount of labor involved various activities was quantified using both experimental archaeology studies and raw material data from Meier and Cathlapotle. Quantifying the time

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[2] Employing only 6.1 m of usable logs may significantly overestimate amount of trees, but other aspects of this report underestimate amount of wood used. Examples of this include not accounting for underground portion of structural elements or the overhanging portion or possible double coursing of roof planks. Therefore, calculations of trees used must be viewed as rough estimates. Another caveat is that for planks, boards were assumed to be split from felled trunks rather than individually pried from standing trees.

Table 2.4. Features Included in GIS Databases.

	Meier		Cathlapotle	
Feature Class	Count	Percent	Count	Percent
Plankmold	129	33.3%	218	28.8%
Posthole	223	57.6%	87	11.5%
Postmold	23	5.9%	296	39.1%
Rock	4	1.0%	0	0%
Step	1	0.3%	0	0%
Wall trench	7	1.8%	29	3.8%
Pegmold	0	0%	109	14.4%
Peghole	0	0%	14	1.8%
Puddle	0	0%	2	0.3%
Woodstake	0	0%	1	0.1%
Log	0	0%	1	0.1%
Total	387	100%	757	100%

Table 2.5. Descriptive Statistics for Meier Features with Complete Horizontal Measurements.

Feature		Count	Min. (cm)	Max. (cm)	Mean (cm)	Std. Deviation (cm)
Plankmold	Length	74	6.0	105.0	22.3	19.1
	Width	74	2.0	40.0	7.8	6.8
Posthole	Length	189	2.0	80.0	10.0	11.2
	Width	189	1.0	65.0	8.2	9.1
Postmold	Length	19	4.0	36.0	13.4	10.2
	Width	19	3.0	36.0	11.0	9.9

it would take to fell large cedars is complex; because of differences in technology and tree type, it is difficult to apply ethnoarchaeology or experimental archaeology data to cedar. However, some pertinent points can be drawn from experimental studies. Using stone tools, one group of three experimenters chopped down oak trees one foot in diameter at a rate of about one per half an hour (Iverson 1956). Mathieu and Meyer (1997) show that stone tools can be used to fell trees with 20-30 cm diameter in 30-60 minutes. Specific gravity of trees largely determines the ease of felling the tree, with low specific gravity making trees easier to cut. Cedar has a low specific gravity compared with many other trees that grow on the Northwest Coast (see Gahr 2006, Table 2.2), and also many of the trees used in Matieu and Meyer's study. As data from experimental and ethnoarchaeology related to felling large trees was not available, I used information from small trees to extrapolate to felling times for larger trees. I used as a baseline the figure of .5 hours of work to chop down a tree 30 cm in diameter, and scaled this figure up for larger trees (2 hours for .5 diameter trees and 4.5 hours for 1 m diameter trees).

Person days required for excavation of wall trenches and the semi-subterranean portion of the plankhouses were estimated from an experimental archaeology study. Erasmus (1965:285) conducted several experiments, concluding that in one day (five hours) a person using wooden tools could excavate 2.6 m of earth.

Weight of wood was calculated in order to better understand effort entailed in moving trees for plankhouses. A baseline of 1.55 tons (3,100 lbs) per 1000 board feet of green (undried) lumber was used for calculations (Countryman and Kemperman 2000:34).

Table 2.6. Descriptive Statistics for Cathlapotle Features with Complete Horizontal Measurements.

Features		Count	Minimum (cm)	Maximum (cm)	Mean (cm)	Std. Deviation (cm)
Plankmold	Length	64	7.0	81.0	32.7	19.2
	Width	64	2.0	70.0	9.89	9.7
Posthole	Length	71	2.0	42.0	10.1	7.4
	Width	71	2.0	34.0	9.1	6.4
Postmold	Length	206	3.0	73.0	13.8	11.1
	Width	206	3.0	123.0	12.0	11.9
Pegmold	Length	98	2.0	17.0	6.9	3.3
	Width	98	2.0	13.0	5.7	2.4
Peghole	Length	12	4.0	12.0	7.7	3.2
	Width	12	2.0	12.0	7.2	3.2

Labor involved in maintenance was investigated using data on structural elements, which allowed estimates of how many posts and planks composed structures and enabled more accurate calculations of how much labor was entailed in repair of these elements. Rates of replacement for structural elements were estimated from wood technology studies documenting cedar decay rates, which provide information applicable to assessing how often elements of different sizes would need to be replaced. Although cedar's resistance to decay is well documented compared to other trees found in Northwest Coast forests, it is still subject to rot. Gahr (2006) reports that cedar posts in the area decay at a rate of around 2 cm per year. Experiments from different regions also demonstrate that although cedar is less prone to decay than other wood, small elements fail rapidly because of rotting. In experiments involving cedar heartwood planks with a largest dimension of 15 cm, these elements took about 11 years to fail in Wisconsin (an average of 1.4 cm per year), which is an area with a slightly lower decay hazard rating than the LCRR (Highley 1995). In the decay prone area of Hawaii, 96% of 10 x 5 cm cedar heartwood stakes had decayed within four years (Skolmen 1968). In Norway, 60% of cedar 50 x 5 cm boards failed after five years, with the average failing after just 2.6 years (Flate et al. 2009). Replacement rates for untreated cedar shingles used in roofing range from 5-20 years (Buchanan 1992) to 15-60 years (Park 1989). The density decomposition rate per year for western redcedar in Oregon is 0.009 g/cm (Sollins et al. 1987).

Meier and Cathlapotle are located in a moderately high decay hazard location compared with the rest of the United States (see Carll 2009, Figure 2.2). Decay in cedar is hastened when wood contacts water or soil. Moisture results in loss of wood fiber and increase in splitting (Buchanan 1992) and the anti-decay preservatives in cedar are leachable in water (Loferski 1999). Hence, despite cedar's positive qualities as a building material, structural elements would need to be replaced frequently.

These studies allowed rough estimates of how many times structural elements of varying sizes would need to be replaced during the buildings' uselives (see Chapter 6). The large amount of stress from roof weight placed on corner posts, rafter support beams and eave support beams would have increased deterioration. However, the larger diameter of these elements would result in slower decomposition than smaller elements. Some clues to how often posts were replaced can be seen in Figures 2.15-2.20. Smaller structural posts show signs of being replaced a dozen or more times, while larger elements seem to only have been replaced several times. I assume that the smaller posts (~30 cm diameter) would need to be replaced every 15 years. Scaling up based on volume, I estimate that .5 m diameter posts would need to be replaced every 50 years and 1 m posts would need to be replaced approximately every

130 years. Calculations of overall material used allows better understanding of resource and labor costs involved in maintaining plankhouses over their entire uselives.

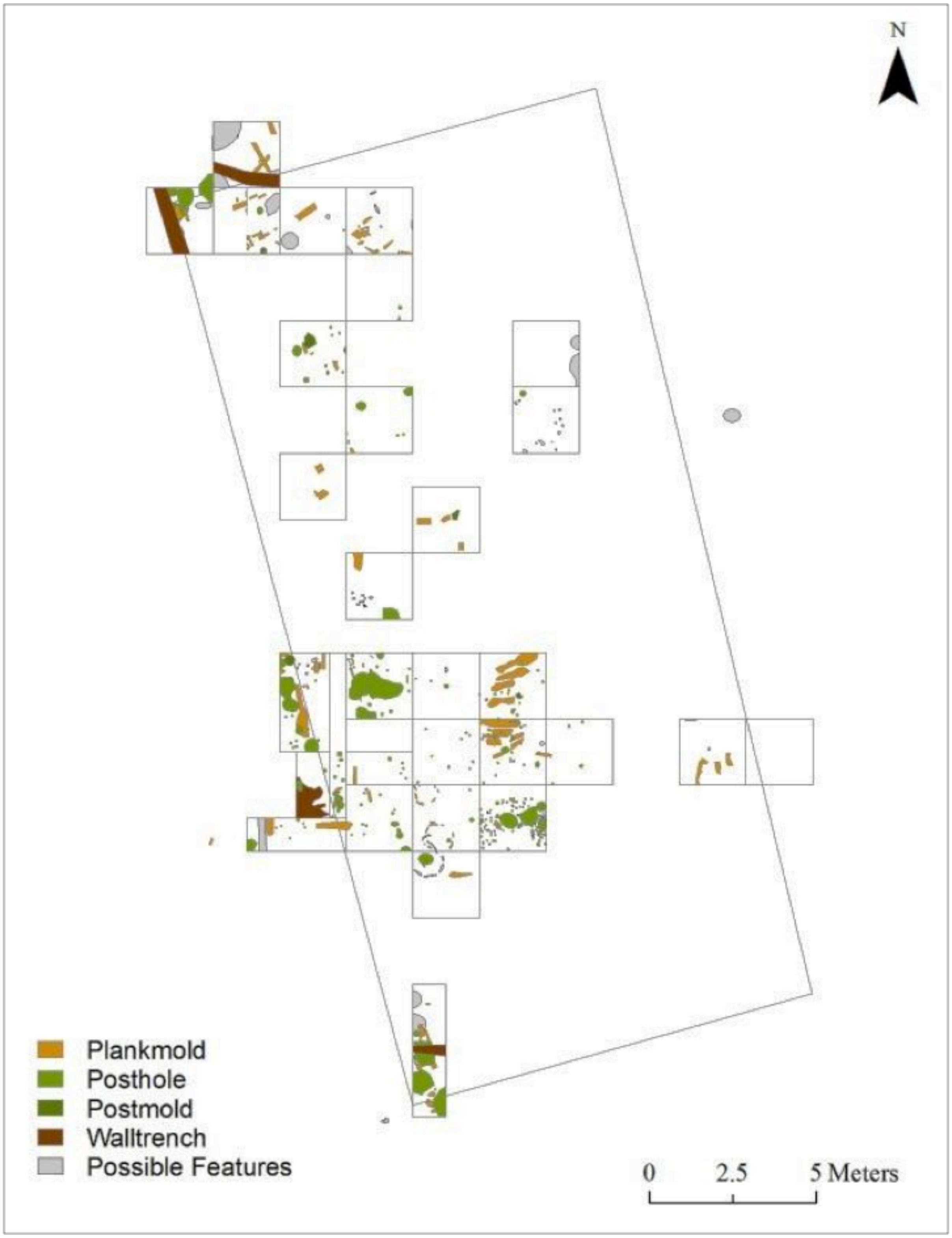


Figure 2.9. Architectural features recorded at Meier, including possible features.

Figure 2.10. Architectural features recorded at Cathlapotle, including possible features, House 1.

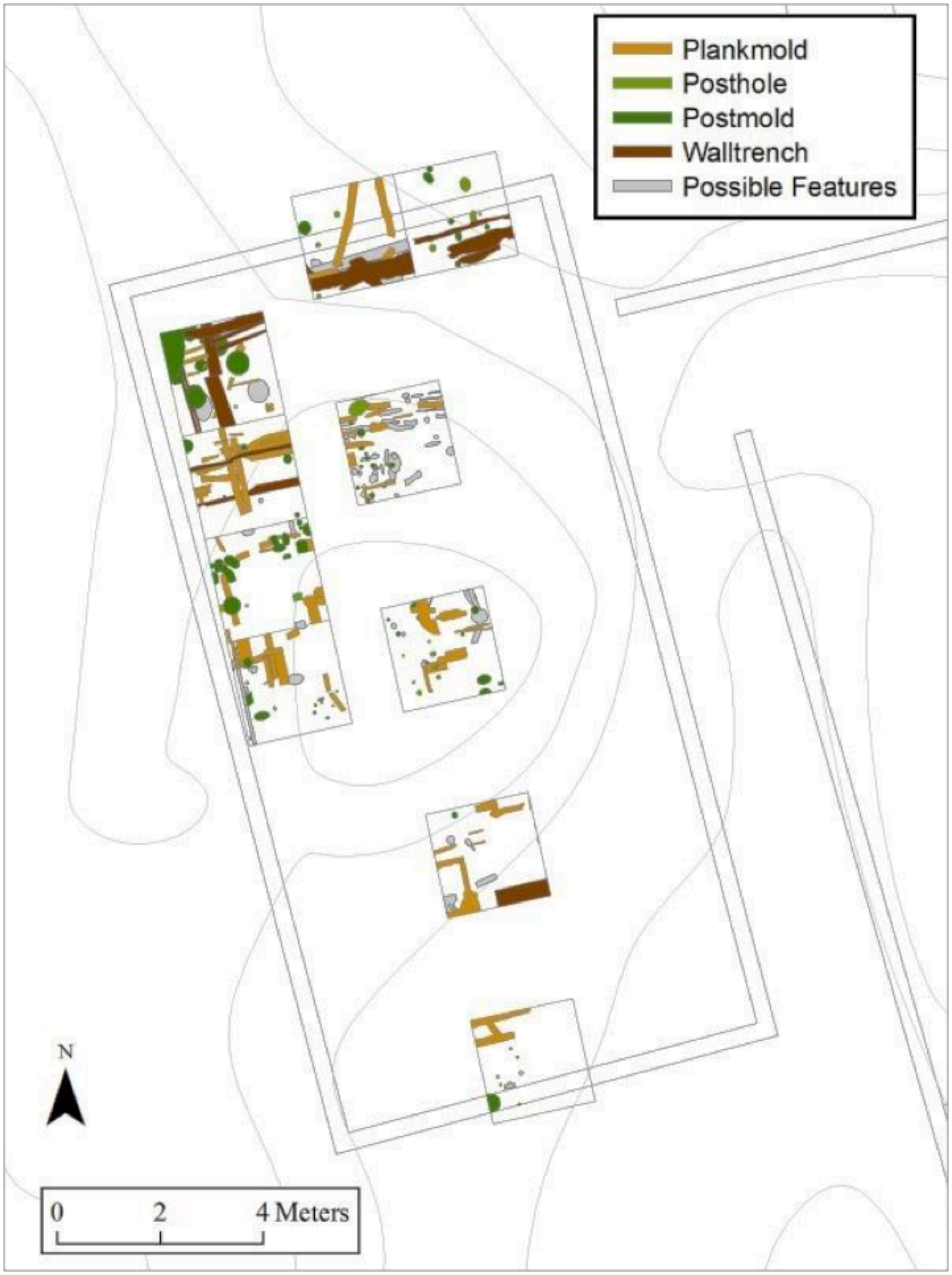


Figure 2.11. Architectural features recorded at Cathlapotle, including possible features, House 4.

CHAPTER 5

RESULTS OF PLANKHOUSE CONSTRUCTION AND MAINTENANCE HISTORY ANALYSIS

This chapter presents an overview of the more than 1,100 features that were digitized at Cathlapotle and Meier. Subsequently, the results of the seven hypotheses related to plankhouse construction and maintenance history are discussed.

Summary of Architectural Features

The Meier GIS database contains 387 features related to house architecture (Table 2.4, Figure 2.9). Of the final 387 features recorded at Meier, 282 have complete horizontal measurements (Table 2.5). Some features were truncated by other features or by the walls of excavation units. Other features were considered incomplete because of missing provenience information on excavation forms or maps. Although dimensions of features should not be taken as exact measurements of structural elements, they provide valuable information in the absence of the elements themselves. For details of GIS databases for both sites, see Appendix A.

Four feature classes recorded at Meier are of primary significance to this project: plankmolds, postholes, postmolds and wall trenches. Comparative analysis of post features between Meier and Cathlapotle was enabled by further parsing post features by size. Small circular features were field classified as pegs at Cathlapotle, but this category was not used at Meier. Hence, for much subsequent analysis, small post features at Meier (largest dimension equal or less than 7 cm) were reclassified as pegs. These posts were likely used for purposes unrelated to architecture, such as drying racks (see Mauger 1978:118). After filtering out peg features, 104 postholes and 15 postmolds remain at Meier. In statistical analyses, postmolds were sometimes grouped with postholes to increase sample size. Plankmolds, postholes, postmolds and combined posts with complete measurements did not have normal distributions in respect to length, width or depth (Appendix A).

The Cathlapotle GIS database includes 757 features related to house architecture (Table 2.4, Figures 2.10 and 2.11). Of the features recorded at Cathlapotle, 451 have complete horizontal measurements. As at Meier, some features were incomplete because of either intersection with unit walls or other features (see Figure 2.12).

Figure 2.12. Example of incomplete features at Cathlapotle, truncated by both unit walls and other features.

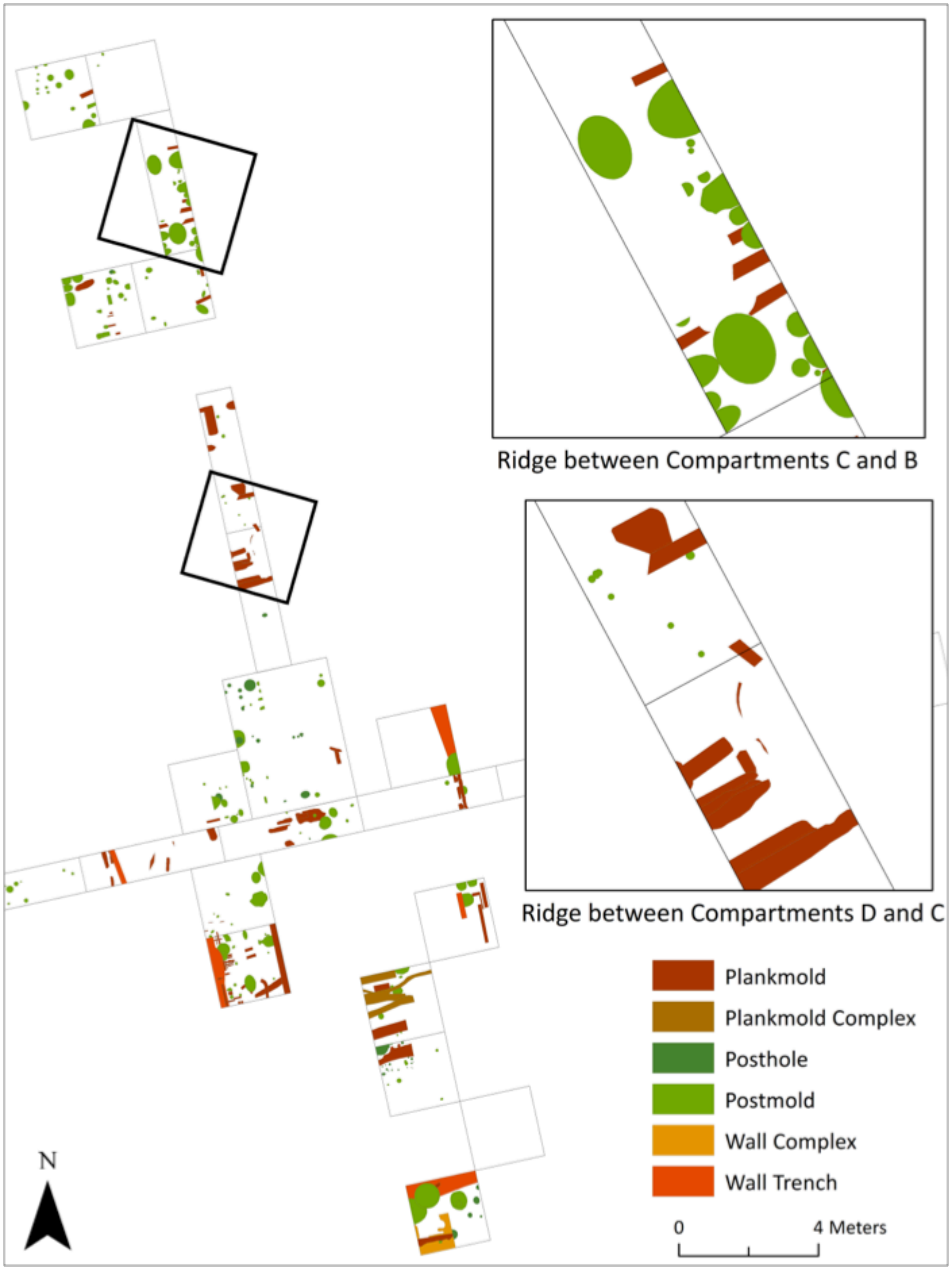


Figure 2.13. Architectural features flanking compartments, Cathlapotle House 1.

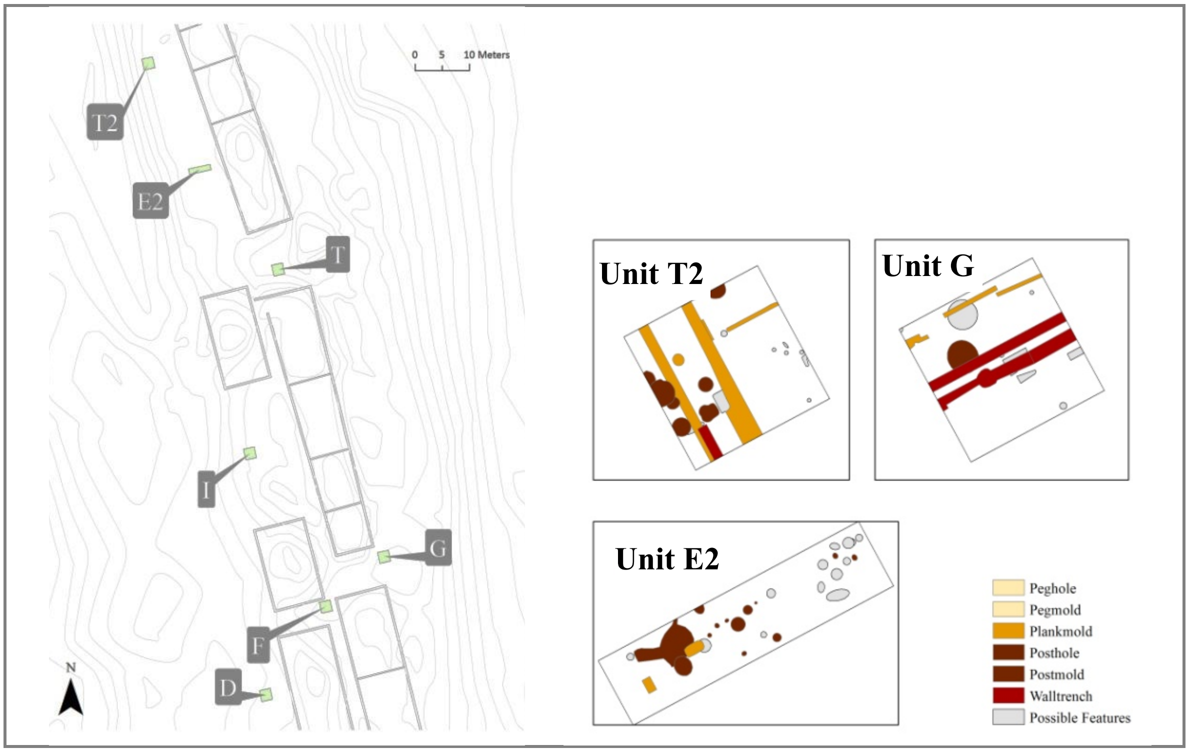


Figure 2.14. Exterior features at Cathlapotle, (left) location of exterior units with major groups of features, (right) selected clusters of exterior features.

Table 2.6 presents descriptive statistics for features with complete horizontal measurements, no wall trenches had complete horizontal measurements. Four of the feature classes at Cathlapotle were significant for this project: wall trenches, plankmolds, postholes and postmolds. Length, width and depth of these classes were not distributed normally (Appendix A).

Plankhouse Construction and Maintenance History

1. *The Cathlapotle House 1 interior was compartmentalized, House 4 and the Meier House were not.*

Patterns of distribution in feature class and size were used to reconstruct the layout of architectural elements to assess evidence for interior compartmentalization for each house. GIS maps support that Cathlapotle House 1 was compartmented, provide ambiguous evidence regarding House 4, and indicate that the Meier House was not divided. Strong evidence for compartmentalization of House 1 comes from the low ridges dividing the house that run perpendicular to house walls. Ridges between the D and C compartments and the C and B compartments are flanked by some large and many medium-sized planks and posts (Figure 2.13). Features present in ridges likely represent elements of planks used to divide the compartments. Maps of feature classes at the Meier House and Cathlapotle House 4 show that similar clusters of features and ridges are not as obviously present at these houses (see Figure 2.9 and Figure 2.11). However, House 4 contains a row of plankmolds running parallel to the north wall in the northernmost center unit. These features likely represent a reset wall, but they may be remnants of a partition that once segmented the house.

2. *Substantial structures were located outside houses.*

At Cathlapotle, 74 of 757 total features are located outside of house walls in 16 units classified as either midden or berm. Exterior units comprise 36% of the total excavated volume at Cathlapotle. However, only 10% of total architectural features at Cathlapotle

Table 2.7. Selected Groups of Exterior Features at Cathlapotle.

Unit	Feature Description	Feature Count
D	Two clusters of features are located in Unit D. In the northwest section of this unit, four small postholes were discovered that are likely associated with a nearby oven. The southeast section one plankmold and three small postholes.	8
E2	This 4x1 unit contains 13 post features and two plankmolds. Most of the features are clustered in the western half of this unit, further away from the house. These features are associated with Feature 60, an outdoor hearth.	15
I	A small concentration of features was found, consisting of two plankmolds and one post feature. These features were likely associated with an ephemeral outdoor structure.	3
G	This cluster of features consists of wall trenches running approximately east-west, three plankmolds north and parallel to the wall trenches, and one post feature. These features suggest a house wall once extended to this area and was then buried in later occupation.	7
T2	Features were found in association with what was noted in the field as a possible outdoor structure with a nut oven. These features include a large (over one meter) plankmold and a wall trench running parallel, three smaller plankmolds and eight post features. The large concentration and variety of architectural elements in this unit suggest a substantial feature. Beginning elevation for features in this unit starts at 5.4 masl, and continue for 50 cm lower, exhibiting variety in upper elevations. However, the three largest features (the two largest plankmolds and the wall trench) and six of the post features begin at the same level, suggesting they are the remnants of a single stucture.	13

Table 2.8. Vertical and Horizontal Positioning of Architectural Features, Meier.

General Area	Specific Area	Units	Observations
Walls (Figure 2.15)	Northwest corner	A, B, C	Several wall trenches are in close proximity to post features that began on a slightly higher elevation (Units A & B), and to several plank features that began on a lower elevation (Units A & C).
	Central west	E2, F2A, F2B, G2, K2, P, Q, W	Much more variation in beginning elevation than the northwest corner. There are two instances where architectural features in close horizontal location begin at different elevations. (1) In the western edge of the wall, three similarly sized posts began at different elevations (Unit P). (2) East of the wall, there are examples of similarly sized posts layered directly on top of another (Unit Q).
	Southwest corner	M2	Three large post features have very similar upper elevations.
Central area (Figure 2.16)	All	S, Y, I2	Most features are largely at the similar elevations - many features in the same class have similar horizontal and vertical locations. Some small features are lower in elevation (most are associated with pits).

were noted in exterior units. These figures reflect an expectedly small proportion of architectural features to be located outside the houses. Of the possible features classified during this project, 26% are located in exterior areas. Generally, these features were located in units where confirmed features were recorded. Although not much information can be drawn from possible features, they could indicate more structural elements were present than previously noted.

Several exterior units were selected for additional study based on the large number of features they contained (Figure 2.14, Table 2.7). Some of these exterior clusters can be associated with other features based on contextual information. Three clusters of features were found in close proximity to known ovens (in Units D, I, T2). Ten exterior earth ovens were located at Cathlapotle (Gardner-O'Kearny 2010). Outdoor ovens in the LCRR were likely used for preparation of fish, roots, bulbs and nuts (Thoms 1998). Plank and post features located by ovens may indicate the presence of racks or other simple structures. Other clusters of exterior features appear to be associated with house walls or small exterior structures.

Some exterior features at Cathlapotle are not associated with house walls or known earth ovens. The eastern edge of Unit G2 contains three post features with similar elevations arranged in a half circle. These scattered posts likely indicate the presence of various small, impermanent structures. Other units, notably Units T, F and D contain scattered small posts and plankmolds.

Several midden units at Cathlapotle contain no architectural features. Of the five exterior units with no architectural features, four are located east of House 1. The lack of features in these units indicates that the east sides of the houses, away from the river, were not heavily utilized for production activities. However, the excavated volume of three units to the east of the house is less than 5% of the site total, meaning the lack of features could result from sampling.

Exterior structures at Meier have a completely different pattern than at Cathlapotle. At Meier, 12 of 45 units (27%) were located in units defined as exterior or midden. However, architectural features were almost completely lacking outside the Meier House. Out of the total architectural features located at Meier, only 5% are found in exterior areas. A total of 21 architectural features were found in exterior areas, consisting of six plankmolds and fifteen postholes. Architectural features were located only in three exterior units. Unit J2 is adjacent to the house wall and contains seven architectural features – two plankmolds and five postholes. Unit K2, which is just east of Unit J2 contains three plankmolds and seven postholes, one of which is a large Class 4 posthole. The close proximity of these units to the house indicates that these features are associated either with the western house wall or with an exterior structure immediately adjacent to the house. Unit O2 is located about 14 meters south of the southern house wall, and contains three small postholes and one small plankmold. The dearth of exterior architectural features extended to possible features, as only 3 of 152 (2%) possible features were noted in exterior areas.

There is a striking contrast between exterior architectural features at Meier and Cathlapotle. At Cathlapotle, although architectural features are clearly less plentiful in exterior areas that in house interiors, these features indicate that some building activity occurred in outside areas. A few exterior structures entailed significant materials and labor, as evidenced by wall trenches and large plankmolds. Most structures, however, were likely temporary and insubstantial. At Meier, if exterior features located in Units J2 and K2 are indeed associated with the house wall, the only evidence of outdoor structures are the few features noted in Unit O2. Clearly, there is more variation in exterior features at Cathlapotle. This aligns with the lack of exterior ovens at Meier, while some were found at Cathlapotle (Gardner-O'Kearney 2010). In contrast, interior pit storage features were more varied in form at Meier than Cathlapotle (Butler 2007:67).

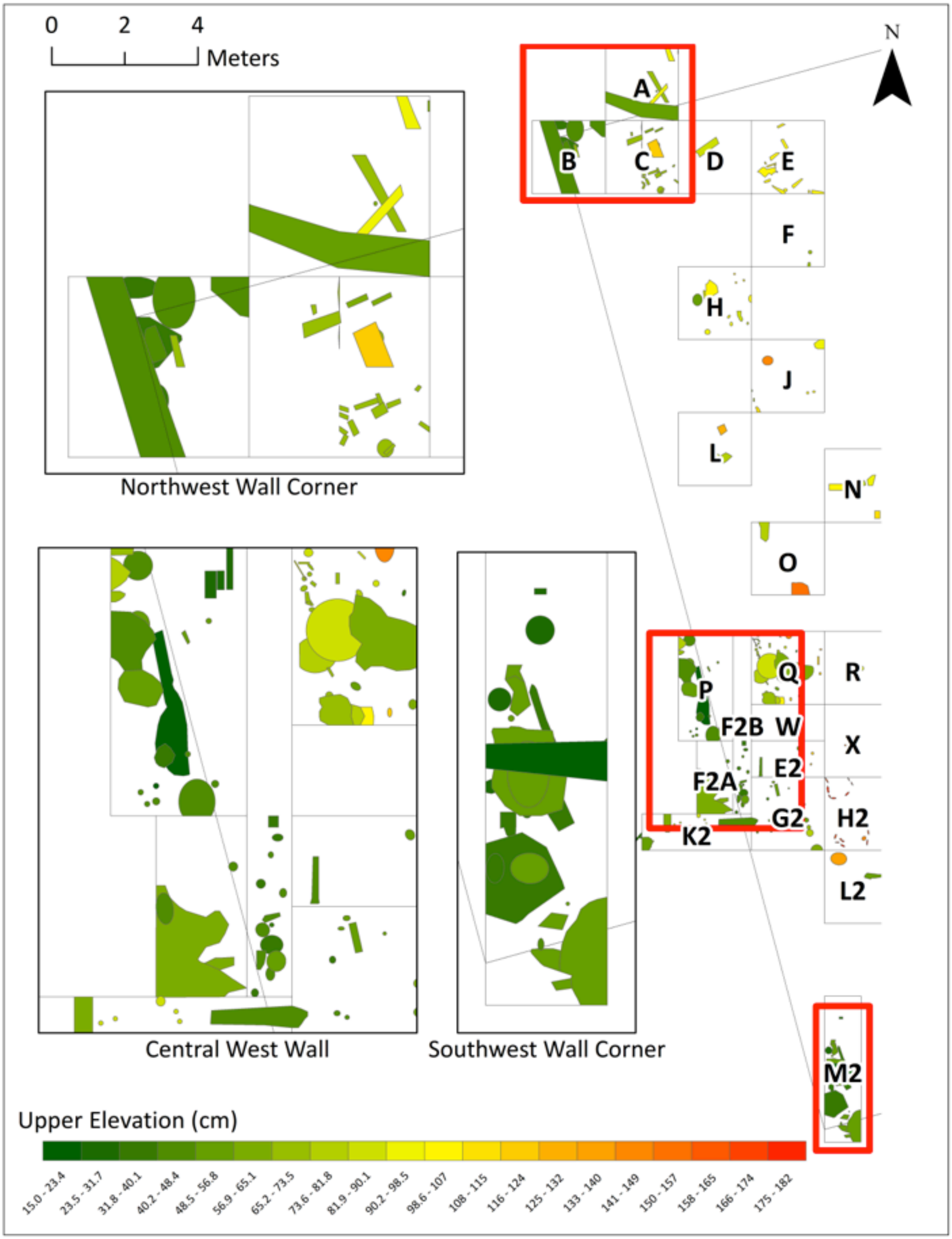


Figure 2.15. Upper elevation of architectural features in the west wall of the Meier House.

Figure 2.16. Upper elevation of architectural features in central areas, Meier House.

Table 2.9. Vertical and Horizontal Positioning of Architectural Features, Cathlapotle House 1.

General Area	Units Compared	Specific Area	Observations
Walls (Figure 2.17)	B2, N2, Y	East wall	Upper elevations of western features appear slightly deeper than those of the eastern line of features.
	I2	West wall	Features vary in upper elevation. This area contains a wall trench and large plankmold with high upper elevations. These features are layered over additional large plankmolds. Several large postholes with even deeper upper elevations are present.
	U	South wall	This area contains several large postmolds with different beginning elevations, and two wall trenches with beginning elevations 30 cm apart. Evidence from postholes and wall trenches in the southern wall suggests possible positioning changes in this part of the house.
Central area (Figure 2.18)	S2	North central area	Most features are very similar in upper elevation, although a cluster of features in the northern area of the unit are deeper.
	O2, P2	Middle of central area	Features are extremely similar in upper elevation.
	C2	Middle of central area	Some variation in upper elevation, with a cluster of deeper features interspersed with several posts with higher elevations.
	W, X	South of central area	Many central ridge beam supports were used in approximately the same elevation. In one area, at least six large plankmolds were noted.

Table 2.10. Vertical and Horizontal Positioning of Architectural Features, Cathlapotle House 4.

General Area	Units Compared	Specific Area	Observations
Walls (Figure 2.19)	N, O, P, Q	West wall	The north area of the west wall is dominated by medium to large posts, while other areas along the wall contained many plankmolds. Features along this wall exhibit some variation in elevation. Small clusters of features with higher upper elevations are noted in Units N & Q.
	R, S	North wall	This unit contains few large architectural features, but they tend to vary in upper elevation.
Center (Figure 2.20)	M	North	A row of features along the north has consistently higher elevations than those in the south of the unit. These features may represent a reset wall constructed later in the house's occupation, or possibly an interior partition.
	L, K, J	South	Upper elevations of southern central features are deeper than those to the north, even when accounting for differences in topography.

Table 2.11. Spearman's Rank Order Test for Groups of Plankmolds.

	Location	Count	Spearman's Rank Order
Meier	West wall	9	p >.5, r_s=0.083
	Central area	28	p >.5, r=-0.103
Cathlapotle House 1	East and west planks	26	.1 > p > .05. r=-0.371
	Central area	35	p >.5, r=-0.08
Cathlapotle House 4	East and west planks	51	p >.1, r=-0.171
	North and south planks	15	p>.5, r=0.169, n=15

3. *Placement of structural elements was consistent through time.*

To examine replacement of planks and posts, I created maps detailing upper elevations of features. These maps were used to compare both spatial redundancy and elevations of neighboring features. Spatial redundancy refers to overlapping features of the same class, which indicates element replacement. As discussed in the methods section, comparisons of elevation must be treated with caution. Elevation is influenced by location within the house – i.e. whether it is on the depression edge or interior. Therefore, effort was taken to primarily compare features from the same facility or house section.

At Meier, several areas in the west wall displayed redundant features with differing upper elevations (Table 2.8, Figure 2.15), suggesting that features were placed in the same area over time, but that their elevations may have changed slightly. This may have been a result of refuse accumulation in tofts. In the central area of the Meier House, elements were replaced in very similar vertical and horizontal positions over time (Table 2.8, Figure 2.16).

At Cathlapotle House 1, most features are in similar horizontal positions, although upper elevation of feature in walls seems to have varied more strongly than at Meier (Table 2.9, Figure 2.17). Evidence from postholes and wall trenches in the southern wall suggests possible positioning changes in this part of the house. At Cathlapotle House 1, central areas have high densities of similar architectural features, suggesting that elements were replaced many times although keeping approximately the same elevations during the house's uselife (Table 2.9, Figure 2.18). Most evidence for larger planks and frequent replacement of these planks was found in Compartment D, the high status area.

At Cathlapotle House 4, feature elevation in walls suggests multiple episodes of element replacement in similar areas (Table 2.10, Figure 2.19). Variation in elevation occurs in the north and west house walls. Architectural features in the central house area also exhibited moderate variation in upper elevation. Since

Table 2.12. Linear Directional Means for Groups of Plankmolds by Depth.

	Location	Elevation	Count	LDM
Meier	West wall	35 or less cmbd	4	166
		35.01-47 cmbd	3	172
		47.01 or more cmbd	2	161
	Central area	78 or less cmbd	7	91
		78.1-98 cmbd	9	29
		98.1 or more cmbd	11	81
Cathlapotle House 1	East and west walls	More than 5.86 masl	6	160
		5.71-5.86 masl	8	150
		Less than 5.71masl	12	146
	Central area	More than 5.77 masl	9	52
		5.59 – 5.77 masl	12	60
		Less than 5.59 masl	14	58
Cathlapotle House 4	East and west planks	More than 5.14 masl	18	156
		4.86 – 5.14 masl	15	155
		Less than 4.86 masl	18	166
	North and south planks	More than 5.10 masl	4	61
		4.92-5.09 masl	6	61
		Less than 4.92 masl	5	58

Figure 2.17. Upper elevation of architectural features in walls, Cathlapotle House 1.

Figure 2.18. Upper elevation of architectural features in central areas, Cathlapotle House 1.

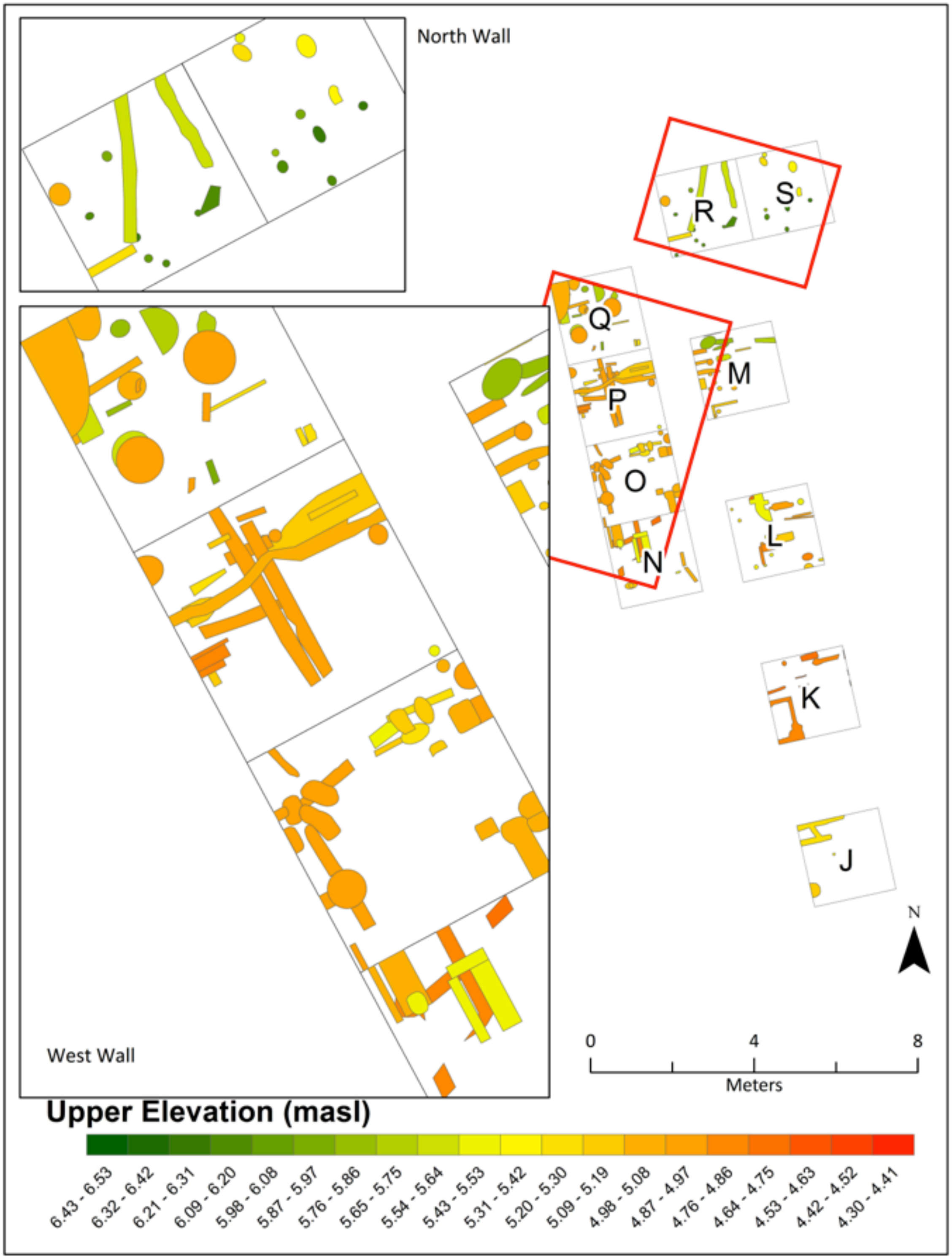


Figure 2.19. Upper elevation of architectural features in walls, Cathlapotle House 4.

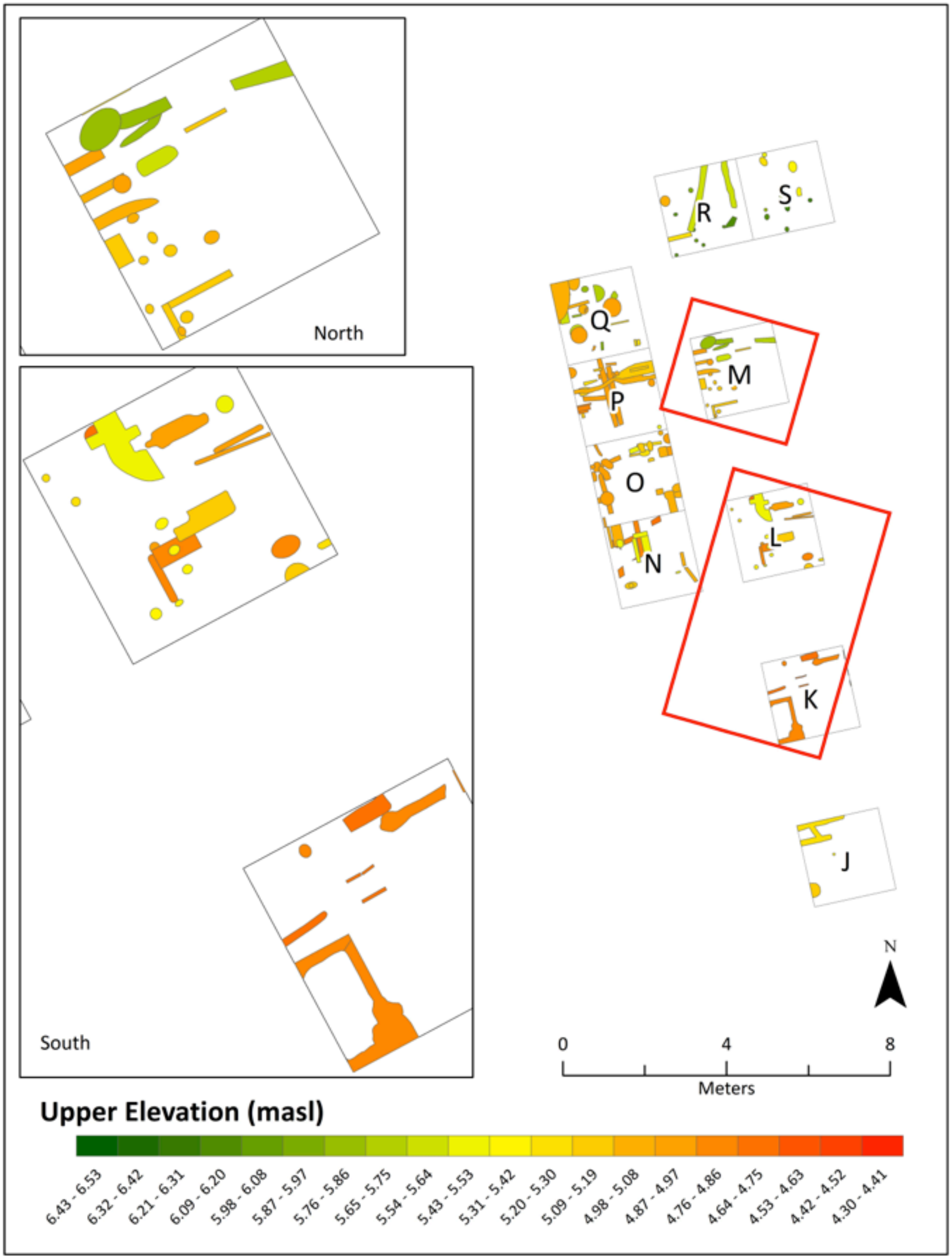


Figure 2.20. Upper elevation of architectural features in central areas, Cathlapotle House 4.

House 4 contains several superimposed sand floors, variation in elevation noted in the central area may be associated with these new floors. Thus, in House 4 feature elevations in the center likely reflect relative age. Overall, there is evidence of multiple replacements of medium sized planks in the center area (likely representing ridge beam supports) and some changes in elevation, with occasional features with higher upper elevations occurring (Table 2.10, Figure 2.20). Additionally, the row of high elevation plankmolds in the north center of House 4 (Unit M) indicate that the northern wall of this structure may have been reset late in the house's uselife.

In this question, episodes of feature replacement were used to investigate continuity in house architecture by examining replacement episodes in wall planks and beam supports at both sites. At both sites, fine-scale maps show many examples of redundantly-placed features, suggesting that structural element replacement occurred regularly and that placement of elements remained rela-

Figure 2.21. Plankmolds in wall and central areas at Meier by upper elevation.

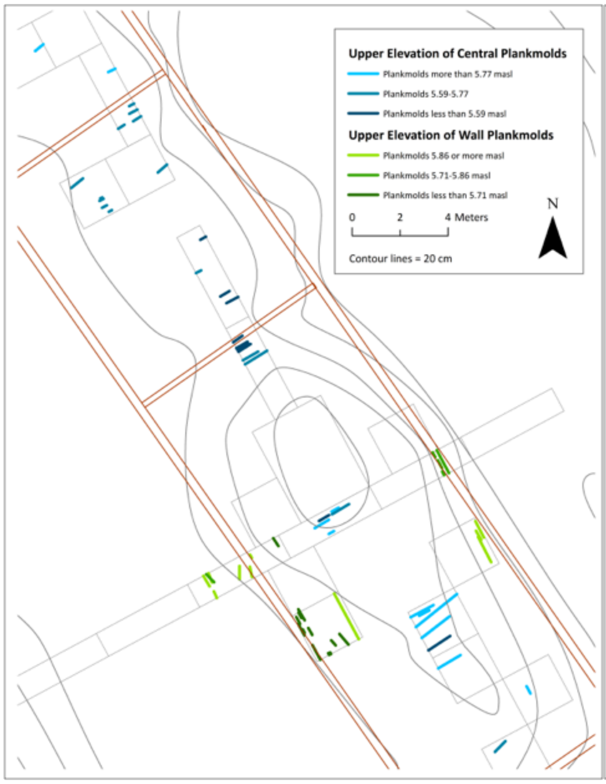


Figure 2.22. Plankmolds in walls and central area at Cathlapotle House 1 by upper elevation.

Figure 2.23. Plankmolds in walls and central area at Cathlapotle House 4 by upper elevation.

Table 2.13. Results of Mann-Whitney Test for Differences in Feature Length and Width between Cathlapotle House 1 and 4.

		Count	Median Length (cm)	Test Results	Median Width (cm)	Test Result
All plankmolds	House 1	32	21	**U=191, p=.001**	6	U=300.5, p>.1
	House 4	24	38.5		7	
Plankmolds > 20 cm	House 1	18	38	U = 134.5, p>.1	9	U = 166, p>.5
	House 4	22	39.5		7	
Postholes	House 1	36	8	U=380, p>.1	7	U=369.5, p>.1
	House 4	22	9		8	
Postmolds	House 1	108	9	U=3174, p>.1	8	U=3136, p>.1
	House 4	65	11		10	
Combined posts	House 1	144	9	U=5776.5, .1>p>.05	8	U=5677, .1>p>.05
	House 4	87	10		8.8	

Significant results are bolded. Only complete features included.

Table 2.14. Differences in Feature Metrics in Facilities, Meier (Only Results where p<.1 Included).

Feature Class	Measurement	Result	
Plankmolds	Length	Hearth > Bench	U=151.5, .1>p>.05, n=42
		Hearth > Cellar	U=147, p<.05, n=44
	Width	Wall > Bench	U=13.5, p<.005, n=27
		Wall > Cellar	U=8.5, p<.005, n=29
		Wall > Hearth	U= 31.5, .1>p>.05, n=27
		Hearth > Bench	U=146, .1>p>.05, n=42
		Hearth > Cellar	U=89, p<.001, n=44
		Bench > Cellar	U=159, p<.05, n=44
Posts	Length	Wall > Hearth	U = 98, p<.05, n=39
	Width	Wall > Hearth	U = 93, p <.05, n=39

tively stable over time. At Meier, features in the walls vary somewhat in elevation, while those in hearth areas remain essentially the same. At Cathlapotle House 1, this same trend of greater variation in elevation in walls as opposed to ridge beam supports is noted. In Cathlapotle House 4, variation in walls and central areas was comparable. Overall, these data show that structural elements were often replaced in similar locations. In walls, structural element position may have varied with depth over time. In interior areas, structural elements were also often replaced, however, depth was usually more carefully maintained. This indicates that continuity of house layout was important in interior areas.

4. *Plankhouse orientation was consistent through time.*

This question examined whether house alignment (which is a proxy for physical appearance) remained stable through time. Changes in orientation were investigated using maps of plankmold orientation, the Spearman's rank order correlation, and linear directional means analysis (LDM). At Meier, I selected plankmolds parallel to the house's west wall to evaluate any evidence that the house shifted in orientation (Figure 2.21). No correlations are noted between depth and orientation (Table 2.11), and the LDM test indicated that plankmold direction is similar in all depths (Table 2.12). To additionally evaluate evidence that the Meier House shifted over time, I selected the plankmolds that were classified as part of hearth facilities (Figure 2.21), many of which likely represent ridge beam supports. No correlation is noted between orientation and upper elevation (Table 2.11). LDM for the three elevation groups exhibit a significant shift for the central elevation group, showing that as a whole, plankmolds

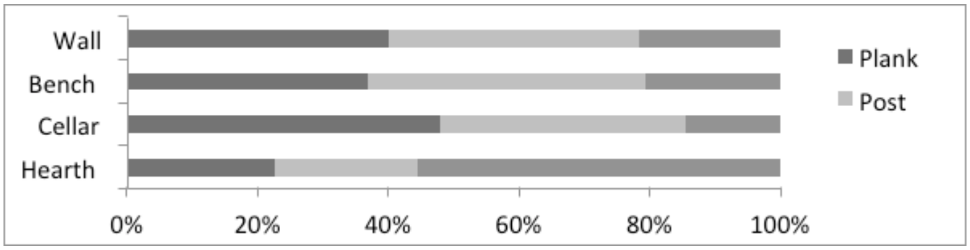


Figure 2.24. Distribution of selected features across plankhouse facilities, Meier.

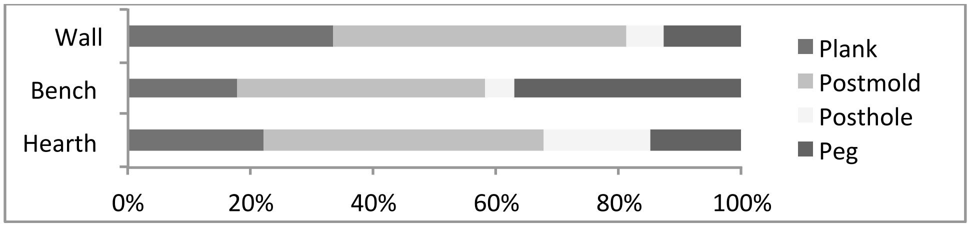


Figure 2.25. Distribution of selected features across plankhouse facilities, Cathlapotle.

in this group are oriented significantly differently than plankmolds in the upper and lower groups (Table 2.12). However, sample size for each group is low, so this result could be impacted by several plankmolds with outlier orientations.

For Cathlapotle House 1, I selected the plankmolds that run parallel to the house's east and west wall (Figure 2.22). A Spearman's rank order correlation shows a potential correlation between upper elevation and orientation, although results are not statistically significant (Table 2.11). Results of a LDM test also suggest that orientation may have shifted very slightly over time (Table 2.12). I also examined plankmolds found in central areas of Cathlapotle House 1 (Figure 2.22). A Spearman's rank order correlation does not show statistically significant correlations (Table 2.11), and no large shift in LDM was noted (Table 2.12).

For Cathlapotle House 4, I selected the plankmolds running east-west (Figure 2.23). A Spearman's rank order correlation also shows no significant correlation between orientation and depth (Table 2.11). Results of the LDM test show that plankmolds in the top two elevation groups are different that the lower group, suggesting that the house may have shifted slightly from its beginning orientation (Table 2.12). For Cathlapotle House 4, LDM were also calculated for plankmolds running generally north-south (Figure 2.23). No correlation between depth and orientation is noted (Table 2.11). Overall, results of LDM analysis suggest plankmold orientation within House 4 was remarkably stable (Table 2.12).

In summary, for all three houses investigated in this study, statistical tests and examination of GIS maps provided little conclusive evidence of shifting orientation. At Meier, central plankmolds may have shifted significantly in the middle elevations, but returned to a similar orientation. However, sample size was small so this result is questionable. At Cathlapotle House 1, plankmolds in walls may have shifted slightly over time, although statistical tests were not significant. Overall, maps and tests indicate continuity of plankmold orientation over depth, and thus stability in house orientation and structure. However, small sample size and the sensitivity of these tests to outliers make interpretation difficult.

5. *Similar structural elements were used in Cathlapotle House 1 and 4, and in Compartments B-D of House 1.*

At Cathlapotle, complete feature metrics

Table 2.15. Differences in Feature Metrics in Facilities, Cathlapotle (Only Results where p<.1 Included).

Feature Class	Measurement	Result	
Plankmolds	Length	Hearth > Wall	U = 187.500, p<.005, n=57
	Width	Hearth > Wall	U = 201.500, p<.005, n=57
Postholes (>7 cm)	Length	Bench > Hearth	U = 222.5, p<.005, n=28
Postmolds (>7 cm)	Length	Wall > Hearth	U = 1207, p<.05, n=116
	Width	Wall > Hearth	U = 1122.5, p<.01, n=116
All posts	Length	Wall > Hearth	U = 5040.5, p<.05, n=182
	Width	Wall > Hearth	U = 4763, p=.006, n=182

from Houses 1 and 4 were compared using the Mann-Whitney test (Table 2.13). Plankmolds from House 4 are significantly longer than in House 1, although there are no significant differences in width. However, many more plankmolds in House 1 are under 20 cm in maximum length than in House 4. When only plankmolds over 20 cm in maximum length were included in analysis, there are no significant differences in plankmold length. Posthole and postmold dimensions were compared between Houses 1 and 4, with no significant differences in length or width for either of these categories. For the combined post category, length and width are not significantly different between the houses, although some evidence suggests that features in House 4 were larger. Overall, results of comparisons between Cathlapotle Houses 1 and 4 do not reveal significant differences in feature size.

Features were also compared within compartments of House 1. Complete plankmolds were found only in compartments C and D. There are no significant differences in length (U=74.5, p>.5, n=32) or width (U=61, p>.1, n=32) for plankmolds in the two compartments. For postmolds, no significant differences are noted between the three compartments for length (H(2)=.716, p>.5, n=108) or width (H(2)=.024, p>.5, n=108). Statistics for postholes were not completed, as complete postholes were found in only Compartment D.

6. *Structural elements differ between facilities.*

Morphological attributes of feature classes were investigated between architectural facilities, although small sample size impacted comparisons between some facilities (see Appendix A). Only features with complete horizontal measurements were used. At Meier, four major feature facilities were used for classification: hearth, cellar, bench and wall. For plankmolds, maximum length does not differ significantly between all four facilities (H(3) = 5.838, p >.1, n=71). Width of plankmolds does differ significantly between facilities (H(3) = 21.637, p=.001, n=71), likely driven by larger widths of plankmolds in walls. When plankmold metrics in the four different facilities were compared one-to-one, several differences are noted (Table 2.14). Plankmolds in walls are wider than in other facilities, and plankmolds in hearths are longer and wider than those in cellar or bench facilities.

Complete combined posts larger than 7 cm were compared for all facilities at Meier. No statistically significant differences are noted when comparing all groups for maximum length (H(3) = 6.384, .1>p>.05, n=86) or width (H(3) = 6.441, .1>p>.05, n=86). One-to-one comparisons found that posts in walls are significantly larger than those in hearths (Table 2.14). In summary, at Meier, features are largest in walls and hearths, likely reflecting the prevalence of major structural elements such as wall planks and roof supports in these facilities.

A chi square test was performed to compare proportions of plankmolds, combined post features, and pegs (posts <7 cm) in bench, cellar, wall and hearth facilities at Meier. Feature classes distributions differ between facilities (χ^2 = 52.232(6), p=.001, n=271). Pegs (posts smaller or equal to 7 cm in length) were more prevalent in hearth facilities (Figure 2.24). When pegs were removed from

Table 2.16. Comparison of Lengths and Widths of Features at Cathlapotle and Meier.

	Length (cm)			Width (cm)		
	Cathlapotle Median	Meier Median	Mann-Whitney Test	Cathlapotle Median	Meier Median	Mann-Whitney Test
All complete features						
Plankmold	30 (N=64)	14 (N=74)	**U= 54858, z=-4.013, p=.000**	7 (n=64)	5 (n=74)	**U= 1837, z= -2.27, p=.023**
Postmold	13 (n=143)	16 (n=11)	U=786.5, z=.863, p>.1	10 (n=143)	8 (n=11)	U = 786.5, Z = -.309 p>.5
Posthole	10 (N=44)	10 (N=67)	U = 1474, z = .045, p>.5	8 (N=44)	9 (N=67)	U = 1474, z=1.88, .1>p>.05
Combined posts	12 (n=187)	10 (n=78)	U=7293, z= -1.67, .1>p>.05	10 (n=187)	8 (n=78)	**U=7293, z= -3.36, p=.001**
Complete features in hearths						
Plankmold	42 (N=20)	18 (n=21)	**U=210, z=2.739, p=.006**	11 (n=20)	7 (n=21)	U=1470 z=1.682, .1>p>.05
Postmold	11.25 (n=58)	14 (n=3)	U=899, z=.567, p>.5	8.75 (n=58)	8 (n=3)	U=899, z=-.150, p>.5
Posthole	10 (n=16)	9.5 (n=20)	U=986.5, z=.891, p>.1	8 (n=16)	7 (n=20)	U=986.5, z= -1.862, .1>p>.05
Combined posts	11 (n=74)	10 (n=23)	U=13899.5, z=-1.416, p>.1	8.5 (n=74)	7 (n=23)	**U= 13899, z= -2.98, p=.003**
Complete features in walls						
Plankmold	20 (n=19)	9 (n=3)	**U=109, z= -2.009, p =.045**	6 (n=19)	8 (n=3)	U=109, z= 1.244, p>.1
Postmold	N/A*	N/A*	N/A*	N/A*	N/A*	N/A*
Posthole	10 (n=14)	10 (n=6)	U=147, z=-.412, p>.5	10 (n=14)	8 (n=6)	U=147, z= -1.402, p>.1
Combined posts	10.5 (n = 50)	10.5 (n=8)	U = 1966.5, z = .440, p >.5	10 (n=50)	9 (n=8)	U = 1966.5, z = -.090, p >.5

* Sample size at Meier are too low to perform test. Significant results are bolded. Significantly larger measurements are underlined.

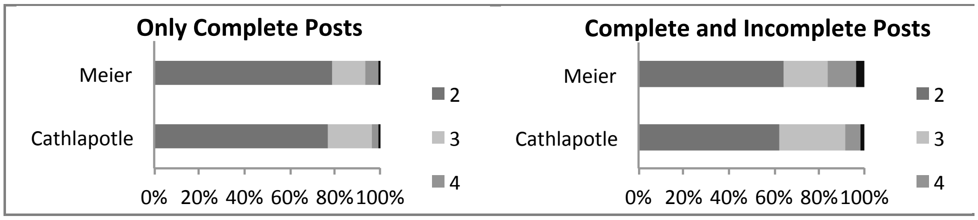


Figure 26. Combined posts by size class, Cathlapotle and Meier.

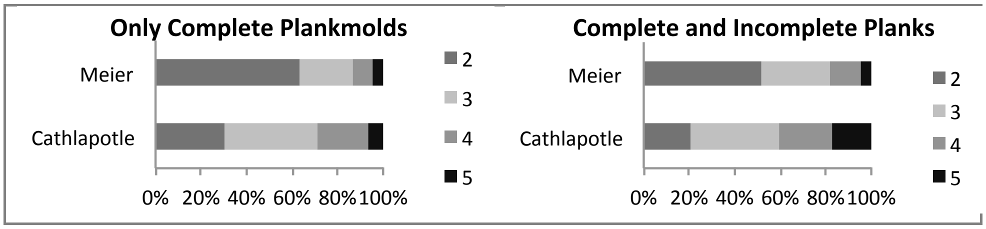


Figure 2.27. Plankmolds by size class, Cathlapotle and Meier.

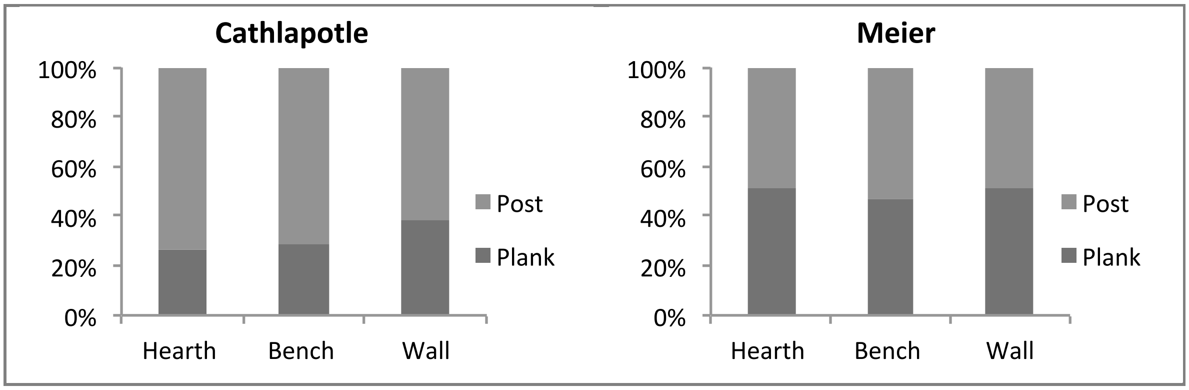


Figure 2.28. Distribution of plank and post feature (>7 cm) across facilities.

analyses, planks and posts are not distributed differently within architectural facilities (χ^2 = 1.002(3), p>.5, 154).

At Cathlapotle, plankmolds, postmolds, postholes and combined posts were compared between hearth, bench and wall facilities. I included features from both House 1 and House 4, as separating houses would decrease sample size. Plankmold metric attributes were compared across facilities (Table 2.15). For plankmolds, maximum length (H(3) = 11.127, p<.005, n=60) and width (H(3) = 11.620, p<.005, n=60) differ significantly across the three facilities, with plankholds in hearths longer and wider than in other facilities.

For postholes, there are significant differences in width between the three facilities (H(3) = 9.208, p<.05 n=63). In a one-to-one comparison, postholes are longer in benches than in hearths. Neither postmold length (H(3) = 1.081, p>.5, n=184) or width (H(3) = 2.828, p>.1, n=184) differ significantly between the three facilities. However, when postmolds are compared one-to-one, those in walls are significantly larger than in hearths (Table 2.15). When postmold and posthole categories are combined, post length did not differ significantly between the facilities (H(3) = 4.802, .1>p>.05, n=247), although there is significant difference in post width (H(3) = 8.450, p<.05, n=247). In one-to-one comparisons combined posts are larger in walls than in hearths (Table 2.15). Overall, at Cathlapotle planks are largest in hearths and posts are largest in walls.

The distribution of feature types among facilities at Cathlapotle was investigated with a chi-square test. This test compared the distribution of plankmolds, postmolds, postholes and pegs in hearth, bench and wall facilities. Feature classes differ in distribution across the three facilities (Figure 2.25, χ^2 = 53.741(6), p=.001, n=410), even when pegs are excluded (χ^2 =33.952(4), p=.001, n=265). Distributions of the combined post category and plankmolds between only hearth and wall facilities also differ from expectations (χ^2 = 24.460(1), p=.001, n=247), with more plankmolds present in wall faculties than in hearth facilities.

Differences between architectural features in facilities were noted at both sites. At Meier, comparisons of plank and post sizes between facilities show that some differences exist in feature metrics in different areas of the house - features in walls and hearths tend to be larger than those in other facilities. Hearths contain many small posts, which were possibly used in drying racks and other food preparation. At Cathlapotle planks are largest in hearth facilities, indicating that large planks were used as ridge beam supports. At both Cathlapotle and Meier, posts are larger in walls than in benches and hearths, suggesting that many small posts were used in these areas for insubstantial interior structures. Plank patterning is different between the two sites, at Meier, wall facilities generally contained larger planks, while at Cathlapotle, hearth facilities did. This points to some differences between interior architecture at Meier and Cathlapotle.

In summary, distribution analysis suggests that facilities assigned at Cathlapotle are quantifiably distinct in respect to distribution of architectural features. Therefore, these facilities are meaningful designations of different areas in the houses with disparate uses by house occupants. At Meier, there is also evidence to support this conclusion. However, this evidence is not as strong, possibly because of smaller sample size.

7. *Similar structural elements were used at Meier and Cathlapotle.*

In order to assess differences between architecture at the two sites, I compared metrics of complete features. Analysis of length and width for plankmolds, postmolds, postholes and combined posts between Meier and Cathlapotle demonstrate some differences in metrics between the two sites. Table 2.16 presents comparisons of feature metrics between all complete features at Cathlapotle and Meier as well as comparisons between metrics in both hearth and wall facilities between the sites. Plankmolds at Cathlapotle are significantly longer and wider than those at Meier. Combined posts are significantly wider at Cathlapotle than at Meier, and may also be longer although not significantly.

Metrics of architectural features were also compared for the two sites within two architectural facilities: hearths and walls. These facilities were selected for analysis because they have the most potential to provide information on architecture and because of large sample size. Several differences were noted between feature metrics in hearth facilities at Meier and Cathlapotle. Plankmolds are significantly longer at Cathlapotle, and also may be wider, although this result is not significant. Combined posts are also wider at Cathlapotle, and postholes also may be wider, although not significantly. Fewer differences were observed for feature metrics in wall facilities between the two sites, this may be because of very low sample size for complete features at Meier. Plankmolds were significantly longer at Cathlapotle than at Meier. No other test result showed significant metric differences for wall features.

Subsequently, feature size classes were compared between each site using four size classes (Class 2: 7.1-20 cm, Size Class 3: 20.1-40 cm, Class 4: 40.1-70 cm, Class 5: > 70 cm). Size Class 1 was excluded from analysis these features are likely unrelated to house structure. The chi square test was performed for combined posts (postmolds and postholes) and plankmolds. Separate tests were run for only complete features, and for all features. No difference in size class distribution is noted for complete posts between Meier and Cathlapotle (Figure 2.26, $\chi^2(3)=2.46$, $p>.5$, $n=274$). No significant difference in distribution was found when all posts (complete and incomplete) were considered, although some difference may be present ($\chi^2(3)=6.44$, $.1>p>.05$, $n=407$). When Class 2 posts are removed from analysis and all posts (incomplete and complete) are considered, there is a difference in distribution of size classes between the two sites ($\chi^2(2)=6.48$, $p=.039$, $n=150$). More Class 3 posts were noted at Cathlapotle than expected and more Class 4 posts were noted at Meier than expected.

For plankmold size class between the two sites, test results demonstrate a clear difference in distribution. This is true whether all planks are considered ($\chi^2(4)=38.1$, $p= 0.000$, $n=347$), or whether only complete planks are considered ($\chi^2(4)=18.0$, $p= 0.001$, $n=138$). This is also true when all planks from the Meier House and Cathlapotle House 1 are compared ($\chi^2(4)=12.43$, $p= 0.006$, $n=219$). There are more Class 2 plankmolds at Meier than expected, and more Class 3 and 4 plankmolds at Cathlapotle (Figure 2.27).

Furthermore, in all facilities, Meier contains a higher percentage of planks compared to posts (>7 cm) than Cathlapotle across all hearth, bench and wall facilities (Figure 2.28). Hence, planks may have been used for architecture or lining storage pits more often at Meier than at Cathlapotle.

In summary, results suggest some differences in structural elements between the two sites. Planks are larger in both wall and hearth facilities at Cathlapotle than at Meier. Additionally, there are more planks of larger size classes at Cathlapotle than at Meier. In contrast, these results show that more large planks may have been used at Cathlapotle than at Meier. Comparison of feature classes also suggests that, in general, planks were used more often in houses at Meier than at Cathlapotle. Taken together, these results also suggest that minor structural differences existed between houses and Meier and Cathlapotle, despite their proximity.

CHAPTER 6
RESULTS OF PLANKHOUSES LABOR LITERATURE REVIEW

In Chapter 7, architectural features are used to investigate questions regarding plankhouse building and repair, such as amount of trees required for construction activities, person hours involved in various tasks, and organization of communal labor endeavors. However, since the archaeological record at Meier and Cathlapotle cannot provide information regarding many aspects of house morphology and activities involved in plankhouse production, it is also necessary to consult other sources. The first section of this chapter summarizes historical, ethnographic and archaeological literature regarding plankhouse production activities. The second section presents environmental and forestry data on cedar, enabling labor estimates to be extended to resource acquisition costs.

Plankhouse Construction and Maintenance

Historical Accounts and Ethnographies of Plankhouse Construction and Maintenance

Although house form on the Northwest Coast is well-researched, less is recorded regarding the processes of building these structures. However, some historical documents and ethnographies provide descriptions of labor tasks that are related to building and maintaining the dwellings. The following ethnographies and historical sources were consulted in this discussion: Boas' (1916) description of Tsimshian tree felling and plank spitting based of notes of Henry Tate; Drucker's (1966) summary of traits associated with construction and tree felling in central and northern areas; Goddard's (1972) ethnography of various central and northern groups in the early 20th century; Jewitt's (1987) memoir of life on western Vancouver Island from 1803-1805; Koppert's (1930) interviews with Clayoquot (Tla-o-qui-aht First Nation) elders in 1923 on westerm Vancouver Island; Niblack's (1970) volume on northern British Columbia and southeastern Alaska groups based on his observations from 1885-1887; Stewart's (1984) summary of cedar building technologies; and Wilson's (1866:287) description of structural element morphology and house architecture on Vancouver Island. These accounts demonstrate that acquiring materials for plankhouses was a substantial task.

Beams and posts were made from logs that were usually felled, but were sometimes acquired from downed trees. Offering a prayer prior to felling was customary (Boas 1921:619; Mauze 1998). Large trees were felled using chisels, wedges, mauls and hand hammers, as well as the strategic application of fire and systems of scaffolding. Jewitt (1987:93) notes that three workers took 2-3 days to fell large trees, which was a "slow and tedious process". The excess top portion and tree branches were then removed from the log, and bark was stripped from the trunk. Logs were then floated down rivers and streams to the village. In addition to manpower, a combination of skidding and ropes was used to transport logs to the watercourse and from the beach to the house building site. Koppert (1930:10-11) provides a description of obtaining cedar for buildings:

> Nine or ten men go into the woods in search of good cedar trees… These trees are felled near the shore and usually on a grade in order to facilitate their transportation… Sixty or more men pull on the rope. While some men push, others, armed with poles, work on the sides of the log. In this way they lift it and at the same time push it along. By repeated effort they succeed in bringing the log to the water and setting it afloat. It is difficult to specify the time it takes for all this because there are so many variable factors, e.g., the number of men available, the size of the tree, the amount of underbrush, the grade of the land, and the nearness to the water. Ordinarily, it may be said it takes two hundred men about twenty-four hours to 'roll' a good-sized log from where it was felled to the water.

Once logs were transported to the village site, they were shaped and adzed. Support posts were notched at the top, providing a place for beams to rest.

Planks for walls and roofs were split either from large logs using wedges or directly from standing trees. In some regions of the Northwest Coast, roof planks were specially shaped to fit together and prevent rain from entering the building. Jewitt (1987:71) discusses replacing planks:

> The planks and boards which they make use of for building their houses, and for other uses, they procure of different lengths as occasion requires, by splitting them out, with hard wooden wedges from pine logs, and afterwards dubbing them down with their chizzels, with much patience, to the thickness wanted, rendering them quite smooth.

To split planks, logs were usually hauled to the village site, although sometimes planks were split where the tree was felled. Newcombe (1902) describes the process of felling trees and splitting planks at the felling site,

> A tree of a suitable size was chosen…The tree was then pulled down taking care that the side with the most braches was the uppermost…Once properly on the skids the top of the tree was cut through and removed. Next a long rope of cedar bark was taken and stretched on each side for the whole length of the tree. Notches were now made down the line so marked, dividing the upper portion of the trunk into several sections which were split off with the wedge and sledge hammer (quoted in Turner 2004:82).

During house construction, systems of ropes, scaffolding and complex levers were used to raise posts and beams (Figure 2.29). An 1866 house raising in British Columbia sketched by Henry Elliot (reproduced in Niblack 1970:375) underscores several important aspects of house raisings: (1) use of skids to move large logs, (2) use of ropes in transportation and beam raising, and (3) large amounts of labor needed to move wooden element. House repair activities are not well documented in historical accounts and ethnographies, although Stewart (1984:46) provides examples of sophisticated and time-consuming techniques for repairing warped or split planks.

Historical documents attest that amassing requisite material and wealth for house building could take years and that house building entailed “great labor and expense” (Niblack 1970:374). These methods required not only physical strength, but also a great deal of coordination and planning.

Archaeology of Plankhouse Construction and Maintenance

Excavation of numerous plankhouses on the southern and central Northwest Coast provides information regarding architectural feature metrics (Table 2.17). The most significant archaeological study of household architecture on the Northwest Coast emerged from the remarkable excavation of Makah plankhouses at the Ozette site on the Olympic Peninsula. The Ozette houses were covered by a mudslide in A.D. 1700, resulting in excellent preservation of organic material, including wooden architectural features (Mauger 1978). This allowed researchers to recognize and measure structural elements of buildings, discern how the houses were built, and identify methods of architectural repair. Although some details of

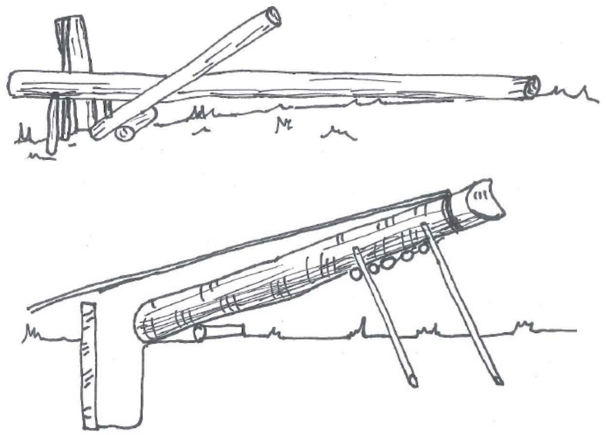


Figure 2.29. Methods of raising posts and beams: (left) a Kwakiutl method of raising a beam (redrawn from Goddard 1972:29), (right) a Clayoquot method of raising a beam (redrawn from Koppert 1930:14).

Table 2.17. Selected Southern Northwest Coast Plankhouse Architectural Element Descriptions.

Site	Area	Architectural Element	Description	Citation
35-TI-76	House 8	Postmolds	Several posts <10 cm in diameter found along centerline of house	Losey 2005:414
Dionisio Point	House 2	Postholes	Likely rafter support posts. 10 posts > 45 cm, 15 posts between 26-45 cm, 17 posts between 16-26 cm	Grier 2001: 171
Middle Village	Entire site	Postholes	Often 20 cm or less in diameter. Depth about 30 cm. Often associated with heaths or bench areas.	Wilson 2009: 109, 200
	Area F Block	Plankmolds	Width: 4-6 cm, length: 7-43 cm, average length 23.8 cm.	
Netarts Sandspit	Pit 5	Plank	One partially charred, horizontally laid plank 70 cm tall, base dimensions 25 x 1.5 cm	Losey 2005: 404-406
	Pit 12	Corner posts	18-30 cm in diameter, extended deep below floor midden (at least 45 cm)	
	Pit 13	Postmolds	At least 46, ranging from 5-27 cm in diameter, 6-43 cm deep below floor fill.	
	Pit 13	Plank	Horizontally laid, at least 6.2 m long.	
Ozette	House 1 & 2	Split planks	Mean height: 3.96 m, mean width: .31 m, mean thickness: 3 cm	Mauger 1978: 71, 73
	House 1 & 2	Dressed planks	Mean height: 3.92 m, mean width .41 m, mean thickness: 2.6 cm	
	House 1 & 2	Rafter support posts	Mean height: 4.47 m, mean width (bottom): .38 m, mean thickness: 16 cm	
Scowlitz	Structure 3	Postholes	Most about 30 cm in diameter. Excavated into sterile gravel.	Lepofsky et al. 2000: 401
Shingle Point	House 1 & 2	Rafter support posts	Mean length: 4.47m, mean width at bottom: .38 m	Matson 2003

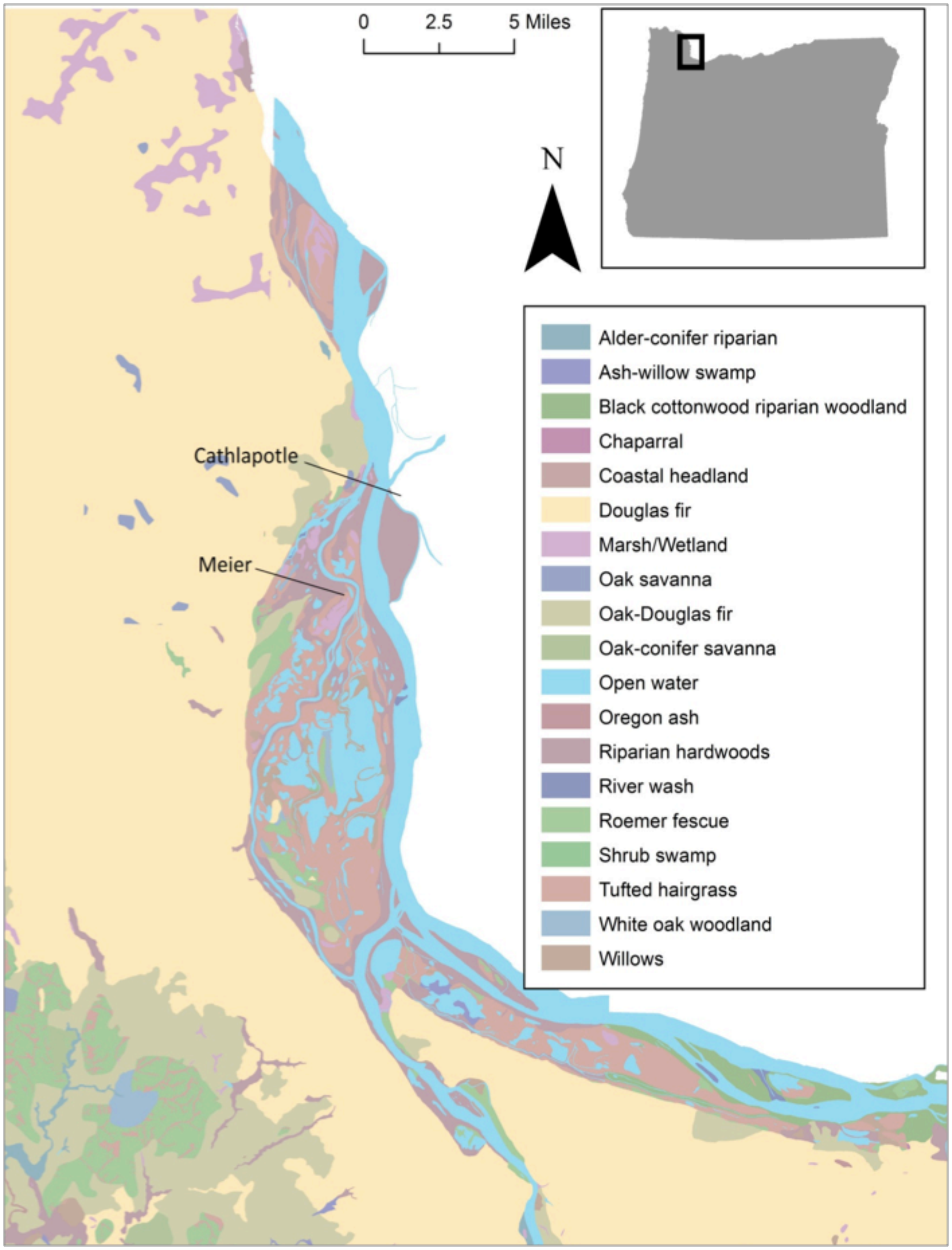


Figure 2.30. Historic vegetation in the Upper Willamette Valley, 1938 (Tobalske 2002).

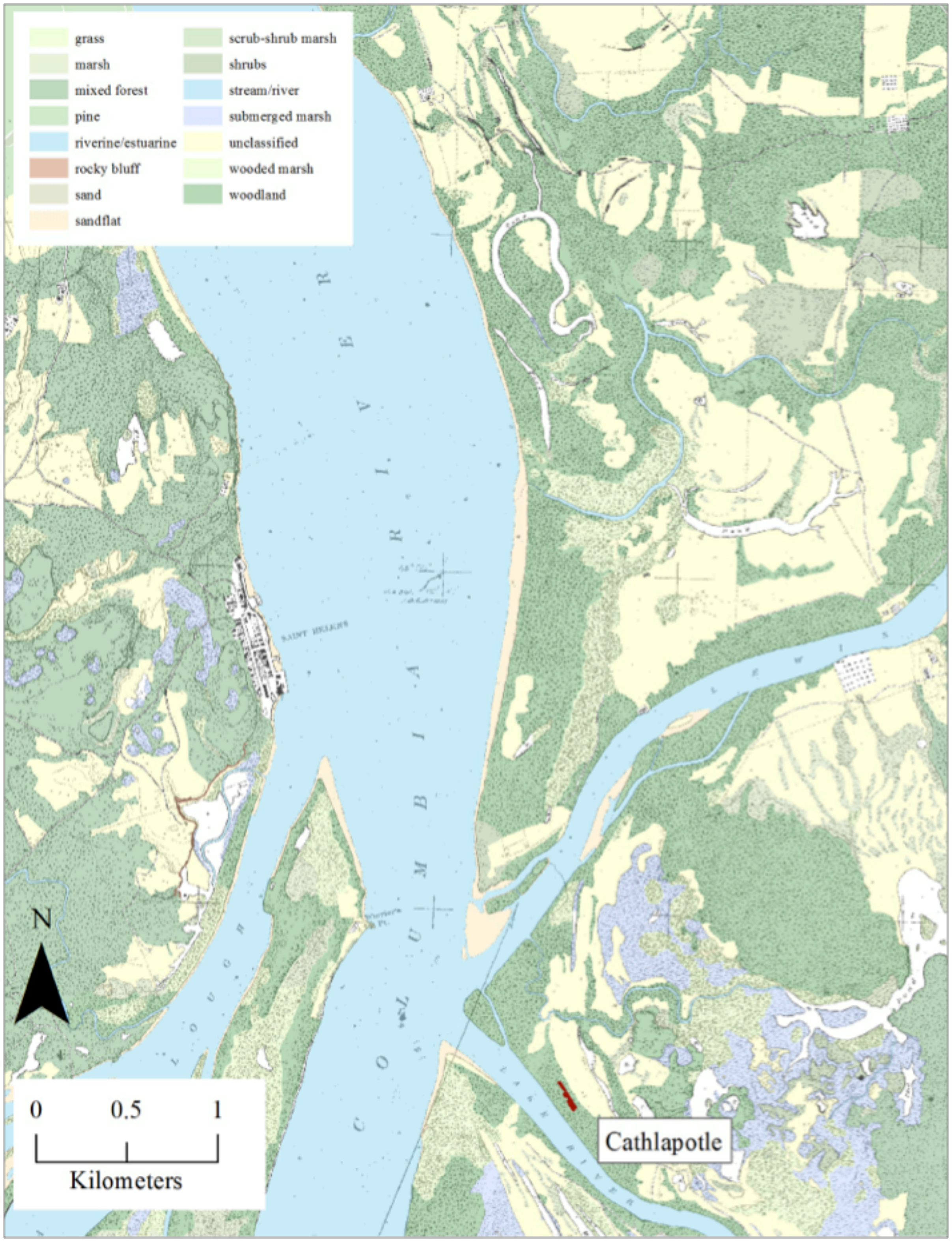


Figure 2.31. Cathlapotle historical vegetation based on 1850s T-sheets (Burke 2010).

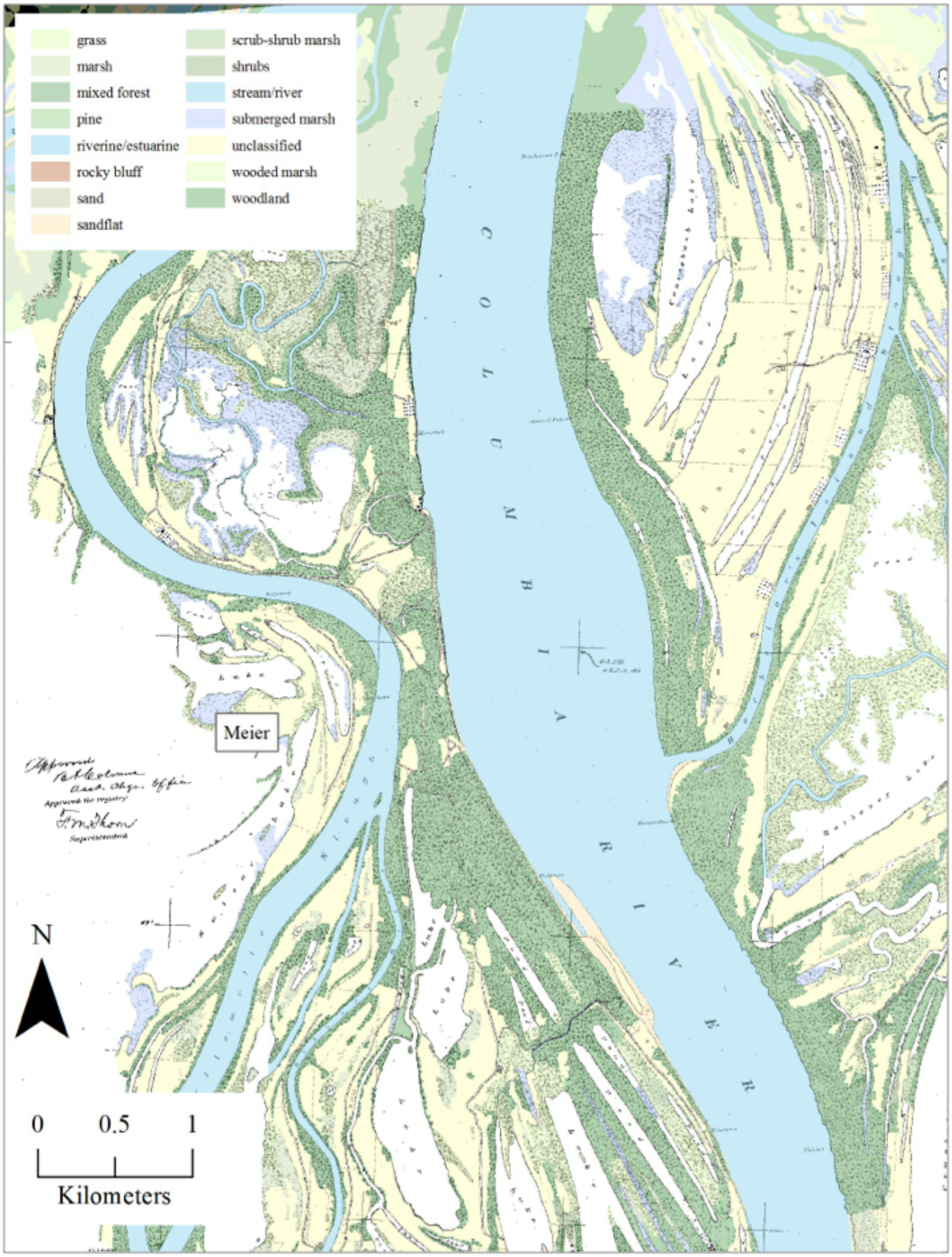


Figure 2.32. Meier historical vegetation based on 1850s T-sheets (Burke 2010).

house architecture are not applicable to the LCRR, as houses in this area were shed-roofed rather than gabled, archaeological data regarding Makah logging and house building techniques allows a rich picture to emerge regarding the myriad activities that were involved in building and repairing plankhouses.

Evidence of structural element repair is common at Ozette, suggesting that maintenance was a continuous activity. Many planks show signs of mending and recycling, implying that house repair was an extremely important household task (Mauger 1978:92-96). Planks with longitudinal cracks were stitched together with cedar withes and entire walls would rot and need to be replaced. Planks were often reused, for example parts of canoes were repurposed in walls. The effort invested in repairing and reusing rather than replacing planks suggests that obtaining new planks was difficult and time consuming. Further evidence of the intensity of building activities is found in the frequency and variety of woodworking tools (such as wedges) noted at Ozette (Gleeson 1980). This also demonstrates that much time and planning was invested in manufacturing and repairing tools for tasks such as splitting planks.

Archaeological data can aid in reconstructing replacement rates for house elements by providing information regarding weathering of house elements. In their investigation of standing remains of a Nuu-chah-nulth plankhouse built in the mid-19th century, Smith et al. (2005) note that beams not exposed to the ground were in relatively good condition compared to elements in the soil. Corner posts displayed large amounts of rot, and building elements needed to be replaced more frequently if they contacted the ground or bore a heavy load. Dendrochronological data from this study where researchers obtained cutting dates from house posts suggest that elements were continually replaced as they became structurally unsound.

Other than wet sites and intact houses, direct archaeological evidence of woodworking and wood harvesting activities related to plankhouses is limited. One culturally modified tree (CMT) that was formed when a plank was split from a tree trunk has been documented in Oregon (Gilsen 2009). Three planks, with widths of about 40 cm and lengths ranging from about 4-6 m were harvested from this tree. Although this CMT demonstrates that planks were sometimes removed from standing trees rather than split from felled logs, the rarity of this site type tentatively suggests that this method of obtaining planks was not often practiced in the area. This type of culturally modified tree is more prevalent in British Columbia (Stryd and Feddema 1998; Stryd 2001).

Plankhouses and Western Redcedar

As plankhouses were constructed from western redcedar, cedar properties and growth patterns are important to investigating how these dwellings were constructed for several reasons. Paleoecological data informs the antiquity and development of plankhouses on the Northwest Coast. Metric data are necessary for approximations of the quantity and weight of trees needed to build and repair structures. Properties of cedar wood are requisite for estimating element replacement rates. Cedar distributional data is important to understanding labor costs involved in procuring materials for plankhouses.

Reconstructions of climate on the Northwest Coast during the Early Holocene demonstrate that temperatures were too warm and dry to support cedar (Hebda and Mathewes 1984). By the Mid-Holocene, more moisture and cooler temperatures enabled expansion of cedar and other flora adapted to changing conditions (Whitlock 1992). Regional studies from Oregon and Washington involving palynology, microfossils and genetics demonstrate the dramatic increase of cedar from 6000-5000 B.P. (Barnosky 1981, 1985; Hebda 1995:75; Wainman and Mathewes 1987; Worona and Whitlock 1995).

A basic understanding of cedar size enables estimates of the amount of trees harvested for house construction and repair. Historical information regarding cedar metrics and distribution in the LCRR is unavailable, however current dynamics of old growth stands are well known. Throughout the Northwest Coast, cedars average almost 60 meters in height and about two meters in diameter at the base, with a rapidly tapering trunk (Pojar 2004; Waring and Frankin 1979). Cedar grows most often below 1,000 meters above sea level, where total annual precipitation is less than 300 cm, and mean annual temperature is between 6-8 C° (Lesher and Henderson 2010). Cedar growth is sensitive to climate variables, and the most important factors in producing large cedars are warm summers and winters, and high summer precipitation (Harrington and Gould 2010:101). Although cedars were present in the LCRR, they probably did not reach the maximum sizes as conditions are not as favorable in this area as on other places on the coast. However, these measurements provide a baseline for estimating ranges of probable cedar metrics in the vicinity of Meier and Cathlapotle.

Although cedar was present in the LCRR, it was likely not abundant. Cedar is rarely the dominant tree species in Northwest Coast forests, and in fact patterns of distribution were "patchy" throughout the region (Deur and Turner 2005:11). In old-growth forests of western Oregon, cedar populations are small compared to other trees (Poage and Tappeiner 2005:335). In a forestry study of land west of the Cascades in Oregon and Washington in 1934, 1.1% of about 35 million acres were classified as containing predominantly large cedar (Harrington 2003). Maps of historic vegetation illustrate that although some of the upper Wapato Valley was forested, vegetation zones containing cedar were not plentiful (Figure 2.30). In the Willamette Valley, 1850s survey assigned only about 14% of land to vegetation classes that could contain cedar (Christy and Alverson 2011). The immediate areas surrounding Meier and Cathlapotle were likely largely prairie, wetlands and deciduous forests in the past (Figures 2.30-2.32). However, modern cedar stands do exist around Mud Lake, which is located in close proximity to Cathlapotle (Kenneth Ames, personal communication).

In addition to patchy distributions, availability of cedar for building materials was also restricted as quality and size of trees varied considerably. Older cedar has a higher content of thujaplicin, a fungitoxin that provides anti-fungal and anti-bacterial protection (Buchanan 1992), and therefore older trees may have been sought for building materials. Many cedar fungicides increase with tree age (Russell and Daniels 2010), meaning that larger elements may have been more resistant to decay than smaller elements. Cedar suitability for building is variable (Gahr 2006). For example, trees growing in dense stands or close to water are more likely to have knots or low branches (Stewart 1984:24).

Further restricting the availability of cedar was its utilization for a plethora of other technologies. Wood was used for purposes including canoes and boxes and inner bark was important in a variety of technologies such as clothing and baskets (Stewart 1984). Harvesting inner bark alters the growing patterns of trees, which may render them unsuitable for most construction uses. Turner (2004:84) notes that "tremendous quantities" of cedar inner bark were harvested on the Northwest Coast. One study of cedar culturally modified trees shows that the majority of trees within specific use areas were subject to inner bark harvesting (Lepofsky and Pegg 1996). Paleoecological research also indicates that selective harvesting depleted cedar stands near village sites on the Northwest Coast (LaCourse et al. 2007).

Even considering these issues, cedar was the obvious choice for structures. Cedar is an exemplary building material for house construction: it is easy to work with, splits well, keeps its shape when drying, and resists decay and rot (Stewart 1984). Cedar is much less prone to volumetric shrinkage that can warp and split wood than other LCRR trees - its volumetric shrinking percentage of 6.8% is half of that of most trees on the southern Northwest Coast (Countryman and Kemperman 2000). Low shrinkage rates and low wood density contribute to western redcedar's excellent dimensional stability (Gonzalez 1997:17). Although cedar is resistant to warping and decay, it has comparatively low strength when used as posts and beams and has low shock resistance (Forest Products Laboratory 2010). The use of massive posts and beams in houses would have mitigated this weakness, minimizing the number of times elements would need to be replaced because of the threat of failure.

In summary, it is evident that although using cedar in structures had many benefits, issues did exist. Cedar is prone to decay and distortion from weight stress. Building elements would need to be replaced frequently because of rot. Furthermore, cedar trees were not unlimited resources, conversely, they may have been quite scarce in and around villages, especially considering their high demand for a variety of technologies.

Table 2.18. Square Meters of Planked Roof, Siding and Floor, Meier and Cathlapotle.

	Surface Area (m^2)		Board Feet	
	Low Range	High Range	Low Range	High Range
Meier with floor	1,032.8	1,158.2	33,351	37,401
Meier without floor	612.8	738.2	19,789	23,838
Cathlapotle House 4	209.8	277.0	6,775	8,946
Cathlapotle House 1B	148.6	198.8	4,798	6,419
Cathlapotle House 1C	215.3	279.8	6,954	9,036
Cathlapotle House 1D	320.2	407.4	10,339	13,155
Cathlapotle House 1 Total*	1,098.0	1,389.3	38,699	44,867

*Includes six short axis sides representing compartment dividers.

Table 2.19. Trees Represented in Initial Construction of Houses, Meier and Cathlapotle.

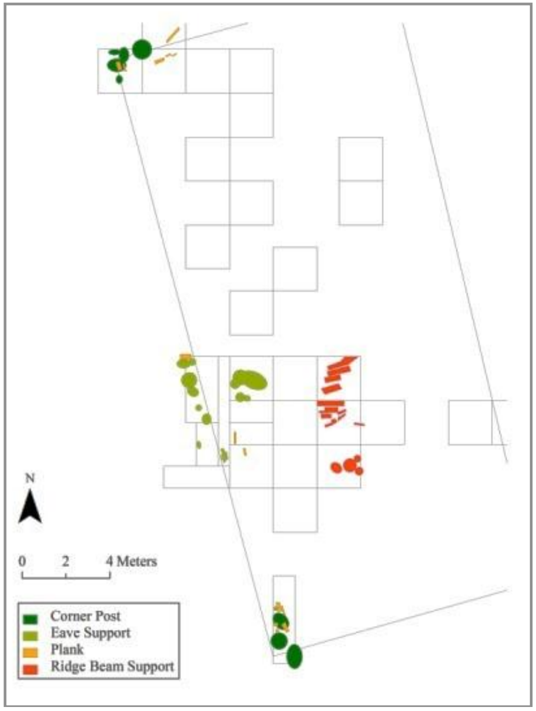
	Siding, Roofing and Flooring		Posts and Beams		
	Trees represented low range*	Trees represented high range*	Trees represented low range**	Trees represented high range**	Total
Meier with floor	29	33	22	30	51-63
Meier without floor	17	21	22	30	39-51
Cathlapotle House 4	6	8	10	13	16-21
Cathlapotle House 1	31	39	47	63	78-102

*Derived from board feet. **Derived from meters of circular wood calculations.

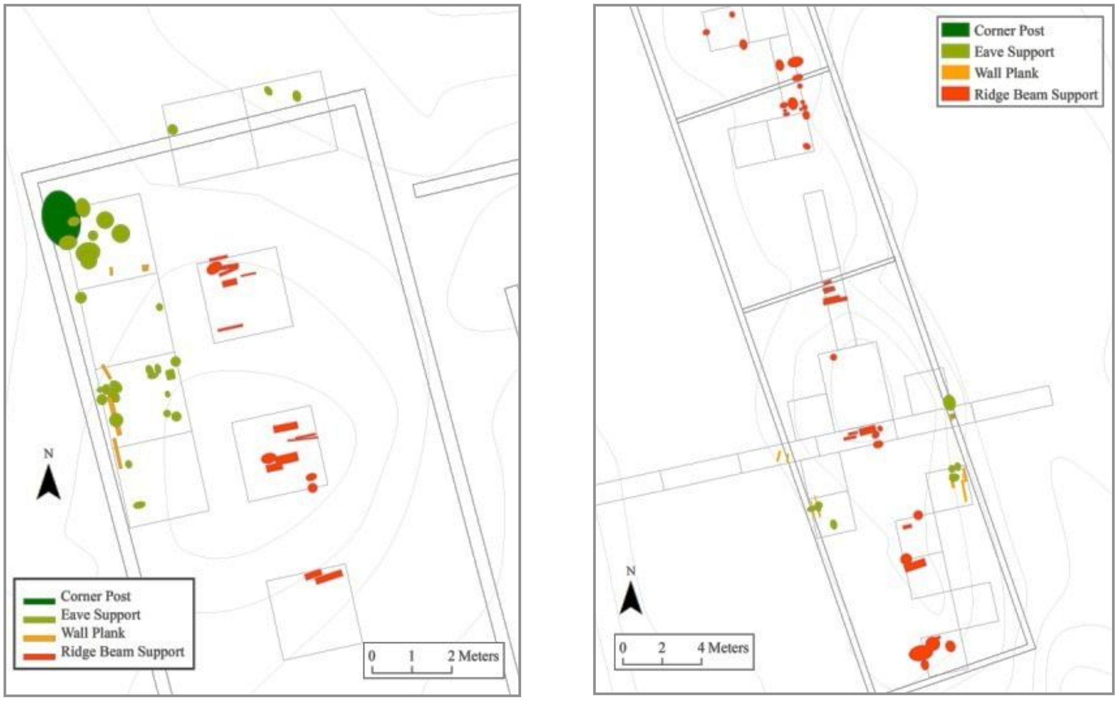
Table 2.20. Hours Required to Fell Trees, Meier and Cathlapotle.

	Group Time				Person Time		
	Posts and Beams (Hours)	Planks (Hours)	Total (Hours)	Days	Minimum Hours[1]	Maximum Hours[2]	Person Days
Meier with floor	19.5-95	130.5-149	150-244	19-30	300-487	1500-2435	38-304
Meier without floor	19.5-95	76.5-94.5	96-189.5	12-24	192-379	960-1895	24-237
Cathlapotle House 4	12-42.5	27-36	39-83	5-10	78-166	390-830	10-104
Cathlapotle House 1	52-215.5	140-176	192-391	24-49	382-782	1910-3910	48-489

[1] Based on Jewitt 1987:93. [2] Based on Koppert 1930:10.



Meier House



Cathlapotle House 4 Cathlapotle House 1

Figure 2.33. Structural features at Meier and Cathlapotle.

CHAPTER 7
PLANKHOUSE LABOR ON THE NORTHWEST COAST RESULTS OF LABOR CALCULATIONS

Quantifying Materials

The first step to assessing how much raw material was required for plankhouses is to understand the size of structural elements in these houses. Information from plankmolds and post features can be applied to specific structural components of houses. Four categories of structural elements were investigated: corner posts, eave supports, ridge beam supports, and wall planks (see Figure 2.7). Features were assigned to structural element based on morphology and house positioning (Figure 2.33).

Since complete, large features are rare, some incomplete features were 'completed'. At Meier, 53 features fitting into these four structural elements types were either complete (n=23) or able to be completed with a reasonable degree of certainty (n=30). At Cathlapotle, 125 features fitting into these four categories were either complete (n=52) or able to be completed to a reasonable degree of certainty (n=73). Descriptive statistics for features are compiled in Appendix A, while documents used to calculate morphological attributes of structural features are discussed in Chapter 4 and detailed in Appendix B.

Board feet measurements were used to estimate how many trees were used for planks in roofs, siding and floors. First, surface area of roofs, planks and floors was calculated, taking into account differing combinations of wall and roof height, which resulted in a range of possibilities. Table 2.18 presents ranges of board feet for one course of siding at both Meier and Cathlapotle. Importantly, these figures are underestimates for several reasons. They do not take into account underground portions of wall planks or overhanging portions of roof planks. Also, they do not include posts used on top of roofs to secure planking. Finally, these numbers reflect planks that are laid side-by-side, if planks overlapped (as they may have on roofs) more material would have been used.

Structural element metrics and element counts were used to determine the amount of material and trees used for posts and beams (see Appendix B). Element metrics rather than board feet were used for this calculation, as board feet calculations eliminate curved portions utilized in post and beam elements. Meters of circular wood needed for posts and beams was translated into trees required. To calculate trees needed for initial construction meters of posts and beams were combined with board feet (Table 2.19).

Plankhouse Construction Production Sequence

A production sequence allows delineation of tasks associated with plankhouse construction and maintenance. The following discussion is heavily based on material drawn from background research presented in Chapter 6. Importantly, this overview neglects many significant expenditures of labor, time and resources. These included pre-construction planning, ceremonies and prayers associated with tree felling and construction, as well as various costs of recruiting, organizing and deploying workers. Ethnographic and historical accounts demonstrate that these activities required much labor, time and other resources (Gahr 2006). Additionally, enormous quantities of tools would be needed for harvesting, transporting and construction. These would include woodworking tools such as wedges, chisels, mauls, adzes, as well as scoopers for removing soil and baskets for carrying material. Tools would require both manufacture and repair. Other materials would include poles used for skidding, props, bracing and scaffolding. Also, strong rope would need to be manufactured to pull heavy logs and guide posts as they were raised. Therefore, although the following discussion of materials and construction attempts to be as inclusive as possible, it must be seen only as one part of a larger process.

Procuring Building Materials

The first step in obtaining building material was to locate and select cedar trees. In addition to the sheer quantity of trees required for initial construction, cedars would be selected for certain characteristics. Different sized trees would need to be located and assessed for quality. Finding suitable trees may have been time consuming because of cedar distribution and growth characteristics. It is difficult to quantify the time and ef-

Table 2.21. Weight of Wood Material Needed for Initial Construction, Meier and Cathlapotle.

	Planks for Siding (metric tons)		Posts and Beams (metric tons)		Total (metric tons)
	Low Range	High Range	Low Range	High Range	
Meier with floor	47.03	52.73	5.54	31.32	52.57-84.05
Meier without floor	27.9	33.61	5.54	31.32	33.44-64.93
Cathlapotle House 4	9.55	12.61	3.37	15.88	12.92-28.49
Cathlapotle House 1	50.01	63.26	11.47	71.94	64.48-135.20

Table 2.22. Number of Planks Needed for House Sheathing, Meier and Cathlapotle.

	Meier with Floor	Meier without Floor	Cathlapotle House 4	Cathlapotle House 1b	Cathlapotle 1c House	Cathlapotle House 1d	Cathlapotle House 1 Total
Wall*	220	220	107	83	107	144	379
Roof	150	150	66	33	57	94	329
Floor**	30	-	-	-	-	-	-
Total	400	370	173	116	164	238	708

*Wall planks were likely shorter than other planks and therefore multiple planks could have been cut from one long plank. **I used a default plank length of 7 m for Meier floor calculations.

Table 2.23. Plankhouse Excavated Depth and Estimated Person Days to Excavate, Meier and Cathlapotle.

	Wall Trench		House Depressions			Corner Postholes		Pits and Cellars	
	Volume (m^3)	Person Days	House Area (m^{2})	Excavated Volume (m^3)	Person Days	Volume (m^3)	Person Days	Pit Volume (m^3)*	Person Days
Meier	5.7	2	420	126.0-840.0	49–323	0.7-2.6	1	127	49
Cathlapotle House 4	2.6	1	132	39.6-264	15–102	0.7-2.6	1	52	20
Cathlapotle House 1	10.1	4	658	197.4-1316.0	76-506	0.7-2.6	1	92	35

* Based on Ames et al. (2008:6).

Table 2.24. Labor Estimates of House Raising, Meier and Cathlapotle.

	Floor Area (m^2)	Low Labor Estimate (Number of People)	High Labor Estimate (Number of People)
Meier*	420	1,273	2,211
Cathlapotle House 1	658	1,994	3,463
Cathlapotle House 4	132	400	695

*Numbers differ slightly from Gahr's calculations because of different house metrics employed.

fort that would be spent searching for and selecting the numerous trees needed for posts, beams and planking. Adding to this situation is lack of specific information regarding population dynamics of cedar stands in the vicinity of Meier and Cathlapotle. Nevertheless, it is important not to disregard effort involved in finding and selecting trees.

Once suitable cedars were located, the next step was felling the trees. The work of cutting down the tree was not the sole aspect of tree felling – it was also important to guide the fall of the cedar so that it would not hit other trees or be damaged when falling on the ground. Rough estimates of time spent felling trees were calculated based on the experimental archaeology studies discussed in Chapter 4 with an eight hour work day. Based on this information, group time spent felling trees for initial construction at Meier was around 19-30 days, at Cathlapotle House 1 it was 24-49 days, and at Cathlapotle House 4 it was 5-10 days (Table 2.20). Person days were also estimated. Koppert (1930:10) implies group size for felling was about 10 people, while Jewitt (1987) writes that 2-3 people were involved in felling. Importantly, these figures do not account for interior furnishings such as benches.

After felling trees, the next step was removing tree tops, limbs and bark. The tree then would be hauled from the felling location to a watercourse in order to float logs to the house site. Hauling was accomplished by many people working together to push, lift, pull and haul the log across skidding. This major undertaking required varying numbers of people and time depending on the size of the log, the terrain, and the distance from the felling spot to the water. Logs were extremely heavy and moving them over dense forest and uneven topography would have been a monumental effort. Although precise calculations of time and manpower needed to move logs are not feasible without information regarding terrain and cedar distribution, estimations of weight of the logs represent many metric tons of material and hint at the massive effort entailed in these efforts (Table 2.21).

Koppert (1930) indicates that moving one large log from the felling site to the water in one day took 60-200 people. This would indicate that an astonishing amount of time was devoted to hauling logs needed for initial construction: 3,060-12,600 person days at Meier, 930-4,200 at Cathlapotle House 4 and 4,680-20,400 at Cathlapotle House 1. However, because only one historical source provided data regarding moving logs, I decided these numbers were too speculative to include in final labor calculations. However, even if partially accurate, they demonstrate that transporting logs was a major task associated with house construction.

After logs were transported to the water, log drivers guided the logs down the watercourse to the building site. Once the tree arrived at the village's beach, it would again be a massive task to drag the log up to the area of house construction. This would likely be accomplished by hundreds of workers pulling the log with strong rope.

Preparing for Building

Both the construction site and materials needed to be prepared for building. One essential task was splitting planks (again, I assume most planks were split from logs rather than pried from trees). Using a default plank width of 40 cm, I calculated the number of planks needed for house roofs, walls and floors (Table 2.22). Length of these planks varied according to the pitch of the roof. This number reflects one course of non-overlapping planks. Although these numbers are rough estimates, it is evident that a great deal of time would be spent splitting planks. Post, beams and many planks were likely adzed. Mauger (1978) reports that half of all planks at Ozette were adzed, including all roof and bench planks. Considering the large number of planks, posts and beams needed for construction, this would represent a considerable output of time and labor. Roof planks may have been specially grooved to control rain runoff, which would have entailed additional effort.

Prior to construction, the house site was cleared of vegetation and cultural debris. A great deal of earth moving occurred as the plankhouse itself, interior cellars, wall trenches, and postholes were all excavated. Volume of soil moved and person days required to do so were calculated using morphological information from the two sites as well as data from experimental archaeology (see Chapter 4). The precise depths to which the Meier

Table 2.25. Person Days Associated with House Construction Tasks.

Production Step	Specific Task	Meier	Cathlapotle House 4	Cathlapotle House 1
Planning	Plan architecture and labor	Unknown	Unknown	Unknown
	Prepare tools	Unknown	Unknown	Unknown
Procure materials	Locate and select trees	Unknown	Unknown	Unknown
	Fell trees	38-304	10-104	48-489
	Transport logs	Unknown	Unknown	Unknown
Prepare materials	Split and adze wood	Unknown	Unknown	Unknown
	Excavate soil	101-375	37-124	116-546
Construction	Frame and sheath house	1,273-2,211	324-563	1,994-3,463
	Build furnishings	Unknown	Unknown	Unknown
	Feed and organize laborers	Unknown	Unknown	Unknown
Total excluding unknown labor estimates		1,412-2,890	371-791	2,158-4,498

Table 2.26. Total Planking Needs for House Lifespan (Walls, Roof and Floor), Meier and Cathlapotle.

	Board Feet	
	Low Range	High Range
Meier with floor	667,023.6	748,011.8
Meier without floor	395,770.8	476,759
Cathlapotle House 4	135,497.2	178,923.6
Cathlapotle House 1	773,974.6	897,330.0

Table 2.27. Numbers of Trees Needed for Replacement of Planks and Posts over 400 Year House Lifespan.

	Trees represented siding, roofing and flooring		Trees represented in posts and beams		
	Low range*	High range*	Low range**	High range**	Total
Meier with floor	580	650	134	610	714-1,260
Meier without floor	344	415	134	610	478-1,025
Cathlapotle House 4	118	156	40	246	158-402
Cathlapotle House 1 Total	673	780	229	1229	902-2,009

*Tree estimates derived from board feet (1 m diameter logs). **Tree estimates derived from meters of logs.

and Cathlapotle houses were originally excavated are difficult to discern because of the complex stratigraphy of the sites (Hamilton 1993), so a low estimate of 0.3 meter to a high estimate of 2 meters was used (based on Hajda 1994:179). Although estimates encompass wide ranges, they demonstrate that a great deal of labor was needed to excavate the underground portion of plankhouses, pits and corner post holes (Table 2.23). At Meier approximately 101-375 person days were needed to excavate soil, at Cathlapotle House 4, 34-104 days, and at Cathlapotle House 1, 116-546 days.

Other tasks needed to be accomplished prior to building. Rocks were found and transported to the building site for packing postholes to reduce decomposition. While some rocks may have been small, a few massive boulders approaching one meter in diameter were noted at each site, which would have entailed great effort to move. A variety of tools were made to be used in felling, transporting, splitting and dressing wood, including mauls, wedges, adzes, scaffolding, ladders, and ropes.

Construction: Framing and Sheathing

Understandings of house raising techniques are predominantly based on accounts from the northern and central Northwest Coast. Still, this information provides important clues to how inhabitants of Meier and Cathlapotle may have accomplished the substantial task of house construction. Raising the massive corner posts, eave supports and ridge supports entailed the efforts of a large amount of people. Wall planks were fitted in trenches and fastened against eave beams. Roof planks, which stretched between the eave post and ridge post, were lifted and secured. Smaller poles were attached to the roof perpendicularly to the roof planks. A variety of people contributed to labor other than those involved in house raising. Specialists directed and coordinated these operations and were in charge of ensuring that house parts were joined and stable. Prominent people conducted ceremonies. Other people prepared food for the hundreds (or possibly thousands!) of workers, and possibly tended to injuries incurred during building.

Gahr (2006) uses several historical accounts of house construction to calculate the number of people needed to erect one dwelling. She estimates that one person is needed for every 0.19-0.33 m^2 of house area. By applying these figures to houses with population estimates, Gahr concludes that the number of people required to construct a plankhouse would be 20-48 times the dwelling's population. These numbers seem reasonable, especially when considering how much manpower it would take to move and hoist the giant posts and beams. Table 2.24 outlines the number of people that would be needed to build houses at Meier and Cathlapotle based on Gahr's figures.

Construction Totals

In addition to the tasks outlined in the above sections, additional work was required that is difficult to quantify. Much work was devoted to benches and interior furnishings. Wood for small posts and planks would need to be harvested, transported and prepared, and sleeping platforms were built around the entire interior. These benches were around 2 m wide (Smith 2004:33) and may have included storage features or decoration. Special attention was likely paid to interior elements at the high status end of the house. Other tasks associated with building a plankhouse are difficult to quantify, but entailed a large amount of labor. Hearths would have needed to be excavated and sided with wood. Many pits would have been lined with planks or clay. Cathlapotle house floors may have been capped with a thin layer of clay or otherwise prepared. Some support posts may have received special decoration.

A summary of person days involved in initial construction of plankhouses is difficult. I was unable to quantify many activities necessary to build these houses. Table 2.25 reviews the major tasks associated with initial construction, listing maximum and minimum person days when this information is accessible. Although this presentation is incomplete and rife with estimations, it is clear from these data that a massive investment of labor was required to obtain materials for and build houses. Importantly, while some work may have occurred on the same day with many people (see Gahr 2006), other tasks may have included few people over a long period of time.

Quantifying Maintenance

Work and materials required for plankhouses did not stop at the completion of construction. Conversely, a large amount of wood and labor was used in throughout the uselife of the plankhouse in maintenance activities. At Meier and Cathlapotle, similar to many Northwest Coast villages, houses stood for hundreds of years, representing continual inputs of both labor and building materials. The following section attempts to quantify the amount of labor and materials used in the approximately 400 years the houses at Meier and Cathlapotle were standing.

Gahr (2006:73) considers many aspects of plankhouse repair in her analysis of the plankhouse 'life cycle', and stresses an "enduring commitment of labor and materials" would have been required for plankhouse upkeep. She outlines the stresses placed on wood elements, including load, creep, high winds, earthquakes, hydraulic pressure, fire, and biological decay organisms. Ames et al. (1992, 1996) use excavation data to estimate that each house element, depending on its size, would need to be replaced at a minimum of 5 times over the house's 400 year uselife, and probably closer to 20 times.

Further precision of these replacement estimates can be achieved by applying information from forestry studies (Chapter 6) to data from features at Meier and Cathlapotle to estimate replacement rates. Bearing heavy loads and direct contact with the soil would cause elements to deteriorate more quickly, so wall and floor planks would have a heightened risk of rot. Roof planks would have also been at high risk of decay because of their exposure to moisture. Based on information presented in Chapter 6, I estimate that a plank with base dimensions of 40 cm in length by 7.6 cm in width would need to be replaced every 20 years. This figure was used to approximate planking material needed over the houses' 400 year existence (Table 2.26).

I also estimate material that would be needed for post replacement, although rates of post replacement were difficult to determine. It is likely that deteriorating posts would be monitored and quickly replaced, as failure in posts and beams (unlike failure in wall planks) could be catastrophic. I used this calculation to approximate the number of trees that would be used over each house's 400 year lifespan for repairs. These calculations yielded an astronomical number of trees needed for repairs of planks, posts and beams ranging from hundreds of trees for a smaller house to a number approaching 2,000 trees for a larger house (Table 2.27).

In addition to locating, felling and transporting trees for new posts and planks, the process of replacing these elements would have entailed considerable effort and skill. Reyonds (1994) writes about the experience of building and repairing a roundhouse, emphasizing that removing a rotting post from a standing structure is an extremely difficult task. The mechanics of replacing a corner post or ridge beam in an inhabited plankhouse would have been extremely challenging. Given that larger posts and beams were likely replaced infrequently, these events may have occurred only about once a generation. Thus, people with knowledge of the mechanics of this operation – building specialists - would have been relatively rare.

It is important to note that in addition to repairs associated with architecture, a number of other activities were necessary for upkeep. Houses at both Meier and Cathlapotle included massive pit complexes, which were constantly re-dug. Hearths were continually maintained and cleaned (see Gardner-O'Kearny 2010). Other ongoing house activities would include sweeping and refuse disposal. Taken together, obtaining and preparing raw materials, repairing wooden elements, and sundry house upkeep tasks would have required an enormous expenditure and variety of different types of labor

CHAPTER 8
DISCUSSION

Research Questions

GIS and statistical analyses of architectural features at Meier and Cathlapotle support previously proposed models based on field observations. Results inform understandings of house spatial organization, differences and similarities between houses in the LCRR, and structural stability.

Spatial Organization of Houses

Results highlight differences between spatial organization at the three study houses. Interior spatial divisions – likely according to rank – were conspicuous and permanent at Cathlapotle House 1. The presence of ridges dissecting other house depressions at Cathlapotle suggest that at least three other houses (Houses 2, 3 and 6) were similarly divided. At Meier and Cathlapotle House 4, compartments within houses were either absent or more ephemeral. This indicates that at these two houses, house interior as a signifier of status was not as important as it was at Cathlapotle House 1.

Space outside houses was organized differently at the two sites. There is more evidence of outside structures at Cathlapotle than at Meier. Notably, two of the most substantial exterior constructions at Cathlapotle were noted between the front of House 1 and the nearby river. There are several possible reasons for the difference in exterior structures between the two sites. First, production activities may have differed between the villages. Meier occupants may have produced fewer goods that necessitated outdoor production, and instead processed goods either from afar or inside houses. Second, this difference may reflect aspects of living in a multi-house village rather than a single-house village. Cathlapotle residents may have engaged in production activities outside of the house to facilitate conversation or exhibit their house's products to neighbors. Third, Cathlapotle villagers may have worked outside in order to display their house's specialties to potential traders passing on the river. Fourth, the Cathlapotle house interior may have been more crowded, requiring outdoor production. Perhaps Cathlapotle experienced a large influx of people during winter months, such seasonal variation in settlement in the LCRR is posited by Boyd and Hajda (1989).

In general, data from structural features confirm prior models of interior facilities. Architectural features often differed in size and class distribution between facilities. For example, hearths contained more small posts (or pegs) than other facilities, indicating production areas. This evidence strengthens the argument that houses at Meier and Cathlapotle were divided into zones with respect to both structural elements and activities.

Comparison of House Construction in the LCRR

This project allows comparison between plankhouse architecture at Meier and Cathlapotle. However, it is important to stress that results were constrained by the relatively small sample size of complete features. Comparison of house framing elements suggests that Cathlapotle residents used larger planks than at Meier for some aspects of construction, such as eave supports and wall sheathing. Meier residents may have used more very large posts in house framing. Furthermore, planks were used more often across all facilities at Meier compared with Cathlapotle. Few statistically significant differences in structural elements were noted between the two Cathlapotle houses, although occupants of House 1 may have used more small planks (compared to small posts) than those of House 4. The larger number of small plankmolds in House 1 may be related to pit lining or interior furnishings such as drying racks.

Overall, this evidence suggests that dwellings at the sites were built using similar construction techniques, despite differences in house size. However, variation in construction choices (such as preference for planks or element size) may have existed between Meier and Cathlapotle. These differences may have arisen from factors related to corporate group size, tradition, varying access to materials, or for aesthetic reasons. Regardless, small differences in houses highlight the unique group identity of the houses.

Structural Continuity

Stability of plankhouse appearance underscores the connection between continuity in household groups and their dwellings. Generally, the fine-scale maps indicate that structural elements retained similar vertical and horizontal positioning through time in the houses. Conservation of element placement was especially strong in central house areas. However, maps pinpointed several spots in all three houses where element elevation changed in house walls. The most variation in vertical positioning of elements seems to have occurred in Cathlapotle House 4, and it is also possible that the house underwent a significant change in length during its lifespan. The Meier House also may have been substantially altered, as evidenced from wall trench placement indicating that the house was shortened by at least one meter. Overall, however, evidence of changing house attributes is the exception rather than the norm.

Continuity in house appearance was also studied by examining changes in plankmold orientation. It is important to note that results were affected by small sample size and possible outliers, which may have inhibited detection of trends. Using maps and several statistical tests, I was unable to identify clear instances of shifting house orientations over time. Meier may have experienced a shift in orientation in the middle of its uselife. This result is tentative, but interesting in light of prior evidence suggesting a change in Meier house orientation by 10-15 degrees (Ames et al. 1992) and plankmolds noted under hearths that indicate changing use of interior space (Gardner-O'Kearny 2010). Despite some minor modifications, houses were overall remarkably stable in structural appearance over the passing centuries and changing of many generations.

Since household groups were inextricably linked to plankhouses, change in the physical house structure would indicate possible shifts in social organization. Results of this project strengthen previous assessments (Ames et al. 1992; Smith 2004:66) that households maintained remarkable continuity over hundreds of years. Importantly, this continuity does not reflect stasis in the community as a whole. Rather, household stability persisted in light of climatic and environmental shifts (Calkin et. al 2001; Grove 1988:231-239) as well as changes in demographic, economic and technological changes in the protohistoric period (Boyd 1999; Lightfoot 2006). Remarkable stability in the midst of other changes demonstrates that much value was afforded to and effort was directed towards sustaining household continuity.

Broader Implications

Information regarding plankhouse construction and maintenance history, as well as materials and labor requirements, can be used to inform understanding of economic organization and sociopolitical aspects of Northwest Coast groups. Additionally, results of this study enable a richer understanding of everyday life for residents of the Meier and Cathlapotle communities.

Everyday Labor

This study identifies specific types of labor that people routinely engaged in on the Northwest Coast. Some plankhouse-related tasks involved short bursts of highly coordinated work, such as house raising, which also required a massive amount of physical strength and cohesion. Many undertakings comprised physical labor (such as moving logs through the woods or digging soil) or repetitive tasks (such as splitting and adzing planks). Most aspects of plankhouse labor involved mechanical ingenuity and principles of physics, which were needed to fell trees, transport logs, and raise heavy posts for house frames. Ecological knowledge and a deep familiarity with the landscape were necessary to locate and select appropriate building materials. Felling required experience and knowledge of how to properly cut trees in order to minimize damage to lumber and avert potentially hazardous accidents.

Although specialists likely possessed specific knowledge, all people involved in plankhouse building tasks made day-to-day decisions and calculations that were predicated on an intricate combination of knowledge and experience. This is seen in tasks that on the surface seem mundane and purely physical, such as moving logs though the forest, but were in fact complex activities requiring many facets of knowledge, decision making, and organization. Importantly, these tasks would also require an intimate knowledge of the landscape.

Specialization

Specialization was integral to the remarkable social complexity of Northwest Coast societies (Ames and Maschner 2000). This study provides continuing evidence for embedded specialists on the Northwest Coast who performed fundamental tasks for household continuity (Ames 1995), and reinforces evidence for specialization by rank at Meier and Cathlapotle (Smith 2006; Sobel 2004). Tasks connected with plankhouse construction involved a rubric of calculations, planning, coordination, and careful organization at each step. Supervisors would need to possess not only technical skills to coordinate movement of heavy (and potentially deadly) large logs, but also the ability to strategically plan and designate tasks to workers. Also required was the ability to make complex calculations regarding raw materials, time and labor.

Varying degrees of organization and direction would be needed for different tasks. Activities such as tree felling, splitting, and adzing hundreds of planks could likely be directed by one person and carried out by a relatively small amount of household members (including slaves), especially over a long period of time. However, other tasks such as moving logs and house raising would have needed skilled supervision over dozens, hundreds, or even thousands of people. Therefore, it is likely that for complex tasks, a system of direction was utilized.

Specialized knowledge was necessary for initial building activities as well as house raising. A great deal of specific knowledge was needed to plan the house layout, locate and select appropriate trees, and direct the multitude of activities associated with preparing for building (laying out wall trenches and cellars, shaping support posts, etc.). Importantly, as house building was not a common occurrence, the person(s) in charge of directing initial construction may not have overseen similar tasks before or again in their lifetime. This highlights cooperation between houses and villages, not just in terms of labor, but also in sharing knowledge, advice and oral traditions. Specific aspects of house building were likely curated and passed through generations orally.

Similar specialization and specific knowledge would be required for maintenance tasks. Results of this project suggest that some repair tasks, such as replacing small posts or roofing, would have occurred fairly regularly (i.e. every 10-20 years). However, larger posts would need to be replaced only every 50-130 years. Since there were few large posts per house, generations could pass between major replacement episodes. Thus, similarly to house construction, knowledge regarding performing these tasks would need to be shared and passed down through generations.

Cedar Management

Managing cedar resources was an important aspect of building and maintaining plankhouses, as approximately 90 trees were needed in initial construction for Cathlapotle House 1, 20 for Cathlapotle House 4 and 50 for the Meier House (see Table 2.19). A large village like Cathlapotle would require an enormous amount of trees for continued maintenance. By extrapolating from the House 1 and 4 estimates to the other houses in the village using depression size, I roughly calculate that for the entire Cathlapotle village, upkeep of the houses over 400 years would require 3,026-6,908 trees.

It is clear that cedar would need to be carefully managed rather than haphazardly harvested, given the constant need to replace rotting elements, the limited distribution of cedar in the LCRR, and the need to conserve cedar for use in other technologies. Consequently, knowledge of proper tree characteristics for building, the ability to locate these trees, and the balancing of competing demands on this resource are aspects of plankhouse construction that should not be underestimated. Management almost certainly entailed careful consideration of harvesting, and may have involved 'tending' activities evident for other Northwest Coast plant resources (Derr 2012; Deur and Turner 2005). Although we do not know the mechanics of this system, continued use of cedar for both houses and other technology in the same area through hundreds (if not thousands) of years clearly indicates that people practiced sustainable decision-making. If a thoughtful and strategic resource management system was used for cedar, these same practices may have been in effect for other resources.

Selecting and harvesting cedar is an example of an economic activity that occurred away from villages, where much research on Northwest Coast production is focused (Oliver 2007). Archaeological evidence of Indigenous logging and cedar management is scarce, on the southern Northwest Coast, with the exception of preserved woodworking tools and the occasional CMT. The large amount of wood used in houses allows an inference to be drawn that both large-scale logging and cedar management occurred. Although we may not be able to detect direct evidence, forests were not the closed, foreboding places described by many European explorers (see Deur and Turner 2005), but were in fact cultural landscapes that were frequently traveled through, worked in, and managed by native inhabitants.

The large amount of choice cedar needed for building tasks and the limited distribution of these trees implies that cedar stands may have been owned by households. Ownership of cedar patches accords with Richardson's (1982) suggestion that patchy resources (meaning those that are predictable and relatively abundant but constrained to certain locations) are likely to be owned by kin groups. Ownership of cedar stands by elites has been noted in the ethnographic record on other areas of the Northwest Coast (Turner and Jones 2000).

Expense of Construction

This project corroborates previous studies which found huge volumes of raw material and labor were required for plankhouse construction (Ames et al. 1992; Gahr 2006). Data from this project also show that a great deal of labor was needed to fell, transport and prepare lumber for both building and repair. The amount of labor entailed in house construction and maintenance activities is staggering. To summarize, Cathlapotle House 1 required a minimum of 2,134–4,058 person days for initial construction, with 363–677 for Cathlapotle House 4, and 1,393–2,616 for Meier. The amount of time spent preparing the house site, as well as selecting, transporting and felling trees for maintenance efforts, would have required that others in the household provide food and other necessities for the workers involved in these tasks. For initial construction, workers would have needed to transport around 70-150 tons of wood for Cathlapotle House 1, 15-30 tons for House 4, and 60-90 tons for Meier.

The massive amount of person hours bound up in plankhouses, especially for events such as house raising and log transport, would have required time not only from house members, but also an influx of labor from two other sources. First, as in other complex production tasks in the region, a great deal of labor likely was performed by slaves (Ames 2008). Second, people to aid in large tasks were contracted through social and political ties and obligations. Recruitment of workers would have been a formidable task. The numbers of people involved in house raisings and log transport would have required enlistment of people from other household groups, and almost certainly from neighboring villages. Amassing a large body of labor would have demanded a massive output of wealth and social capital.

Household Continuity

The construction and maintenance of plankhouses is an example of cultural continuity achieved through purposeful actions of household members. Houses were an integral aspect of household group identity, a connection that was present through all stages of house building and uselife, from initial planning to continued maintenance. By examining the processes of building plankhouses and ensuring their upkeep, it is clear that vast amounts of materials, labor and ingenuity were bound up in these structures. The clear output of work entailed in plankhouses is evident not only in retrospect to archaeologists, but would also be apparent to house inhabitants as it was bound up in the physical structure of the house. The large amounts of workers needed to transport logs and construct a house frame provided a display of group strength and solidarity that continued to be apparent throughout the house's uselife. House maintenance was continuous and required large amounts of labor and raw materials. House structure and layout was maintained over many generations, not by chance, but by deliberate thought and hard work of household members. Villagers would not only be reminded of continuity and enormity of labor costs by houses, but also by stumps encountered in the forest that were cut by ancestors.

Future Directions

In this report I use archaeological information on plankhouse building to provide a window into the organization and orchestration of one complex labor task: the construction and upkeep of plankhouses. This knowledge can be applied to other complex labor tasks on the Northwest Coast where archaeological signatures are less visible. Such tasks include cornerstones of Northwest Coast economies such as salmon fishing and processing, berry harvesting, and protohistoric fur trapping and processing. The organization of plankhouse construction suggests the presence of both specialists and resource patch ownership, and also demonstrates that large amount of labor could be deployed for major production activities.

Further research into both architecture and plankhouse related labor will increase our understanding of Northwest Coast groups. Several avenues for future study seem particularly promising. Larger sample size of comparable architectural datasets would enable fine-grained comparisons of structural elements between different geographic areas. Additional experimental archaeological data regarding felling, transporting, splitting, and adzing logs would greatly refine labor calculations. Data on geographically-specific cedar degradation rates for different sized elements would improve estimates of replacement rates. Continued research into historical vegetation would illuminate the availability of cedar near specific villages, and would be an important step in characterizing indigenous resource management. Finally, conducting interviews with tribal members would illuminate the continuing role of plankhouses and cedar for peoples of the Northwest Coast.

CHAPTER 9
CONCLUSIONS

In this study, elements of political economy are used to understand labor involved in the plankhouses produced by Northwest Coast hunter-gatherers. Political economy is typically associated with studies of capitalist societies and world systems theory (Roseberry 1988). However, in light of increased globalization and homogenization of modern economic systems, archaeologists have an important role to play in this research. In contrast to modern economies, pre-capitalist economies were extremely diverse. Archaeological studies of hunter-gatherer political economies not only illuminate the unique history of individual groups, but also remind us that different economic formations are possible outside of the current capitalist economy (Cobb 1993:46; Earle 2002:8). Plankhouse production increases knowledge of LCRR political economy related to all three aspects of Saitta's (2012) definition of this theory: production, social labor, and "cultural conditions that sustain relationships".

Plankhouse production is a clear example of hunter-gatherers in western North America organizing complicated tasks and strategically managing resources (see Anderson 2006; Deur and Turner 2005). Labor tasks associated with plankhouses entailed foresight, careful management of resources and labor, mechanical skill, strength and cooperation. In recent decades, researchers across the world have sought to dismantle previous assumptions regarding hunter-gatherers to demonstrate that the variety of tasks and planning these groups engaged in was far more sophisticated and nuanced than previously assumed (see Ames 2004; Kelly 1995). This project sheds light on a small range of household undertakings at two villages, but in doing so adds to the literature documenting the incredible diversity and ingenuity of cultures in western North America.

Although this report touches on a diverse range of topics, the daily work of household group members is a unifying thread. Through investigating how houses were built and maintained, we see the tasks and decisions that were part of everyday life for LCRR peoples. It is clear that although physical tasks were certainly part of working, equally important was communal organization, thoughtful planning and strategic management of resources. In the large amount of labor entailed in maintaining dwelling appearance over time, we see the daily actions of individuals adding up to stability of houses and household groups over many generations.

In accounting for continuity of Nuu-chah-nulth households in the face of massive social and political upheavals in the contact era, Marshall (2000:74) argues that the strong kinship and social ties exhibited by household groups were dependent on material aspects of the culture: the household economy, house members, and the plankhouse dwelling itself. Using archaeological and historical data, she demonstrates that "the corporate identity of a house must be performed into existence by a dwelling's inhabitants through their actions as co-residents". In this report, I argue that the household group was, in part, 'performed into existence' through the numerous everyday tasks of building and repairing plankhouses.

APPENDIX A

Architectural Features

Descriptive Statistics

A total of 387 features related to house architecture were included in the Meier GIS database. In the field feature catalog, 199 architectural features were noted. In 2000, 104 features were added. Of these 303 total features, two were not included in analysis and were instead added to the Meier possible feature GIS database. Additionally, eight of these features were combined into four features, as they overlapped both horizontally and vertically. I added 90 features to the GIS database that were not listed in the catalog. These consist of 44 features that were documented in the excavation but were not recorded in the original feature catalog, including one step feature, four rocks associated with architectural features, and seven wall trench features. I reclassified 10 features that were originally classified as pits as postholes (Kenneth Ames, personal communication). I also added 36 new architectural features noted during reexamination of feature forms, level maps, wall profiles, unit ending maps and field notes.

Feature measurements at Meier did not conform to normal distributions when the Shapiro-Wilk test was performed (Table 2.A.1). Table 2.A.2 presents descriptive statistics of features at Meier with complete depth measurements (both upper and lower elevation measurements). It is important to note that these numbers do not necessarily represent the actual depth to which the structural element was buried in the ground, as parts of the original hole could have been cut off by subsequent building events.

A total of 152 possible features were entered in a separate GIS database. Attributes described in this database were identical to architectural features database, although attribute fields for possible features were often incomplete or missing. Possible features comprised 16 plankmolds, 134 postholes, one step, and one wall trench. Many possible features represent small (< 7 cm) postholes.

The Cathlapotle GIS database consists of 757 architectural features. Of these features, 743 were included in the original Cathlapotle feature catalog. I added 14 features based on reexamination of CAD drawings, photos, feature forms, lev-

Table 2.A.1. Normal Distribution of Architectural Features at Meier (Shapiro-Wilk test).

Feature Class	Length[1]	Width[1]	Depth[2]
Plankmolds	No (W=.743 df=74 p =.000)	No (W=.719, df=74, p=.000)	No (W=.906, df=65, p=.000)
Postholes	No (W=.522, df=189, p=.000)	No (W=.524, df=189, p=.000)	No (W=.619, df=161, p=.000)
Postmolds	No (W=.795, df=19, p<.005)	No (W=.721, df=19, p=.000)	No (W=.890, df=19, p<.05)
Combined posts	No (W=.660, df=86, p=.000)	No (W=.692, df=86, p=.000)	No (W=.611, df=94, p=.000)

[1]Complete horizontal measurements. [2]Complete vertical measurements.

Table 2.A.2. Architectural Features at Meier with both Upper and Lower Depth Measurement.

Feature Class	Count	Minimum Depth (cm)	Maximum Depth (cm)	Mean Depth (cm)	Std. Deviation (cm)
Plankmold	65	1.0	51.5	14.1	10.5
Posthole	161	1.0	142.0	16.4	19.5
Postmold	19	2.0	24.0	9.2	6.7
Wall trench	4	18.0	77.0	43.5	2.8

Includes features with incomplete horizontal measurements.

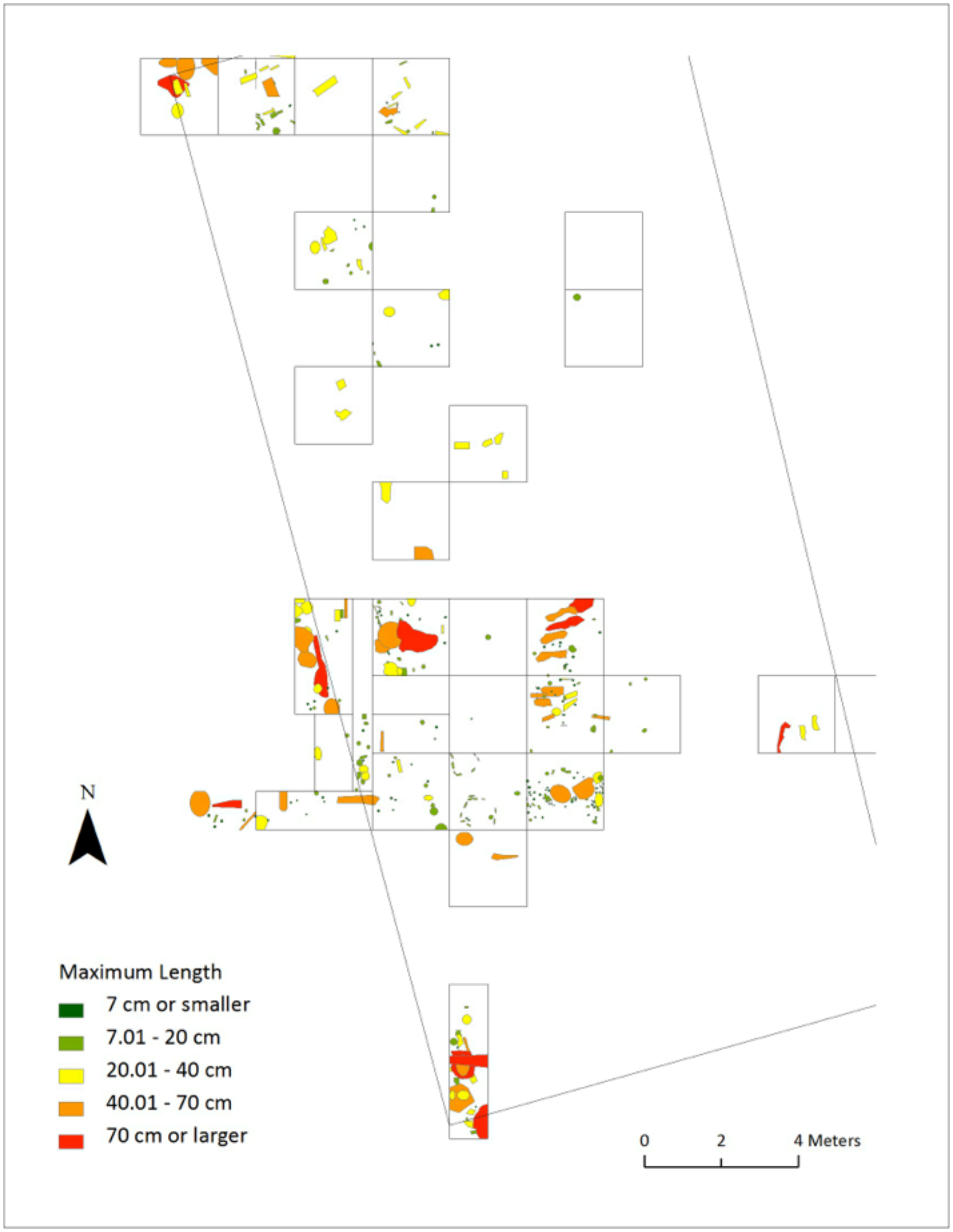


Figure 2.A.1. Features by size, Meier.

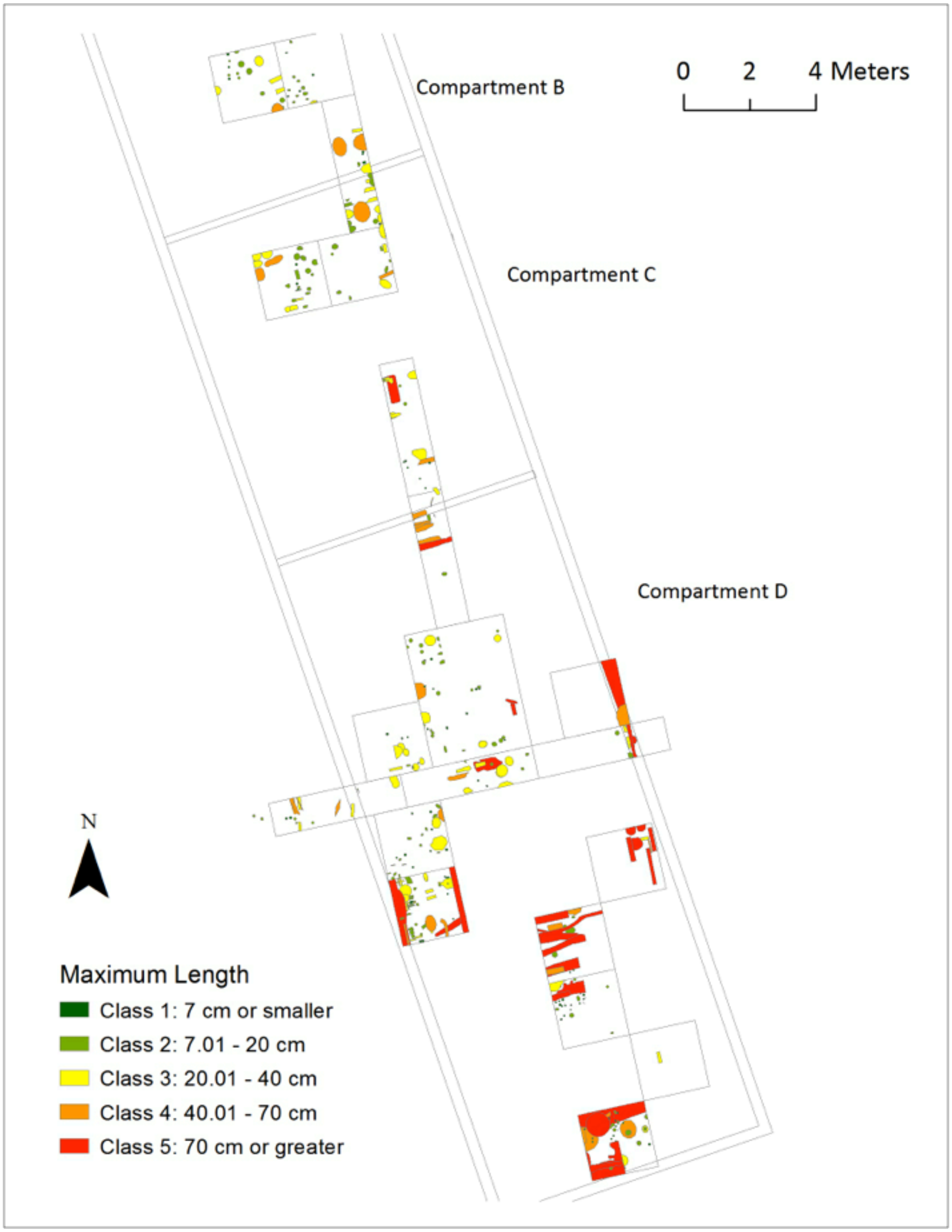


Figure 2.A.2. Features by size, Cathlapotle House 1.

Figure 2.A.3. Features by size, Cathlapotle House 4.

Table 2.A.3. Normal Distribution of Architectural Features at Cathlapotle.

Feature Class	Length	Width	Depth
Plankmolds	No (W=.932 df=64 p <.005)	No (W=.613, df=64, p=.000)	No (W=.804, df=188, p=.000)
Postholes	No (W=.750, df=71, p=.000)	No (W=.785 df=71, p=.000)	No (W=.810, df=82, p=.000)
Postmolds	No (W=.742 df=206, p=.000)	No (W=.56, df=206, p=.000)	No (W=.753, df=268, p=.000)
Wall trenches	Not tested	Not tested	No (W=.874, df=26, p<.005)

[1] Complete horizontal measurements. [2] Complete vertical measurements.

Table 2.A.4. Cathlapotle Features with Both Upper and Lower Depth Measurements

	Count	Minimum Depth (cm)	Maximum Depth (cm)	Mean Depth (cm)	Std. Deviation (cm)
Wall trench	26	4.0	56.0	23.0	15.7
Plankmold	188	2.0	59.0	14.8	11.8
Posthole	82	2.0	60.0	12.0	8.6
Postmold	268	1.0	77.0	14.0	12.3

Includes features with incomplete horizontal measurements.

Table 2.A.5. Descriptive Statistics of Architectural Features with Complete Horizontal Measurements at Cathlapotle Houses 1 and 4.

		House 1				House 4			
		Count	Mean (cm)	Std. Deviation (cm)	Median (cm)	Count	Mean (cm)	Std. Deviation (cm)	Median (cm)
Plankmold	Length	32	26.5	19.2	21	24	40.7	15.9	38.5
	Width	32	9.9	12.7	6	24	9.3	4.9	7
Posthole	Length	40	9.8	7.7	8	23	10.9	8.2	9
	Width	40	8.8	7.4	7	23	9.4	5.3	8
Postmold	Length	108	14.1	14.1	9	65	13.9	9.1	11
	Width	108	11.8	11.8	8	65	12.8	15.4	10
Total Posts	Length	148	12.9	11.8	9	88	13.2	8.9	10
	Width	148	10.9	9.9	8	88	11.9	13.6	8.8

Table 2.A.6. Dimensions of Plankmolds and Postmolds found in Compartments of Cathlapotle House 1.

			Count	Mean(cm)	Std. Deviation (cm)	Median (cm)
Plankmold	Compartment C	Length	6	24.8	14.9	21
		Width	6	10.2	7.4	7.5
	Compartment D	Length	26	26.9	20.3	21
		Width	26	9.9	13.7	6
Postmold	Compartment B	Length	14	13.3	14.2	8
		Width	14	11.5	9.9	8
	Compartment C	Length	25	12.7	11.4	9
		Width	25	10.5	9.2	8
	Compartment D	Length	69	14.8	13.2	10
		Width	69	12.2	11.3	8

Compartment A was unexcavated. Compartment B contained no complete plankmolds.

Table 2.A.7. Architectural Metrics by Facility, Meier.

			Count	Mean (cm)	Std. Deviation (cm)	Median (cm)
Plankmold	Bench	Length	21	17.14	11.03	14
		Width	21	6.19	5.2	5
	Cellar	Length	23	14.96	10.37	13
		Width	23	4.61	3.12	4
	Hearth	Length	21	25.86	16.42	18
		Width	21	9.00	6.19	7
	Wall	Length	6	42.67	41.83	25.5
		Width	6	16.17	12.62	11.5
Total Posts (Posthole and Postmold)	Bench	Length	29	14.76	11.22	12
		Width	29	12.41	11.49	9
	Cellar	Length	15	18.27	11.36	14
		Width	15	14.13	8.46	10
	Hearth	Length	27	15.52	14.27	10
		Width	27	11.63	12.31	8
	Wall	Length	12	28.83	28.00	23.5
		Width	12	23.00	21.40	20.5

Table 2.A.8. Architectural Metrics by Facility, Cathlapotle.

			Count	Mean (cm)	Std. Deviation (cm)	Median (cm)
Plankmold	Hearth	Length	21	43.76	19.79	40
		Width	21	14.86	14.41	12
	Bench	Length	3	21.00	14.73	13
		Width	3	3.67	2.89	2
	Wall	Length	36	27.08	15.21	24
		Width	36	6.94	3.66	6
Posthole	Hearth	Length	38	8.97	7.94	8
		Width	38	7.72	6.63	6
	Bench	Length	3	11.67	11.55	5
		Width	3	10.00	8.66	5
	Wall	Length	22	11.96	7.05	9.5
		Width	22	11.09	6.24	8.75
Postmold	Hearth	Length	86	11.80	7.67	8.75
		Width	86	9.88	5.84	8
	Bench	Length	22	14.36	10.70	9.5
		Width	22	11.23	9.49	7
	Wall	Length	76	15.74	14.26	10
		Width	76	14.41	17.14	9
Post (postmold and posthole)	Hearth	Length	124	10.93	7.83	8
		Width	124	9.22	6.15	8
	Bench	Length	25	14.04	10.59	9
		Width	25	11.08	9.23	7
	Wall	Length	98	14.89	13.06	10
		Width	98	13.67	15.41	9

el maps, wall profiles and unit ending maps. Feature measurements at Cathlapotle did not conform to normal distributions when the Shapiro-Wilk test was performed (Table 2.A.3). Table 2.A.4 presents descriptive statistics of features with complete depth measurements. At Cathlapotle, an additional 247 possible features were included in the possible features database. These possible features consisted of 60 plankmolds, 97 postmolds, 72 postholes, 13 pegholes, two wall trenches, and three miscellaneous structural features.

Spatial Distribution

I created GIS maps that display feature size distribution using five size classes (Class 1: 7 cm or smaller, Class 2: 7.1-20 cm, Class 3: 20.1-40 cm, Class 4: 40.1-70 cm, Class 5:70.1 cm or larger). At Meier, there are several patterns in post distribution (Figure 2.A.1). Class 1 posts were distributed through the house interior, but

Table 2.A.9. Feature Metrics for each Structural Class.

		Length (cm)				Width (cm)			
	Count	Maximum	Minimum	Mean	Median	Maximum	Minimum	Mean	Median
Meier									
Corner Post	8	110	38	71.8	73	78	25	51.9	52.5
Eave Support	17	129	16	41.2	30	78	10	35.8	27.0
Ridge Beam Support	15	103	24	54.2	48.8	62	8	25.3	24.0
Wall Plank	13	38	21	38.0	36.0	21	5	11.7	10.0
Cathlapotle									
Corner Post	1	143	143	143	-	143	98	98	98
Eave Support	42	89	16	35.7	16.5	31.5	65	12	28.9
Ridge Beam Support	57	124	15	60.0	22.9	48.0	78	2	25.2
Wall Plank	25	112	15	47.6	29.0	40.0	63	3	12.1

Table 2.A.10. Wall Trench Measurements and Tests for Normal Distributions, Cathlapotle and Meier.

	Count	Minimum (cm)	Maximum (cm)	Mean (cm)	Std Deviation (cm)	Median (cm)
Depth	30	4.0	77.0	25.8	18.5	23.5
Width	31	4.0	120.0	38.0	31.8	29.0

were concentrated in hearth areas, supporting the supposition that these small posts represent pegs used in domestic or production activities. Class 2 and Class 3 posts were found in hearth and bench areas, strengthening the inference that they were used in small structures such as drying racks and sleeping platforms. Class 4 posts were found mostly along house walls, but also in interior areas. Class 4 posts found along walls likely served as eave beam support posts, while those in the interior would have been ridge beam support posts. Class 5 posts are predominantly found in house corners, and represent large corner support posts. One Class 5 post is located just inside the middle of the house structure. This post may represent a large central ridge beam support post. Overall at Meier, maps indicate that the largest features mostly occur in house walls and also in the center of the house, running parallel to long axis walls. These large posts and planks were likely used as eave and ridge beam supports. At Meier, it seems that large planks were used primarily for ridge beam supports, while large posts were used for corner posts.

Patterns in post feature size were also noted at Cathlapotle. Figure 2.A.2 illustrates the dispersion of post size classes through House 1. Small posts or pegs in Class 1 and 2 are most frequently located in hearth areas. Class 2 and Class 3 posts are often located in parallel rows in bench and interior central areas. Class 4 posts are found mostly in walls and also between compartments. Class 5 posts are located in the southern and eastern walls of Compartment D. Overall, large structural features in Cathlapotle House 1 are located in the house central interior and walls. Large planks are present in the central area, while larger posts were used primarily in walls or as part of compartments divisions.

Post patterning in Cathlapotle House 4 illustrates that Class 1 and 2 posts were found scattered in interior areas, presumably reflecting their use as pegs or for small structures (Figure 2.A.3). As opposed to House 1, Class 3 posts were not well represented in interior areas, and were almost exclusively located close to house walls. Class 4 and Class 5 posts are less numerous than in House 1, and all but one of the posts from these classes are located in wall areas. Overall, almost all large structural features at House 4 are located in wall areas, although some Class 4 and Class 5 plankmolds are present in the central interior area of House 4. Overall, these maps suggest that smaller structural elements were used in the interiors of House 4 compared to House 1, although this trend was not statistically significant (see Table 2.13).

Descriptive Statistics of Subcategories

Several subcategories of features were investigated to address specific research questions. Features from Cathlapotle were divided into groups based on location in House 1 or 4 (Table 2.A.5). Plankmolds and postmolds from Cathlapolte House 1 were also divided in the subcategories based on compartment location (Table 2.A.6).

Subcategories of features were created to compare features between facilities. Facilities employed for analysis at Meier consist of bench, cellar, hearth and wall, while those at Cathlapotle consist of hearth, bench and wall. Descriptive statistics for feature classes in each facility are presented in Tables 2.A.7 and 2.A.8.

Features were also categorized by structural class. Four structural elements types were used for this classification: corner posts, eave supports, ridge beam supports and wall planks. As discussed in Chapter 4, structural classes were assigned to features (when possible) based on house placement and morphology. Table 2.A.9 presents feature metrics for structural element footprints at Meier and Cathlapotle.

Descriptive statistics of wall trenches were also calculated (Table 2.A.11). Features from both sites were combined to increase sample size. It is important to note that depth may have been greater than recorded if intrusive features or soil mixing destroyed upper feature elevations. Additionally, the width of trenches may have grown with successive wall plank replacement episodes. Hence, these calculations are estimates and should not be taken precisely.

APPENDIX B

Structural Element and Materials Calculations

Metrics of Structural Elements

When possible, metrics of structural elements were based on feature size data from the Meier and Cathlapotle excavations. Consultation of ethnographies, historical documents and other archaeological excavations was required to determine the metric attributes of some elements that left no archaeological correlates at Meier and Cathlapotle, such as element height and beam diameter. Wall plank, corner post and eave support height was based on ethnographic and historical sources cited by Hajda (1994) and Ames et al. (1992) and was estimated at 1.5-2.4 m. Ridge beam support height was based on these same sources and was estimated at 4-6.1 m. Beam diameter was estimated from Stewart (1984), who reported beams diameters of 0.6-1.2 m, and from Ozette data. Although Ozette plankhouses were not architecturally identical to those in the LCRR, they represent one of the only data sets for examining certain architectural elements. Beam dimensions were approximated using the dimensions of notches of support posts that held beams (Mauger 1978:99-104). At Ozette, notches ranged in width from .32-.51 m. This number was used as an approximation of minimum beam diameter. Since Stewart included very large houses in her sample, and the Ozette houses were smaller than the Meier house and Cathlapotle House 1, an estimate of .3-1 m for beam diameter was employed.

Quantity of Structural Elements

Quantification of each type of structural element per house is possible with the aid of historical sources and archaeological data from Ozette. Table 2.B.1 presents estimated number of structural elements in each house studied at Meier and Cathlapotle. Distance between structural elements and house measurements were used to extrapolate number of elements in each house. Distances were derived from historical accounts and sketches (Hadja 1994), and from Ozette data (Matson 2003; Mauger 1978). A caveat is that houses at Ozette were built in the shed roof style, and so had pairs of rafter support posts rather than ridge and eave beam support posts. Ozette House 1 had five pairs of rafter support posts, and distance between them ranged from 4-5.2 meters. Ozette House 2 had four pairs of rafter support posts, ranging from 4-6.4 m apart (Matson 2003: Figure 4.11). For this study, eave and ridge beam support posts were considered to be 4-6 m apart. Each house was assumed to have four corner posts, with four corner posts in each compartment of Cathlapotle House 1.

Number of wall planks in each house was estimated by dividing the house length by the median plank length of 40 cm, which was determined using Meier and Cathlapotle metrics and measurements cited in historical documents. Median plank length at the sites ranged from 14–30 cm. However, these numbers are smaller because of the inclusion of planks used in benches, as pit liners, and in other house structures. Features assigned to the wall plank class had median lengths of 38 cm at Meier and 48 cm at Cathlapotle. Therefore, using

Table 2.B.1. Number of Structural Elements in each House, Meier and Cathlapotle.

	Meier	Cathlapotle House 1B	Cathlapotle House 1C	Cathlapotle House 1D	Cathlapotle House 1 Total	Cathlapotle House 4
Corner Post	4	4	4	4	16	4
Eave Beam Support*	6-12	0	2	2-6	6-16	0-2
Ridge Beam Support*	10-16	2-4	4-6	6-10	22-32	4-6
Wall Plank	220	83	107	144	379	107
Ridge Beam	1	1	1	1	1	1
Eave Beam	2	2	2	2	2	2

*Represent minimums and maximums based on different estimations of distance between elements.

Table 2.B.2. Roof Area Given Different House Measurements, Meier and Cathlapotle.

	Wall Height (m)	Ridge Beam Support Height (m)	Roof Width (m)	Roof Length (m)	Total roof area (m^2)
Meier	1.5	4	7.43	30	445.8
		6.1	8.38	30	502.8
	2.4	4	7.18	30	430.8
		6.1	7.92	30	475.2
Cathlapotle House 4	1.5	4	4.76	13.2	125.7
		6.1	5.69	13.2	161.8
	2.4	4	4.43	13.2	114.8
		6.1	4.36	13.2	144.8
Cathlapotle House 1B	1.5	4	5.59	6.6	73.8
		6.1	6.4	6.6	89.7
	2.4	4	5.31	6.6	69.3
		6.1	5.99	6.6	82.1
Cathlapotle House 1C	1.5	4	5.59	11.3	126.3
		6.1	6.4	11.3	153.5
	2.4	4	5.31	11.3	118.7
		6.1	5.99	11.3	140.6
Cathlapotle House 1D	1.5	4	5.59	18.7	209.1
		6.1	6.4	18.7	254.1
	2.4	4	5.31	18.7	196.4
		6.1	5.99	18.7	232.6
Cathlapotle House 1 Total	1.5	4	5.59	65.8	735.6
		6.1	6.4	65.8	894.1
	2.4	4	5.31	65.8	690.9
		6.1	5.99	65.8	818.6

Table 2.B.3. Angles of Roof Pitch Given Different House Measurements, Meier and Cathlapotle.

	Wall Height (m)	Ridge Beam Support Height (m)	Angle A	Angle B
Meier	1.5	4	19.7	70.3
		6.1	32.2	57.8
	2.4	4	12.9	77.1
		6.1	27.9	62.1
Cathlapotle House 4	1.5	4	31.7	58.3
		6.1	44.8	45.2
	2.4	4	34.7	55.3
		6.1	42.4	47.6
Cathlapotle House 1	1.5	4	26.6	63.4
		6.1	42.6	47.4
	2.4	4	17.7	72.3
		6.1	36.5	53.5

the means and medians from Meier and Cathlapotle structural features, it is reasonable to use 40 cm as a default plank length for wall planks.

Surface Area Calculations

In order to determine board feet of planking required for houses, I calculated the surface area that would need to be sheathed with planks for siding and roofing. Roof area was calculated using the Pythagorean Theorem (Figure 2.B.1). Wall plank height, ridge beam support height, and structure width were used to complete this equation. Side A was determined by subtracting ridge beam support height from wall height. Side B was calculated by halving the width of the house. Side C was completed with the Pythagorean Theorem, and represents estimated roof width. Roof width was multiplied by the length of the house. This figure was multiplied by two (to account for both sides of the roof), which represents the total roof area in square meters. For each structure, four roof area calculations were obtained representing the different combinations of ridge beam and wall height (Table 2.B.2).

Since roof area made up a significant portion of the raw material required for houses, I wanted ensure that my calculations were reasonable. To test roof area calculations, two angles of the roof pitch were calculated for each possible wall height and roof beam support combination that were used to estimate roof area. Angle A represents the intersection of the wall and the roof, and Angle B represents the pitch of the roof (Figure 2.B.2). These angles were then compared to two historical depictions of LCRR plankhouses. In Paul Kane's painting (Interior of a Ceremonial Lodge), Angle A is 22 degrees and Angle B is 68 degrees (Eaton and Urbanek 1995). In the Richard Dodson's engraving (Chinook Lodge in 1841, based a sketch by Alfred Agate), Angle A is 37 degrees and Angle B is 51 degrees (Oregon Historical Society 2003). These numbers are within the ranges of angles that I calculated from feature height estimates (Table 2.B.3).

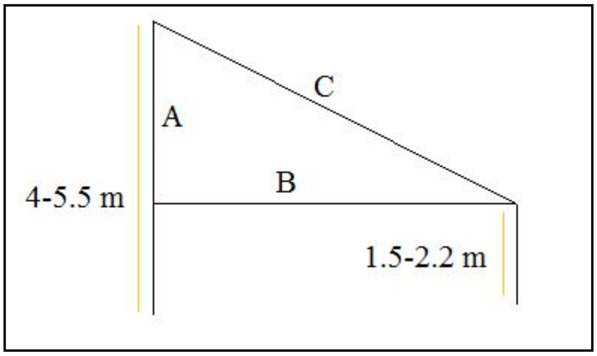


Figure 2.B.1. Schematic of roof area calculations.

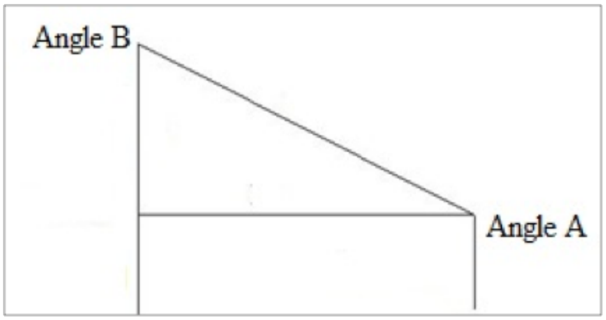


Figure 2.B.2. Schematic of roof angle calculations.

Wall area was also calculated for each possibility of wall height and ridge beam support height combination (Table 2.B.4). Total wall area was calculated by multiplying the long axis wall area by two and the short axis wall area by two . adding these numbers. The short axis calculation took into account the triangular portion of the short axis wall. Again, four different numbers for each house were created using all possible combinations of wall height and ridge beam support post height.

Post and Beam Calculations

Number of elements in each house was combined with element height to estimate meters of wood required for posts and beam elements (Table 2.B.5). A useable tree height of 6.1 meters (20 feet) was employed to maintain consistency with methods for calculating board feet. This number was divided by meters of wood needed for each diameter size (1 m, .5 m and .3 m) needed for different post and beam elements. Fractional numbers were rounded up in final calculations of number of trees required.

Table 2.B.4. Wall Surface Area Calculations Given Different House Measurements, Meier and Cathlapotle.

	Long Axis Wall Height (m)	Ridge Beam Height (m)	Long Axis Wall Area (m^2)	Short Axis Area (m^2)	Total House Siding Area (m^2)
Meier	1.5	4	45	38.50	167.0
		6.1		53.2	196.4
	2.4	4	72	44.8	233.6
		6.1		59.5	263
Cathlapotle	1.5	4	19.8	22.27	84.1
House 4		6.1		30.78	101.2
	2.4	4	31.68	26.74	116.8
		6.1		34.43	132.2
Cathlapotle	1.5	4	9.9	27.5	74.8
House 1B		6.1		38	95.8
	2.4	4	15.84	32	95.7
		6.1		42.5	116.7
Cathlapotle	1.5	4	16.95	27.5	88.9
House 1C		6.1		38	109.9
	2.4	4	27.12	32	118.2
		6.1		42.5	139.2
Cathlapotle	1.5	4	28.05	27.5	111.1
House 1D		6.1		38	132.1
	2.4	4	44.88	32	153.8
		6.1		42.5	174.8
Cathlapotle	1.5	4	98.7	27.5	362.4*
Total House 1		6.1		38	425.4*
	2.2	4	157.92	32	507.8*
		6.1		42.5	570.8*

* House 1 total uses five total short axis siding figures to account for the wood used in dividing the compartments.

Table 2.B.5. Trees Needed for Initial Construction, Meier and Cathlapotle.

	Element	Diameter (m)	Height (m)	Count	Wood required (m)	Trees required
Meier	Corner post	1	1.5-2.4	4	6-9.6	1-2
	Ridge beam support	.5	4-6.1	5-8	20-48.8	4-8
	Eave beam support	.3	1.5-2.4	6-12	9-28.8	2-5
	Beam	.3-1	30	3	90	15
						22-30
Cathlapotle House 4	Corner post	1	1.5-2.4	4	6-9.6	1-2
	Ridge beam support	.5	4-6.1	2-3	8-18.3	2-3
	Eave beam support	.3	1.5-2.4	0-2	0-4.4	0-1
	Beam	.3-1	13.2	3	39.6	7
						10-13
Cathlapotle House 1	Corner post	1	1.5-2.4	16	24-38.4	4-7
	Ridge beam support	.5	4-6.1	11-16	44-97.6	8-16
	Eave beam support	.3	1.5-2.4	6-16	9-38.4	2-7
	Beam	.3-1	65.8	3	197.4	33
						47-63

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PART III

DOMESTIC HEARTH FEATURES AT THE CATHLAPOTLE (45CL1) AND MEIER (35CO5) SITES IN THE WAPATO VALLEY OF OREGON AND WASHINGTON

William C. Gardner-O'Kearny

ABSTRACT

Much as lithic tools or faunal remains, features have the potential to be independent lines of evidence in archaeological hypothesis testing. Using household archaeological theory as a foundation, this report uses hearth and related features from the Cathlapotle (45CL1) and Meier (35CO5) sites to test hypotheses dealing with spatial and temporal variation in production. Spatially, differences should be seen within sites and between sites, with Cathlapotle, with a larger population to support, generally showing greater investment in production. Temporally, the sites were occupied at the start of the fur trade era in the Pacific Northwest. If the people living at these sites were active participants in the fur trade, there should be an intensification of production to meet demand created by that trade. These changes should be reflected in the hearths.

One hundred and seventy-nine hearths, hearth dumps, and ovens were identified at the sites. 8,909 faunal elements from 23 taxa were recovered from excavation units associated with these features. A combination of multivariate exploratory data analysis and traditional significance-based testing are used to analyze feature and faunal data.

Analyses based on feature size show two distinct patterns. First, features in the northern and central sections of the Meier house tend to cluster together. Similarly, features in the southern section of the Meier house and exterior features cluster. This pattern fits production based on the relative status of the occupants of the house sections. Second, features in the postcontact period tend to be smaller than those located in precontact contexts. This was found at both sites.

Faunal analyses tended to reinforce these findings. Analyses of Meier based on faunal remains tended to create northern/central and southern/exterior clusters. Both sites had relatively less variation in faunal remains in the precontact, with increased variation in the postcontact. This variation was often driven by an increase in faunal elements in the postcontact. For example, the faunal assemblages are dominated by deer and elk, which have increased numbers of elements present and increased accumulation rates in the postcontact compared to the precontact. However, the ratio of one to the other remained constant across temporal components. This same pattern holds generally for most mammalian fauna.

Faunal and feature analysis point to a core of production in the precontact, probably driven by household demand. From this core increased variation in the postcontact suggests intensification of production as people at these sites took part in the fur trade.

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CHAPTER 1
INTRODUCTION

Archaeologists have multiple lines of evidence from which they can draw when formulating and testing hypotheses. Among these are ethnographical and historical accounts from which one can form analogies. Floral and faunal remains allow one to build models of past diets and environmental conditions. Technological artifacts open windows on the activities in which past peoples engaged. One line of evidence, however, has often been overlooked or, at the very least, underused. These are the remains of static objects such as - but not necessarily limited to - posts, pits, walls, concentrations of thermally altered rock, or discrete patches of ash. As a category of evidence, these types of remains are commonly called features. The term itself can be ambiguous, and will be more fully defined in the following pages, but as a class of archaeological artifacts features have untapped potential to allow insights into past behavior and social organization.

Features can be identified by such phenomena as changes in the composition and/or consistency of the soil or by increases in frequencies of things like rock, wood, or charcoal. Artifacts themselves, when gathered together in a tight enough spatial grouping can be considered a feature, thus allowing them to become a double line of evidence. Most often in practice, “feature” refers to the remains of some structural element of an archaeological site: a wall, storage pit, cooking fire, and so on. In general, authors of archaeological site reports describe these features in passing, but the focus of much archaeology, especially in North America, is still very much on the artifacts and biological remains found at a site.

This report focuses on hearth features from the Cathlapotle (45CL1) and Meier (35CO5) sites located in the Wapato Valley of northern Oregon and southern Washington. It attempts to connect those features to larger archaeological questions drawn from household archaeology based theory. Household archaeology considers the household, in whatever composition, as the basic unit for analyzing an archaeological site. The framework for this theory was first developed by Wilk and Rathje (1982). It proposes that households fulfill the needs of those within the household by focusing on four functions: production, transmission, reproduction, and consumption. By completing each of these activities, the household can adapt, survive and reproduce itself.

Hearth features provide direct evidence of household functions. These features represent the fires people used to process their food, heat their houses, provide light, and modify their raw materials. It is worth noting that I make a distinction between cooking and processing foodstuffs. Cooking implies preparing food for immediate consumption. However, a household may not necessarily need the food they had gathered at that moment. Rather, it may have been prudent to store food for a later time when food resources were not otherwise available in their environment. Salmon is, of course, the classic example on the Northwest Coast. Salmon were a mainstay of the diet of the people who lived in the Pacific Northwest, but can be harvested during only limited periods each year (Matson 1992). The smoke produced by the fires contained within the hearths of these sites was used to process the salmon for consumption during the winter when the salmon were not running (Graesch 2007). By considering larger implications of this kind of activity, food processing using hearths can be viewed as a kind of risk management system. By lessening the risk of having a caloric shortfall at some point after the salmon stop running, the household is meeting the needs of two of its functions: production (of the food necessary to survive) and reproduction (by creating a situation where members of the household have their dietary requirements met and can thus create and provide for offspring). The hearth is, therefore, one of the technological implements by which these needs are met. Thus, the hearth can be seen as analogous to any other tool that allows food to be captured and processed for consumption, such as a fishing net, knife or projectile point. Losing any of these parts in the sequence of activities to collect and prepare food puts the entire process in danger of failure. All are vital to the successful completion of the goal: having enough to eat. The hearth, therefore, must be viewed as having the same significance as any other link in this resource acquisition chain when attempting to fully understand past life-ways.

This report treats features as any other type of archaeological evidence in testing two hypotheses. Very briefly, this report examines hypotheses dealing with spatial and temporal variation in production. Spatially, differentiation is expected within houses and between sites. Within sites differences in feature size can be associated with specific household segments. Assuming differences in status within houses and between sites, differences in access to resources will also be apparent in the faunal assemblages associated with hearth and related features. Temporally, these sites were occupied during the beginning of the fur trade in the Pacific Northwest. The need to meet the increased production demands of being part of the fur trade should be seen in clear differences between faunal assemblages associated precontact and postcontact periods. Number of hearths should also increase to meet the production demands. These hypotheses and associated expectations are discussed more fully in Chapter 3.

Cathlapotle and Meier provide an excellent opportunity to compare features for several reasons. Both are closely adjacent village sites, which, in principle, should have seen similar activities taking place. Both were populated by Chinookan peoples and had contemporaneous occupations. Both are situated geographically within the larger Portland Basin of the Columbia River. However, within these similarities are the seeds for contrasting the sites. For instance, while both sites were villages in the strict definition, Meier was comprised of only a single plankhouse, while Cathlapotle was composed of at least six and maybe as many as eleven houses (Ames et al. 1992; Ames et al. 1999).

This report explores the similarities and differences between these sites in terms of household production. Organizationally, it is divided into the following sections. Chapter 2 looks at the concept of features and hearth features specifically. Chapter 3 describes the methodology used in analyzing features from these two sites and includes an explicit stating of my hypotheses and related expectation. Chapter 4 presents the results of structural analysis of the features. Chapter 5 presents results of faunal analysis. Finally a discussion of significant results and final conclusions will be presented in Chapter 6.

CHAPTER 2
FEATURES

Archaeological features are artifacts like any other. In the broadest sense, an archaeological feature is a spatially discrete area within a site that can be characterized in some way as distinct from the surrounding space. What makes this area notable varies, and this variation ultimately is what is segregated into groups and named. For instance, an unusually large number of bifaces in close proximity all bound within a relatively small volume of soil can be called a "Cache, biface" feature. The cache is patently different from the surrounding matrix. Similarly, the remains of structural elements of houses leave traces in the ground that are distinct in color and composition from the surrounding soil.

These are the structural features which archaeologists eventually unearth and describe. Northwest Coast plankhouses were complex combinations of structural elements that defined the use of interior space (Rapoport 1990). Northwest Coast plankhouses were part of the household's rights and responsibilities transmitted from one generation to the next within the household (Ames 1996). Eventually, if the house was not maintained, the structure began to decompose. As the wall planks, support posts, benches, hearths and other structural elements rot away, they leave distinctive traces in the soil. These features represent the investment of the people of the dwelling, the elements that in many ways defined how they interacted with their built environment and each other, and the continuance of the household itself.

Despite being sources of potentially significant archaeological data, it has only been in the last few years that a body of literature has begun to emerge that deals with features in and of themselves. While features, including hearths, are often loosely defined and described in archaeological site reports, rarely are features used explicitly for hyporeport testing. More commonly features, and especially hearth features, provide the focal point for defining an activity area as evidenced by a high density of some suggestive tool type or faunal remain. Mitchell et al. (2006) carry out such a study looking at the distributions of several artifact types around four hearths at a Later Stone Age Likoaeng site in the Kingdom of Lesotho, South Africa. Based on densities of artifact types across the site, the authors were able to draw several conclusions concerning what types of activities were associated with which hearth. For instance, Hearth 1 and 2 were associated with flint knapping based on the relatively high density of debitage. Alternately, Hearth 3 was associated with hide working based on the presence of scrapers.

Such studies are one of the cornerstones of archaeological analysis and hyporeport testing, and I in no way wish to appear to be suggesting they are not important. In fact, this report will in part do a similar analysis. However, in such studies features too often become little more than logical, ethnographically correct, or just convenient points around which to draw circles on a site map defining the activity area. The features are not treated as independent artifacts in and of themselves.

Several definitions of features have been proposed. For instance, features have been defined as non-portable, non-discrete objects in the archaeological record that can be treated much as artifacts for analytical purposes (Chatters 1984; Dunnell 1971). Feder (2007:643) states that a feature is "the combination of artifacts and/or ecofacts at a site, reflecting a location where some human activity took place." He goes on to note that features can be considered non-portable, complex artifacts. Similarly, Crabtree and Campana (2001:34) define features as "the immovable products of human activity that are affixed to or imbedded in the landscape..." Definitions of features often have a list of possibilities, although the individual examples are rarely explicitly defined, to help illustrate the broader concept. For instance, Thomas and Kelly's (2006:52) definition includes both ideas of non-portability and a list of examples: "The non-portable evidence of technology; usually fire hearths, architectural elements, artifact clusters, garbage pits, soil stains, and so on."

In reviewing definitions several points come up repeatedly. First, features are often associated with technology. Further, the feature themselves can reflect technology. For instance, earth oven and hearth features represent different, although obviously related, cooking technologies. This blurs somewhat with the second point which suggests features are associated with activity areas. Third, a feature is non-portable. This is perhaps the most common definitional element. However, it is also potentially ambiguous, if not misleading.

The notion of portability, or lack there of, as a characteristic of features may be better considered as two related concepts. First, the notion of convenience of portability is closer to the mark. A large fire pit can be removed in part and samples taken back to a lab for further analysis, but as a cohesive unit it is simply inconvenient to remove. This leads to the second point, breaking this cohesive object in order to make it more portable may destroy part of the information potential of the unit by distorting the spatial relations associated with that object. It is, to a large extent, the spatial relations, both internal and external, that allow one to derive meaning from a feature. For example, a postmold is, on a basic level, simply a bit of discolored earth. It is the relationships between it and surrounding features, artifacts, and landforms that provide the potential for archaeological inference.

To summarize, previous definitions tend to emphasize two points: features to some degree reflect the technological setting in which the people who originally created them operated and that features are, in some sense, non-portable. Concentrations of thermally altered rock reflect certain cooking technologies. Wall and postmolds reflect objects that are inconvenient to move. To some extent, the knowledge that one can derive from a feature is linked to the internal and external spatial relations associated with the feature.

There is still, however, a certain sense of "knowing it when you see it" about this. For instance, three projectile points close together is interesting, perhaps even suggestive of something, but probably not a feature. Ten projectile points within the same space all pointing the same way would probably be called a feature. This is not to say that such a division would not be appropriate. Reduced to a level of absurdity, anything could be a feature, especially if one does not hold the portability criteria too dear. At some level, decisions have to be made as to what is or is not a feature if for no other reason than time and cost of excavation.

Features tend to be labor intensive in terms of time involved excavating and documenting them. In order to optimize what knowledge can be derived in a limited amount of excavation time by a given number of workers, decisions have to be made concerning where effort should be spent. One of these decisions is necessarily what is to be called a feature. Thus, the designation as "feature" is most often made on the fly by field supervisors based on the very intuitive criteria discussed above. At some very basic level, what is and is not reported as a feature in the archaeological literature is arbitrary.

With the above considerations in mind I would like to propose the following as an alternative way of looking at what is or is not a feature: what defines a feature is its spatial relation to the environment in which it is situated and, potentially, the spatial relations of its constituent parts. A feature is a spatially definable unit that is distinguishable from the environment in which it is surrounded. The relations and contrasts, in terms of space and characteristics, of one object to the area surrounding it and to other distinct features within that area are thus fundamental to defining a given feature. A feature's significance is derived from its relation to the external setting as well as its internal characteristics and spatial relations.

Production and Hearth Features

This report deals with points of production within the larger spatial setting of two sites. In the broadest terms the features I am looking at can be broken into three general types: hearths, ovens, and dumps. The first two are basic production facilities while the third is a byproduct of production activities reflecting reuse and maintenance which over the course of generations suggests reproduction of the household unit.

Consistent use of fire in processing of food and lithics (Brown et al. 2009; Wandsnider 1997) date back at least to the mid Pleistocene (Bicho et al. 2006). Hearths are basic not only to production but to archaeology. As such, while the term hearth is often used, it is rarely defined. In a quick review of seven introductory textbooks and eight archaeological dictionaries and encyclopedias, only one had an explicit definition of hearth: "The site of an open domestic fire (cf. kiln, oven), represented by ash, charcoal and discoloration. There may be slight structural additions such as a clay flooring or a setting of stones around it" (Warwick and Trump 1970:102). The Oxford English Dictionary defines a hearth as: "1.a. That part of a room on which the fire is made, or which is beneath the fire-basket or grate; the paved or tiled floor of a fireplace. 1.b. A portable receptacle for fire, or a flat plate on which it may be made" (Oxford University Press n.d.). It would seem the common usage of the word hearth by hunter-gatherer scholars, largely covered by the first portion of the Warwick and Trump definition, is, strictly speaking, wrong. Hearths should refer only to those places where a specific surface has been constructed upon which to set a fire.

While the debates of prescriptivists and descriptivists are quite beyond the scope of this report, for the purposes of this paper I will follow archaeological precedence and fall toward the general definition. More specifically, hearths are simply contained spaces where burning takes place. A hearth feature, therefore, is the material remains of that fire and the construction, if any, associated with that burning. This definition is deliberately left broad. I will use the term hearth in this general manner. Ovens, or earth ovens, are a subset of hearths largely set apart by internal structure and the presence of floral remains. Dumps, or hearth dumps, are the likely remnants of cleaning episodes and lack the formalized structure of a hearth.

The range of structural variation in hearth features is quite high. Hearth size and form are probably related to intended function (Ciolek-Torrello 1984). Hearths found within plankhouses have several common elements which are often present. Burnt sediment, often orange to pinkish in color, marks the center of the feature. The by-product of heating and cooling cycles, thermally altered rock, can be present. The entire feature may sit on a formed base of clay or sand. As this base, or bowl, is worn out a new one may be placed on top of the original creating a series of superimposed features. Exterior hearths do not have formal structures such as boxes surrounding them. In general, they also tend to be smaller in all dimensions. The total volume comprised the hearth feature reflects size of fire the hearth itself could support. This in turn reflects the production potential of the hearth.

Hearths, especially those within the house structure, such as those at Cathlapotle and Meier, tend to have a coherent, approximately semispherical shape. Note that this shape is not universal, for instance cone shaped hearths have been identified in Upper Paleolithic sites in Portugal (Oetelaar 1993). Interior hearths may be placed within a box structure below floor level.

Earth ovens process food through a kind of slow cooking using latent heat stored in rocks and steam. Variously referred to as pit ovens, baking pits, oven mounds (Thoms 1998), these facilities are found throughout the world. On the Columbia Plateau, in Washington's Calispell Valley, earth ovens date back to circa 5500 B.P. and were probably used in camas (*Camassia quamash*) processing (Thoms 1998).

Ovens can range from .5 to 6 m in diameter, with larger examples having been found containing upwards of 1000 kg of thermally altered rock contained within (Thoms 1998). In the Pacific Northwest, besides camas, ovens have been located containing skunk cabbage (*Lysichitum americanum*), potato tubers (*Claytonia sp.*), Oregon grape seed (*Mahonia sp.*), onion bulbs (*Allium sp.*), and wapato (*Sagittaria latifolia*) (Thoms 1989). Additionally, small earth ovens have been found with charred faunal remains. Smaller earth ovens (50 cm diameter) may have been used to cook river mussels (Thoms 1998). In general, earth ovens are distinguished by a high density of thermally altered rock and charcoal and a relative lack of chipped stone. Ideally, they were located in well drained areas. Thoms (1998) notes that there is basically only one way to construct an oven, with variations largely accounted for by differences in the terrain in which the oven is located. Oetelaar (1993) suggests that the oven cooking process would tend to be a smoky and messy affair that cause people to place ovens well away from houses and closer to midden areas.

Dumps are essentially small trash piles. In general, dumps are characterized by concentrations of ash, broken up bisque, and/or FCR. Those found in interior areas were probably primary deposits awaiting removal to formal external middens at which point the discrete feature will tend to blend into the overall midden structure. Unlike hearths and ovens, dumps lack a structural integrity of shape.

Hearth Lifecycle

The features analyzed in this report are considered as either the direct tools of production or the result of maintenance of those tools. As houses have a lifecycle (e.g. Trieu Gahr 2006), so hearths cycle through a series of stages. I propose the following generalized lifecycle for domestic hearth features discussed in this report. Interestingly, there has been no extended study of hearth lifecycles as of the writing of this report. As such, I am presenting a model informed largely by Smith's (2006) hearth maintenance model.

1. A household production need is defined. This may be very basic and general, such as the need for heat and light in the winter, to very specific, as in the case of lithic production. Alternately, cultural norms may dictate that a house must have a hearth. Thus, the building of a new house would require the construction of a hearth. Hearths could be constructed with multiple goals in mind or a singular, possibly short term, aim.

2. The hearth is constructed. Several considerations were probably kept in mind during basic construction, such as what material was available for lining, space, amount of fuel available (both immediately and for the projected long-term needs, if any), expected intensity of use, and expect length of use. Total feature size may reflect some of these decisions.

3. The hearth goes into its primary use stage meeting the production need. At this point the lifecycle of the hearth can take several possible courses.

4. If the hearth was used for long enough, it will require maintenance. Maintenance primarily involves cleaning out accumulated ash, FCR, bisque, and refuse left behind from production activities (faunal remains from cooking, for instance). FCR from the cleaning process may have been reused for other purposes such as lining storage pits (Smith 2006). Maintenance can also involve reconstruction and repair of hearth linings. For instance, if the fire sits on top of a sand lined bowl, clean sand may be added upon occasion. If the bowl is constructed of clay, the old bowl may be removed in large part and a new bowl fabricated.

5. It is possible that there were circumstances in which maintenance is less desirable than starting over, at which point a new hearth bowl may be constructed above and/or adjacent to the current hearth. Over extended periods, multiple hearth bowls can accumulate creating hearth complexes.

6. The debris collected in the course of hearth maintenance and cleaning is moved out of the feature creating a hearth dump. This deposit could either be kept within the house for a period or removed directly to an exterior location such as a midden. If hearths are cleaned regularly it is possible that multiple cleanings were added to one another before removal from the house.

7. Steps 4-6 above largely assume the hearth was inside a house. However, exterior hearths were also constructed. At Cathlapotle especially, there are a number of small, exterior hearths. Often these features are capped with a lens of clean sand, probably deposited by river flooding. These hearths seem to have had relatively short use-lives, possibly negating the need for formal cleaning and maintenance. Alternately, if they were cleaned, the resulting waste products may have been placed relatively close to the hearth. There is a general low level of midden like material spread across Cathlapotle's exterior areas suggesting that primary dump deposits may have only infrequently been removed to more formal midden lobes.

8. At some point the need that the hearth helped fulfill may no longer be present. At this point the hearth may be abandoned. Abandonment could include deconstruction of the hearth and removal to midden contexts. Alternately, a new surface could be constructed on top of the hearth. Obviously, hearth abandonment could be part of a larger process of house abandonment.

9. Finally, it should be noted that ovens are a special case. These are essentially large ex-

terior hearths constructed with plant (such as wapato) processing goals in mind. As such, their internal construction was somewhat varied from interior hearths. The temperatures to which the ovens were heated and at which they maintained for hours produced considerable FCR (Wilson and DeLyria 1999). If these ovens were used consistently and repeatedly for bulb processing they would have needed to be cleaned consistently.

Recent Feature Related Research

Several recent projects have utilized hearths as focal points on which to base studies. Investment in hearths can be related to household production needs, with more hearths being added to meet increased needs. Kapches (1990) found that hearths tended to be more or less permanent locations within an Iroquois longhouse structure in south-central Ontario. However, numbers of hearths could change depending on alterations to the overall house structure presumably reflecting population changes. Further, the area devoted to hearth use could also be altered. These hearth areas were indicated by the spatial relations between numerous small postmolds (which probably once supported cooking or drying racks and poles), the hearths, and surrounding structural features such as benches. Kapches also notes number of hearths in use and intensity of hearth use may have varied seasonally as production needs changed. Friesen (2007) also found stability in hearth row structure within Late Dorset period houses. Rather than associating this with demographics, Friesen sees this as resistance to social change characterized by increasing inequality.

Hoffman's (1999, 2002) research on houses on Uminak Island, Alaska attempted to discern household versus individual or nuclear family production based on hearth placement in multi-family houses. Hoffman's work relates directly to the relation between the house and household, with all segments of the house (both physical and social) connected by central hearths. Hearths were found to be centers of production not only of food but also clothing as reflected in the presence of the majority of sewing needles being found within hearth zones. Hoffman (1998) hypothesizes that people were making use of the light produced by the fires. However, it is worth noting in passing that light levels may not have needed to be all that high for such work to take place (Dawson et al. 2007). Interestingly, although these houses tended to have two hearths each, only one hearth per dwelling had an associated FCR dump. Hoffman found the placement of hearths, the use of driftwood for fuel (a rather limited resource), and the somewhat generalized artifact assemblages suggestive of communal use of hearths.

Coupland et al. (2009) also use hearths to examine social hierarchy and household structure. Their study looks at variations along the length of the Northwest Coast in the relative strength of intra-household hierarchies and communalism (the sense of unified interest). The authors' model idealized houses (based on accepted regional dwelling variations) and household organization (the placement of variously ranked segments of the household) within the houses. Houses along the northern Northwest Coast have a centrally located hearth with higher ranked members of the household living towards the back of the house. Houses along the central coast have similar living arrangements. However, each section of the household has an individual hearth, with a centrally located communal hearth. According to Coupland et al. (2009), houses along the southern coast, including the Wapato Valley, have no clear spatial organization in terms of ranked segments within the house. Hearths are placed along a central line of the house. Nuclear families occupying opposite sides of the house share a hearth.

The main thrust of the authors' argument is that centrally located hearths can be directly correlated with greater communalism. Members of such a group are less likely to leave the household group. They share a greater sense of being part of a single production unit. Conversely, multiple hearths, ostensibly representing individual segments of the household, reflect a less cohesive household group. With less of a sense of operating as a single unit household fission is more likely and each segment works for the household good only insofar as it suits their own interests.

Within this theoretical framework, Coupland et al. (2009) found elite power increases as one moves up the Northwest Coast. Perhaps counter-intuitively, household communalism, the sense of all members working for the common good, also increases as one moves from south to north along the coast. Thus, native cultures along the northern end of British Columbia have highly hierarchical household organization and a greater sense of household communalism in comparison to those groups along the Oregon coast. The central coast area tends to fall somewhere in between. The authors specifically use Meier and Cathlapotle as their exemplars of South Coast houses and households.

In summary, several researchers have begun using hearths as primary source of data for building and test hypotheses. While much of the preceding has influenced and informed my work, my goal is to use hearth feature data in a different way. Along with a more traditional approach centered on the faunal assemblages associated with hearth and related features at Cathlapotle and Meier, I will explore the potential of feature structure in testing hypotheses dealing with variation in production. The methodology for doing this is put forth in the following chapter.

CHAPTER 3
METHODS AND MATERIALS

This report uses hearths and their associated faunal assemblages to examine variation in production. Analyses will test two hypotheses:

1. Spatial: Cathlapotle with a larger labor pool and consumer demand will show more intensive investment in hearth features than Meier. This will be reflected in larger numbers of hearths with a greater diversity in size and form, relative to Meier, to meet demand. Similarly, there will also be a higher density of faunal elements associated with Cathlapotle. Further, these households were spatially organized by status (Smith 2008). This organization should be seen by greater diversity in fauna (driven by the presence of rare species) in high status areas of the house.

2. Temporal: Both sites were occupied at the beginning of the fur trade era in the Pacific Northwest (approximately A.D. 1792). Native populations were active participants in this new economy (Vaughn and Holm 1990). In order to meet the increased demands of the changing economic situation, there will be an increase in production seen in changes in the number of hearths and in the associated faunal assemblages in the postcontact period compared to the precontact period. Again, with its larger labor pool, the relative differences in faunal elements present between precontact and postcontact should be greater at Cathlapotle than Meier.

Exploratory data analysis, parametric and non-parametric procedures will be used to test these hypotheses. Many of the specifics of these tests will be discussed below. At this point, however, it is possible to discuss in general terms some expectations that can be derived from the above hypotheses:

1. Spatial: Differences in size and number of hearths will be seen in simple significance tests such as a non-parametric Mann-Whitney U test. Additionally, differences in the structure of hearths will be seen in grouping by site in exploratory data analysis. For example, in terms of size, if there is in fact greater variation in size in hearth features at Cathlapotle, this will be seen in scattergrams based on components created using principle component analysis. In this case features from Meier should cluster more closely together, while Cathlapotle features should be spread across the graph. When looking at fauna, if one plots the first two components of a principle component analysis based on NISP, one component will be associated with each site. It is important to keep in mind that after A.D. 1792 the fur trade adds an additional variable to be considered in production. Before this point in time production should be more closely aligned with household population. Therefore, differences between sites should be more apparent in the precontact period.

2. Temporal: An increase in production from precontact to postcontact will be seen in statistically significant differences in counts of faunal elements present in each period. Exploratory data analysis will be used to reduce the rather large amounts of variation present in the faunal assemblages. Excavation units with similar numbers of faunal elements of the same taxa will tend to cluster together. If there are differences between temporal components present, clustering procedures should be able to group cases based on increased NISP for fur trade species such as beaver, mink, deer, and elk. Assuming, for a moment, there is an increase in NISP in the postcontact, if the fur trade is an important contributing factor in the increase, principle component analysis and discriminant analysis should identify those species associated with the fur trade as important in defining clustering characteristics. If production demands are driven by the fur trade, the precontact production should be related more directly to household population demands. As such, Cathlapotle and Meier should separate out in exploratory data analyses in the precontact period.

One of the main goals of spatial analysis is to discern patterning in the relationships between specific locations and archaeological remains which can then be tied to higher level hypotheses and theory (Kent 1984). In this report I am examining patterning in relations involving hearth structure, placement, temporal components, and associated mammalian faunal material.

Analysis of the hearths at Cathlapotle and Meier will be broken into two sections. First, I will present a basic analysis of the metric variation of the hearths and related features. The second section will examine variation in faunal remains (previously analyzed by Dr. R. Lee Lyman, University of Missouri – Columbia). Both sections will use exploratory data analysis (Baxter 1994; Baxter 2003; Carroll and Arabie 1980; Cau et al. 2004; Clark 1982; Fletcher and Lock 2005; James and McCulloch 1990; Shennan 1997). In general I follow what Baxter (2006) terms unsupervised and supervised pattern recognition. Several clustering methods will be used including: hierarchical cluster analysis, multidimensional scaling (MDS), principle component analysis (PCA), discriminant analysis (DA) and correspondence analysis (CA). Additionally, direct comparison of assemblage and site characteristics will be carried out. Owing to the distributions of most variables, non-parametric measures of contrast will be largely employed. Diversity measures will also be calculated and used as a basis for comparison.

The data set under consideration is large and may be analyzed from a number of perspectives. One of the advantages of exploratory data techniques is the ability to compress variation into a manageable and comprehensible form. Further, one can generate expectations for this form. The disadvantage of most clustering techniques is that they do not produce tests of significance or association as, for example, a chi-square test does. However, by employing multiple types of tests, used consistently in a set series, one can begin to see if observed patterns are robust. These patterns can then be further explored through the use of tests that produce significance levels (Clark 1982). Essentially, within the larger framework of the hypotheses being tested, exploratory data analysis, such as cluster analysis, sets up a series of ad hoc hypotheses that can be further tested with significance level producing tests. For example, a principle component analysis may have one component associated with a given species. The second component is with associated another species. When graphed, two sites are also associated with one component or the other. Mann-Whitney U or t-tests, as appropriate, can then be used to compare differences in the species associated with each component and site.

A rather substantial number of procedures need to be performed to fully explore the data with this kind of testing. It is often the case that there is patterning in data without their necessarily being statistically significant relationships among that dataset's various elements. In order to determine if a potential pattern is robust, the testing procedure must be reiterative, going back and exploring the data in light of what has already been shown. The goal of this is to avoid either accepting that there is a relationship within the data based on a single test when there is not (type II error), or missing a relationship based on a failure of a test to reach a certain statistical significance level (type I error).

Obviously, one of my overarching goals of this study is to show that by following this reiterative testing process patterns can be shown that support or refute my hypotheses. However, it will often be the case that that there simply is no patterning or very weak patterning present. I believe that these "failures" must be shown, if for no other reason than to act as contrasts to situations where patterning is present.

Unsupervised Learning

Clustering methods have the potential to help uncover patterns in data that might otherwise be lost in cases where there are a great number of variables and/or cases to consider. Baxter (2006) breaks clustering methods into two groups he refers to as supervised and unsupervised learning. Note that this is not a methodology as such, but rather a way of dividing an increasingly large family of statistical modeling and clustering procedures based on strengths and goals. In unsupervised learning "the object is often to identify previously unknown structure in the data" (Baxter 2006:671). There are many procedures that come under the heading of unsupervised pattern recognition including hierarchical cluster analysis, k-means clustering, principle component analysis (and the related factor analysis), and multidimensional scaling.

Hierarchical cluster analysis is a grouping technique that divides large groups of data into groups based on physical characteristics. For instance, if you have 100 projectile points, each with a half dozen measurements recorded, cluster analysis takes the projectile points and groups them based on similarity of the measurements. Fletcher and Lock (2005) suggest that this relation to classification explains the popularity of cluster analysis' popularity in archaeology. In short, each case starts as a group in and of itself. Larger groups are then created, step by step, by placing similar objects together based on some predetermined set of rules.

There are two main considerations to keep in mind when carrying out cluster analysis. First is the choice of variables to be used. Variables must be measured on the same scale and, ideally, should have a normal distribution. Second, there are a number of different algorithms that can be used to produce clusters. Baxter (2006) and Fletcher and Lock (2005) recommend the average linkage method and Ward's method. Average link builds clusters while attempting to maximize average distance (differences) between clusters. Ward's method minimizes variation (based on squared Euclidean distance) within each cluster (Baxter 1994; Baxter 2003).

There are two related problems associated with cluster analysis. First, there is no real test of significance for the procedure. There is no way an archaeologist can state that there is less than a 5% likelihood that actual structure of the data is other than what the analysis is showing. Baxter (2006) recommends labeling results of a principle component analysis (see below) and seeing if they group under cluster analysis as well. This informally tests if the clustering results are stable and distinct. Second, multivariate tests will always produce some kind of result. Whether the result makes sense in terms of broader theory is another question. As such, cluster analysis is often best employed as a heuristic device to explore general patterning within the data.

The second procedure to be used is principle component analysis (PCA). Again, the aim is pattern recognition with an eye toward creating a "map" of the variability present within the data set reduced to a limited number of components or factors. James and McCulloch (1990) state the aims of PCA are to: 1) describe a matrix of data consisting of objects and attributes by reducing its dimensions, usually for graphical display; 2) find uncorrelated linear combinations of the original variables with maximal variance; and 3) suggest new combinations of variables. The advantage over cluster analysis is that PCA produces a clear record in the reduction of variability within the sample. As new dimensions are produced, loadings of the variables are generated. These loadings can then be interpreted. Shennan (1997) points out that it is often productive to "rotate" components (essentially, taking the components and turning them such that each lines up with a single variable without altering the relation between components). Baxter (2006) suggests that it is usually a sound idea to transform (usually with log transformations) the data prior to running a principle component analysis.

Multidimensional scaling (MDS), or principle coordinate analysis (Shennan 1997), specifically compresses variation within a data set into what Orchard and Clark (2005) describe as a map of that variation. MDS reduces variation by producing coordinates for each case, analogous to component scores in PCA, on a number of axes of the multidimensional space. It is these coordinates that one must use for interpretation. MDS can be used to analyze distance-like data, or "data that indicate the degree of dissimilarity (or similarity) of two things" (Norušis 2006a:286). Norušis uses the example of a matrix of flight distances between cities. MDS scales the variation within the matrix down to two dimensions which when graphed essentially places each city where it should be relative to each other city. The MDS procedure used here (SPSS 16.0) arranges pairs of data as points in a multidimensional space such that the distance between pairs of points represents the strongest possible relation compared to similarities among possible points. In other words, the more similar two objects of analysis are, the closer they are placed together, and conversely, the more dissimilar they are, the farther they are placed from one another. MDS can be used with data measured on an ordinal, interval, or ratio scale. Baxter (2003) points out that MDS is particularly suited for analyzing data that have metric differences between cases and the goal is seriation. Although all of the procedures mentioned above have been successfully applied to archaeology, MDS has the advantage of not requiring some of the assumptions of other forms of analysis, most notably that the data have a normal distribution.

In order to gauge how robust the model

produced by the analysis is, the MDS procedure in SPSS allows one to develop solutions based on a range of possible dimensions. The procedure then produces three measures of model fit: S-stress, Kruskal's stress measure (or simple Stress), and a squared correlation coefficient (R2) (Norušis 2006a). S-stress ranges from 1 (worst fit) to 0 (best fit) and is used as a measure analogous to eigenvalues for determining iterations of the algorithm to be completed before reaching a final solution. With each subsequent iteration there should be an improvement in the S-stress value down to a predetermined cut-off value. The default value used by SPSS 16.0 is 0.003. Stress is much like S-stress, in that it is a measure of the fit of distance measures to dissimilarities as calculated by the procedure. R in this case can be interpreted as the proportion of variance of the transformed data that is accounted for by the distances in the model. A R value of one would be a perfect fit.

Supervised Learning

Assuming that there is patterning or structure within the data from the hearths at Cathlapotle and Meier, the next step is what Baxter (2006) refers to as supervised pattern recognition. In this case the structure of the data is known to some degree and this prior knowledge is used in the statistical calculations. Baxter points to discriminant analysis (DA) as a prime example, and it is this which I will be employing. The main purpose of discriminant analysis is to: 1) describe multi-group situations, 2) find linear combinations of variables with maximal ability to discriminate groups of objects, 3) classify current observations or allocate new ones (James and McCulloch 1990).

Discriminant analysis' primary advantage is the ability to create a model based on a "learning" sample of the data set. The model can then be tested by gauging how well it places cases left out of the initial model. In this way DA can also be used as a predictive tool. The analysis also produces a "leave one out" test, similar to bootstrapping, referred to as cross-validation, in which cases are left out of the model calculation process one after another. As each case is left out, the model is regenerated with that case placed in a group. In essence this tests to see how stable the model as a whole is. The more cases that are correctly placed when they are not factored into model creation, the more robust the overall model is.

Again, it is worth noting that this split of supervised and unsupervised learning is not a structured methodology. However, the strengths of each can play off each other. Unsupervised learning can be used to uncover possible patterning in data and identify potential outliers. Supervised learning can then be used to build models that test how robust patterning is or is not.

Significance-Based Statistical Methods

In addition to exploratory data analysis, several significance-based methods are utilized in the course of this report. Most of these are in fairly common use in archaeology and do not require protracted discussion here (for descriptions specifically geared toward archaeologists see Fletcher and Lock [2005] and Shennan [1997]). Most often I will be using tests that compare means and distributions of a given variable or variables. T-tests will be used when appropriate. Often, however, the variables under consideration do not meet required assumptions for t-tests. In these cases Mann-Whitney U and two sample Kolmogorov-Smirnov tests are employed. All three of these tests produce p values. I use a standard α of .05. To determine if the assumption of a normal distribution is met for t-tests I used a number of tests including one sample Kolmogorov-Smirnov, Kolmogorov-Smirnov with a Lilliefors significance level, and Shapiro-Wilk tests. These are discussed in detail below. All tests were run using SPSS 16.0.

Diversity Measures

There is a vast literature that deals with the specifics of diversity indexes (e.g., Leonard and Jones 1989 and papers therein). A group of standard diversity and evenness measures were calculated for both sites individually and combined based on faunal NISP for each unit. Several further measures were calculated for specific circumstances such as testing the sample with deer and elk removed from consideration. Although not strictly a diversity measure as such, an elk index was generated (Lyman 2008). This index, calculated as Σ elk NISP/ Σ (elk NISP + deer NISP), captures the differences in these two dominant species within the assemblage. The main advantage to working with diversity measures as opposed to actual counts is that they summarize at least one aspect of the variability in a given unit in a single number. Diversity measures can be sensitive to different characteristics of the sample being tested such as the presence or rare species or species with unusually abundant species (Borowsky and Ball 1989; Smith and Wilson 1996). Therefore, multiple measures are used here to generate an overall picture that rises above the pitfalls of any one measure. These indices were generally calculated and used as a suite.

The following diversity and evenness measures were calculated using SPSS 16.0 based on syntax written by me. Note, in many cases I followed, or referred back to, Kintigh's (2006) variable names in naming these equations. In other instances the nomenclature is my own and reflects variable naming constraints imposed by SPSS. Equations used include:

$$D = \sum_{i=1}^{s} pi^2$$

(Keylock 2005; Smith and Wilson 1996) where *pi* is the proportion of the ith species

$$H' = -\sum_{i=1}^{s} (pi)(\ln pi)$$

(Pielou 1966; Smith and Wilson 1996)

$$H' (\log 10) = -\sum_{i=1}^{s} (pi)(\log 10 pi)$$

Shannon Scaled = H'/H'max where H'max = Log10 of the maximum possible richness (Kintigh 2006)

$$1\text{-}D = 1 - \sum_{i=1}^{s} pi^2$$

(Keylock 2005)

$$E_{1\text{-}D} = \frac{(1-D)}{1-\frac{1}{S}}$$

where S is richness (Smith and Wilson 1996)

One_Over_D = 1/D

(Stiner and Munro 2002)

$$E_{1/D} = \frac{\left(\frac{1}{D}\right)}{S}$$

where S is richness (Smith and Wilson 1996)

$$J' = \frac{H'}{\ln(S)}$$

where S is richness (Smith and Wilson 1996)

$$\text{Simpson Estimate} = C = \frac{\Sigma (x_j (x_j - 1))}{((\Sigma x) * (\Sigma x - 1))}$$

(Kintigh 2006)

$$\text{Simpson Scaled} \quad \frac{1 - \sum_{i=1}^{s} pi^2}{1 - \left(\frac{1}{N}\right)}$$

where N is the maximum richness (Kintigh 2006)

$$E^{\mathrm{Var}} = 1 - 2/\pi \arctan \left\{ \sum_{i=1}^{s} \left(\ln(x_s) - \sum_{t=1}^{s} \ln(x_t)/S \right)^2 /S \right\}$$

(Smith and Wilson 1996)

Classification

Features were grouped into three general types discussed in Chapter 2: hearths, ovens, and dumps. Initially attempts were made to group features based on a number of classification schemes. Various dimensions were applied including presence or absence of evidence of in situ burning, presence or absence of thermally altered rock, location, size rank, level of boundary discreteness, and presence or absence of floral material. The occasionally incomplete nature of some feature information recorded in the feild, however, inevitably left features incompletely classified. Ultimately, the broadly defined three-way classification was settled upon. This classification was generally based on a parametric method using three basic dimensions:

1. Discrete/diffuse boundaries
2. Presence or absence of burned earth or clay
3. Presence or absence of floral material (except charcoal)

Features with incomplete field notes were placed in classes based on interpretations of photographs. Hearths have evidence of *in situ* burning and structural continuity with discrete boundaries. Ovens have evidence of plant processing (floral material present). Dumps have diffuse boundaries

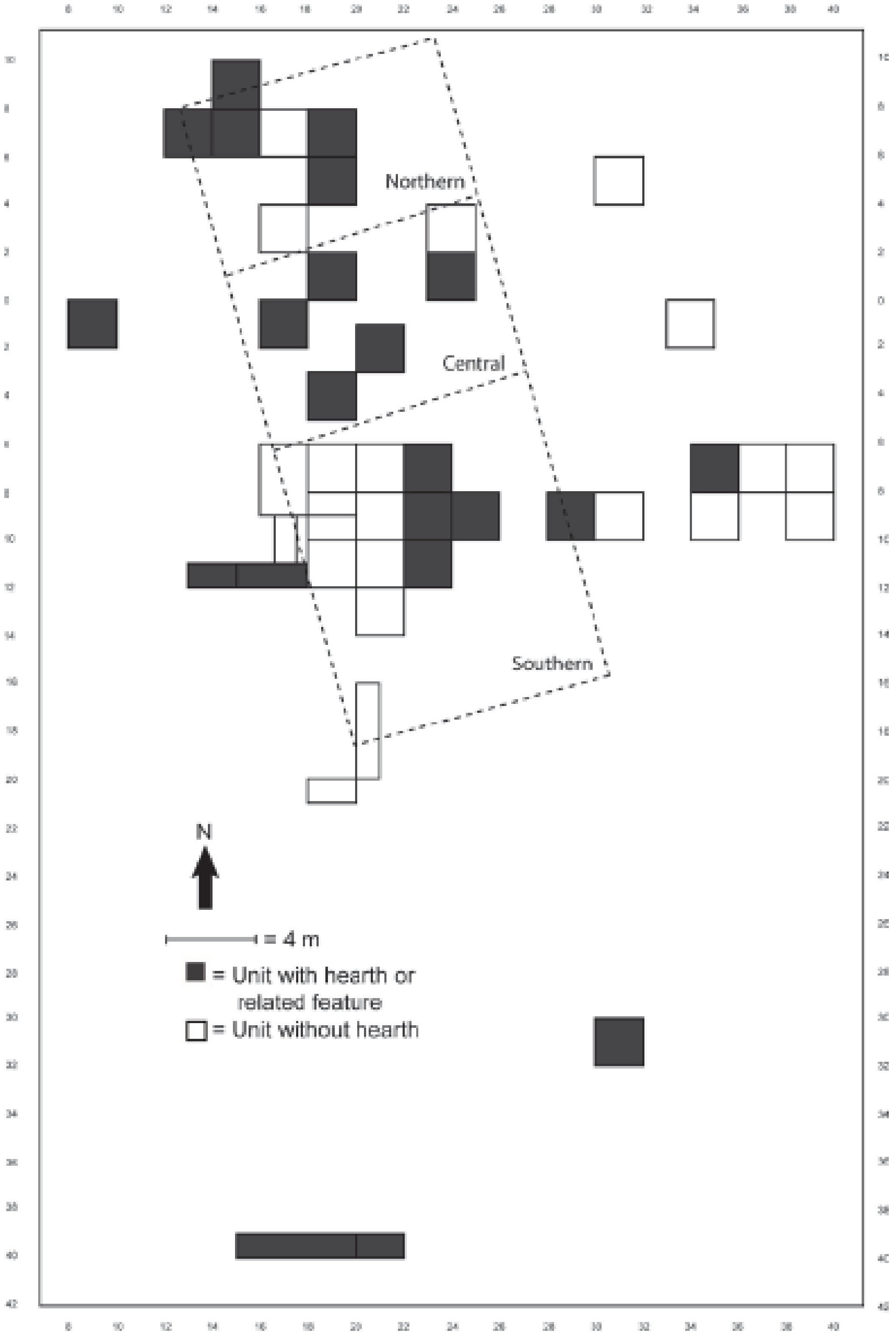

Figure 3.1. Meier excavation units included in sample.

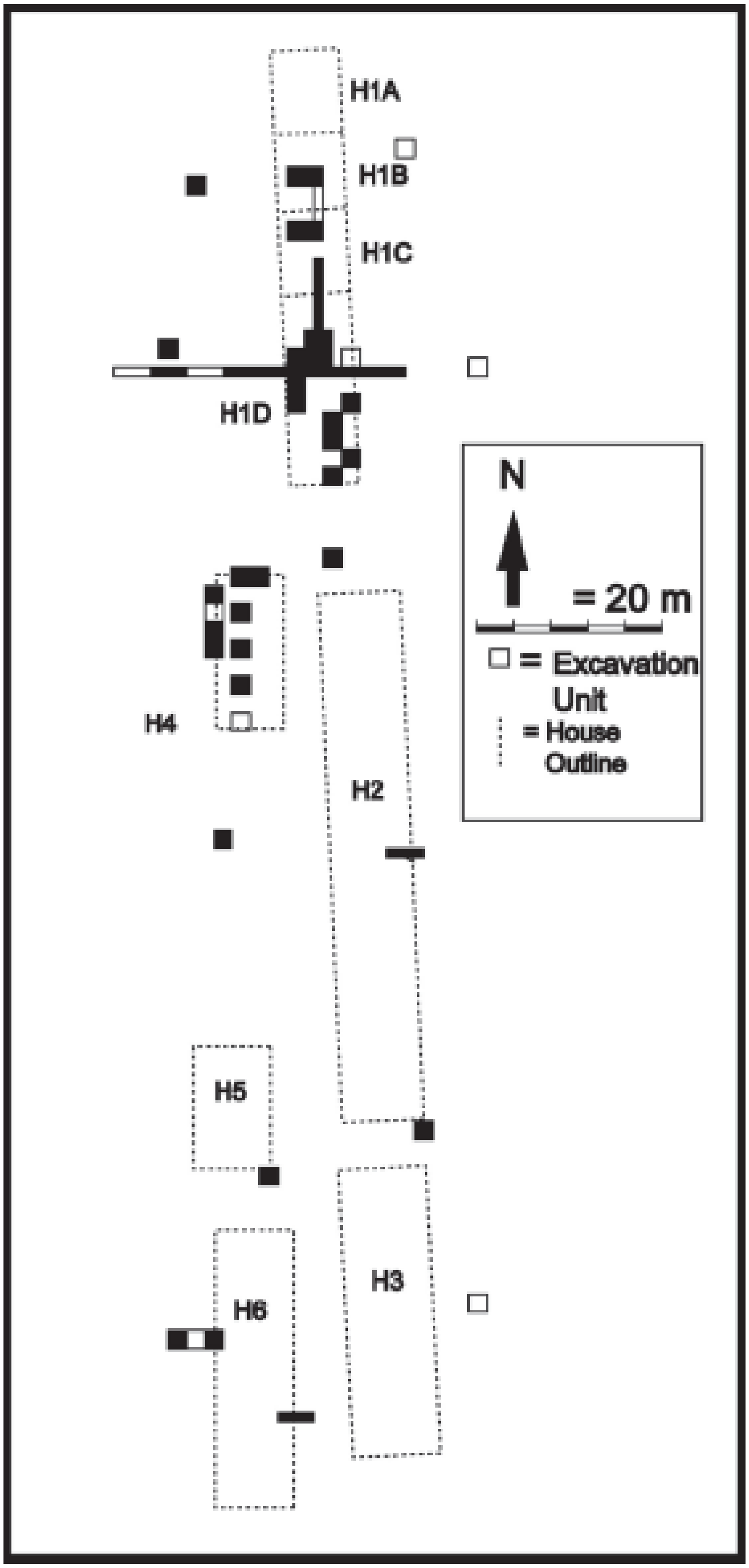

Figure 3.2. Cathlapotle excavation units included in sample.

and are lacking the formal coherence of shape and structure of hearths or ovens but may have similar compositions. For instance, in the field large chunks of bisque, irregularly shaped patches of ash and FCR, and fragments of hearth bowls were identified as dumps.

The Sample

The sites are described in some detail in Chapter 1. My study focuses on those excavation units that contained hearths, ovens, and/or dumps. Most excavation units have a surface area of 2m². The sample of excavation units defined by the presence of hearth, oven, and dump features includes all subdivisions of the sites. Figures 3.1 and 3.2 show excavation units included in the study. NISP totals for mammalian fauna were calculated for each excavation unit containing at least one hearth or related feature. For excavation units that contained both precontact and postcontact components, those levels that occupied each component (as determined by the presence or absence of historic period artifacts) were treated as separate analytical units (AU) in totaling NISP (Figure 3.3). For example, if a unit had ten levels, five each for precontact and postcontact, NISP for levels 1-5 was calculated and a separate calculation was made for levels 6-10 (thus splitting the excavation unit into two analytical units). This division into precontact and postcontact AU's was also used when calculating richness, diversity, and evenness measures. When assigning features to a temporal component, the same precontact/postcontact division was used. However, some features were situated such that they occupied both precontact and postcontact levels of an excavation unit. For this reason a third division was created, which I refer to as crossover.

Feature Measurements

Hearths, ovens, and dumps were measured using several different dimensions. First,

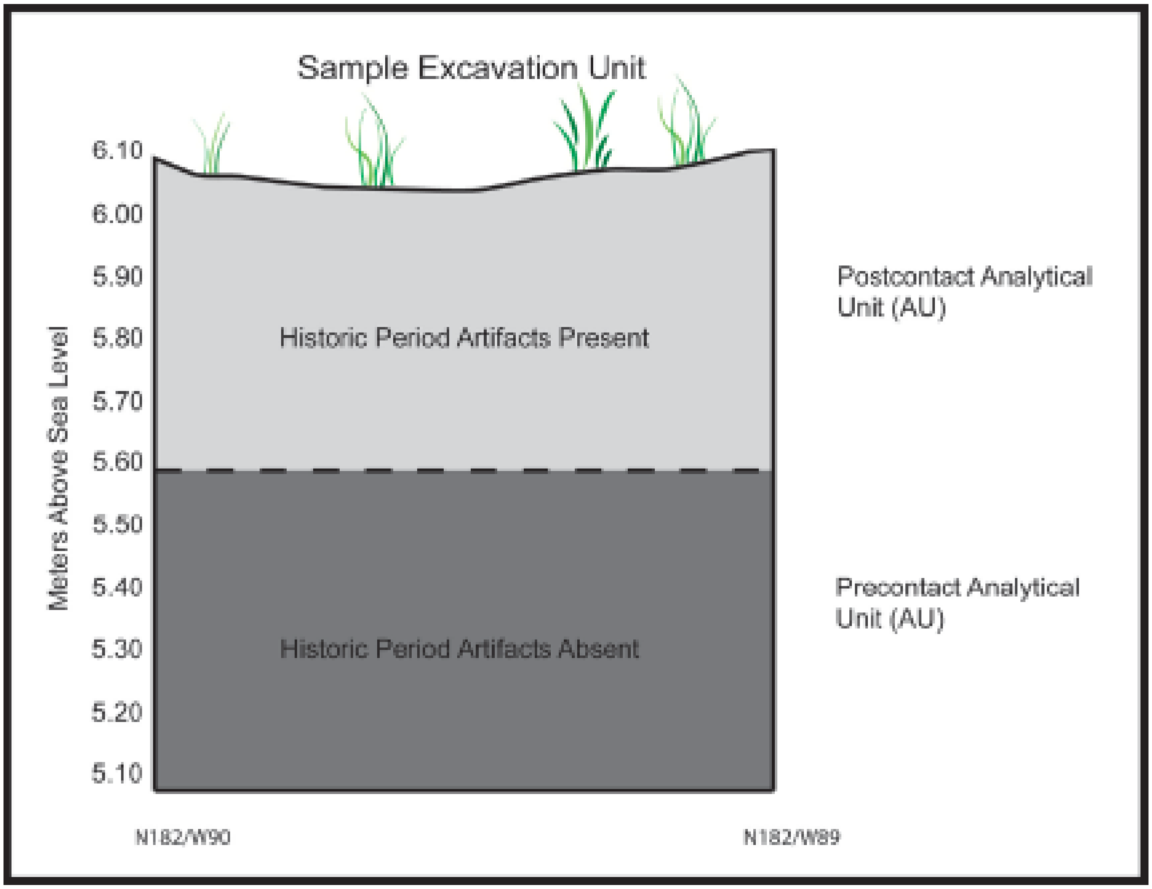

Figure 3.3. Example of separating an excavation unit into precontact and postcontact analytical units (AU's).

simple length, width, and depth measurements were recorded based on field measurements. Most features had measurements taken in the field; however, a number of features had either incomplete or missing measurements. A few had listed measurements that were inconsistent with other sources for the feature (i.e. maps, photos, notebooks, and other feature forms). Further, a few features' listed locations would have placed them well outside the unit in which they were found. In cases where there was a problem with the listed measurements, a good faith effort was made to determine the most likely measurements.

Often the exact shape of a given feature was impossible to determine from the available sources. Given the vagaries of post depositional forces, the original shape may well have been further obscured. It is generally assumed a hearth is a round to semi-round object in plan view, but the actual area occupied by these features cannot ultimately be determined. In order to bracket the range of possible variation in a way that is comparable between features a number of secondary measurements based on length, width, and thickness were calculated. These included feature diagonal measurement and several variations of area and volume.

For example, diagonal measurements were determined based on a simple application of the Pythagorean Theorem, where A = length, B = width, and C = the derived diagonal. In all likelihood this measurement is exaggerated. Thus, rather than being an absolute representation of reality, the measurement simply states that if one

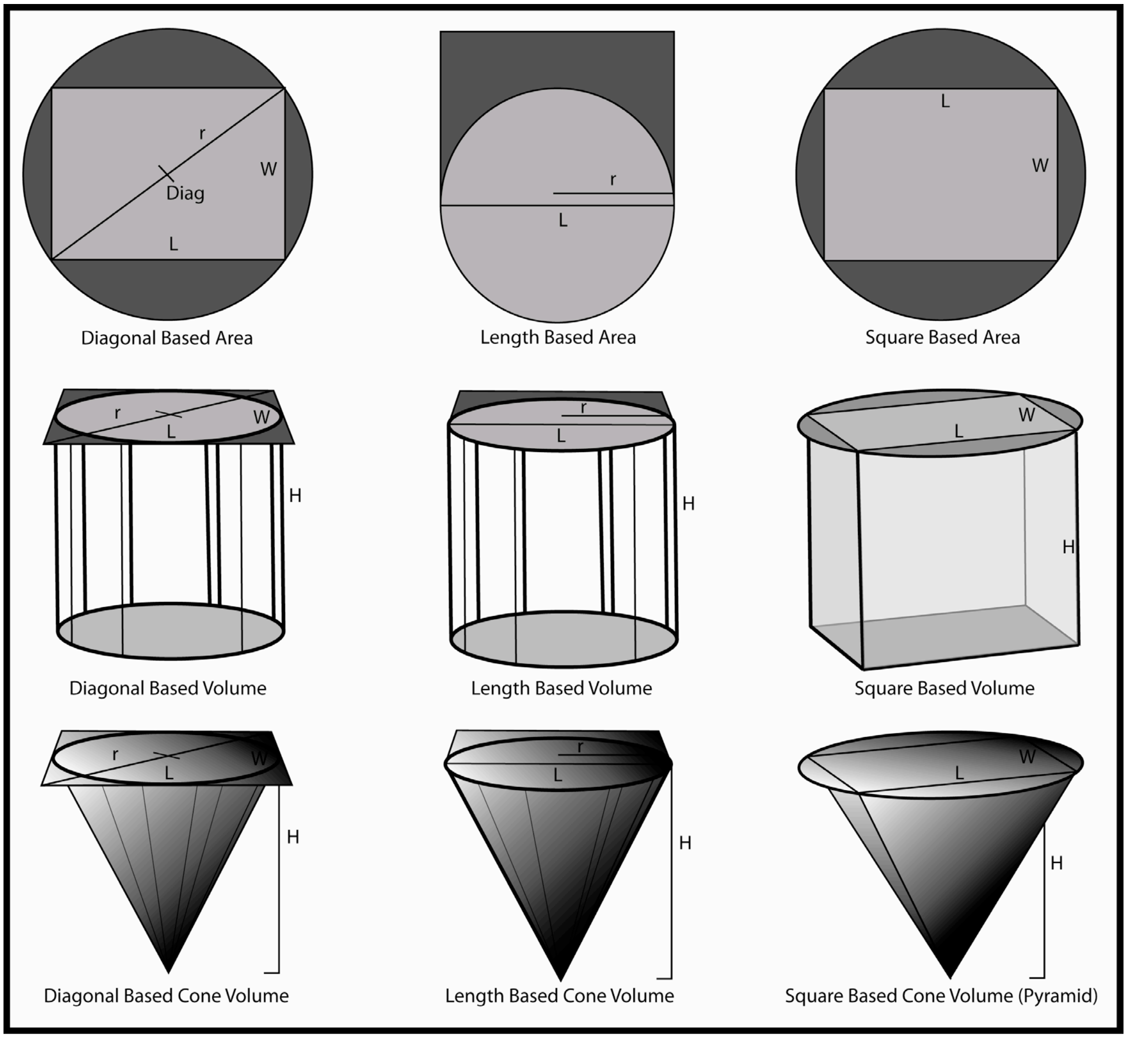

Figure 3.4. Idealized feature models showing dimensions used in estimating size.

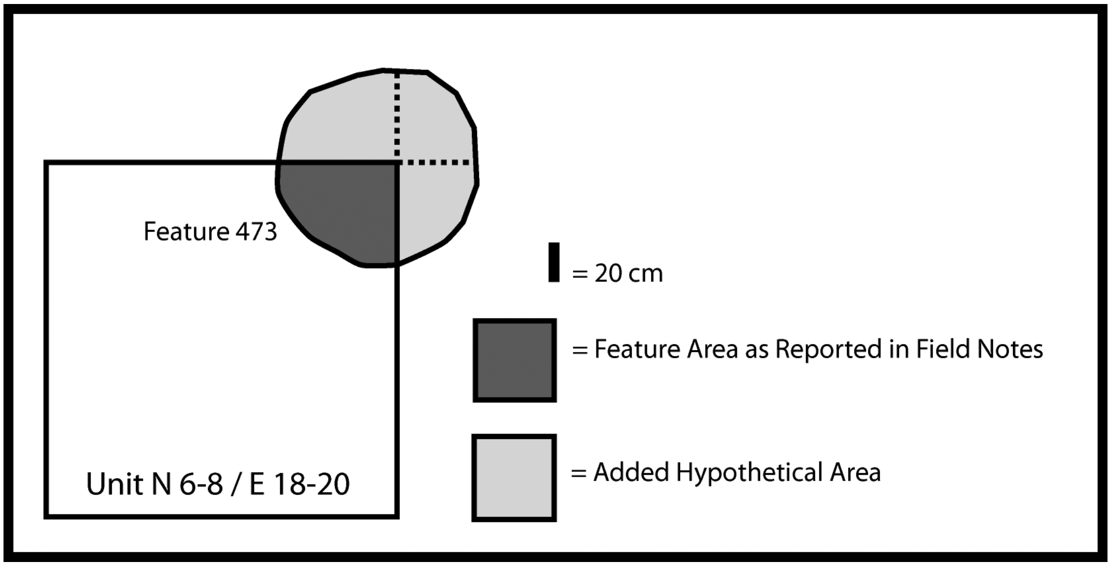

Figure 3.5. Meier Feature 473 excavated and estimated hypothetical area.

knows the first two measurements, the third can be derived and compared to other diagonal measurements calculated in the same manner.

Feature area was broken down in such a way as to create idealized features that were either circular in shape or square (Figure 3.3). Idealized circular shaped area was calculated using both the diagonal and length. Idealized square shaped measurements were simply calculated by multiplying length by width. One advantage of this method is that it tends to create a range of associated measurements with square shaped area at the low end, diagonally based area at the top, and length based circular shape coming very close to an average of the two. Feature volume was estimated exactly as area with the addition of a depth measurement (Figure 3.4). Despite the loosely used term "bowl" to describe the shape of many of these features in three dimensions, there is considerable variation. To capture at least part of that range of possible shapes two sets of volume measurements were calculated. One set of measurements was based on the feature having a perfectly flat bottom creating a cylinder or box shape. The second set of volume measurements idealized the feature as having a perfectly pointed bottom creating a cone or inverted pyramid shape.

Note that one could calculate area and volume to model features as semi-spherical objects. However, this third group of measurements would add little, occupying, as it does, a geometric middle ground between a cylinder and a cone. Again, the goal of these measurements was to attempt to bracket the potential range of feature area and volume. As such, the third option, while possibly appealing to one's mental image of what a hearth bowl should look like, would be redundant.

A potential complication quickly presented itself when calculating these measurements, namely that while some of the features were entirely present within the fully excavated areas of the sites, a great number of features were located at the edges of excavation units. This meant that anything from a few centimeters of likely surface area to a majority of the feature was located in unexcavated sediments next to the working unit.

Thus, hypothetical measurements were calculated to estimate the original size and locations of the features. These measurements follow exactly the form of the actual measurements described above, however additional distance was added to length and/or width measurements based on an examination of photos and unit maps. For example, Meier Feature 473 is located in the northwest corner of Unit N 6-8 / E 18-20 (Figure 3.5). Within the unit it forms a quarter section of a circle, with slightly more of the east/west axis present than the north/south. An assumption was made that what was found within the unit is representative of what is located in the surrounding unexcavated matrix. Therefore, what is missing to the north of the unit is approximately the same as what is present within the unit. Further, slightly less of the feature is missing to the east. In this case, .4 m was added to the east/west measurement and .5 m added to the north/south. This created a symmetrical feature, possibly unrealistically so. In many cases, however, the adjustments were not so “neat”. Ultimately, the goal was to consistently use the same rules for adjusting feature measurements to create hypothetical sizes and thereby create a set of metrics that were comparable.

Measures of Distribution

Many statistical tests assume a normal or near normal distribution (Shennan 1997). Those tests used in this study which have such requirements are discussed above. To test for normal distribution of feature measurements and faunal measures several statistical tests designed for the purpose were employed. These tests were used, for example, to test if the distribution of all hearth feature thicknesses at Meier were normally distributed. Or, as a second example, if the NISP for Elk found in postcontact contexts at Cathlapotle was normally distributed across excavation units. Specific tests conducted included one sample Kolmogorov-Smirnov Z, one sample Kolmogorv-Smirnov with a Lilliefors significance correction, and Shapiro-Wilk’s tests (Norušis 2006b) were calculated. These all essentially attempt to test distributions, however each has slightly different strengths. It has been my finding that the non-parametric Kolmogorov-Smirnov Z test tends to be more liberal in what it sees as normal and is able to test for other types of distributions. The Kolmogorov-Smirnov test with a Lilliefors correction is better for larger samples (Yazici and Yolacan 2007), and a Shapiro-Wilk test is, conversely, more accurate for smaller samples. Most feature measurements were not normally distributed. In order to achieve a normal distribution, a requirement for many standard statistical tests as noted above, Log10 transformations were calculated for all measurements. This allowed both non-parametric and parametric tests to be run.

Table 3.1. Feature Counts for Meier and Cathlapotle.

	Cathlapotle		Meier		Total	
Type	Count	%	Count	%	Count	%
Dump	40	30.53	18	37.50	58	32.40
Hearth	80	61.07	30	62.50	110	61.45
Oven	11	8.40	0	.00	11	6.15
Total	131	100.00	48	100.00	179	100.00

CHAPTER 4
RESULTS: FEATURE MEASUREMENT ANALYSES

Introduction

This chapter presents results of analyses of feature size. A total of 179 hearth and related features were found at these two sites (Table 3.1). Table 3.2 lists summary statistics for features from both sites based on field measurements. As noted in Chapter 1, the sites have been subdivided for analysis. Hearth features were found in all subdivisions of both sites. Sizes range from very small to over a meter in diameter. Based on the analyses that follow several patterns were found. First, at Meier different sections of the house were associated with feature size, a pattern not present at Cathlapotle. Third, ovens present at Cathlapotle were generally larger than either hearths or dumps. Fourth, Meier features were, in general, slightly smaller than those at Cathlapotle. Fifth, precontact features at both sites tended to be larger than postcontact features.

Meier

Table 3.3 summarizes the number of hearths and dumps at Meier for each temporal component and location at the site. No ovens were identified at Meier in the course of field excavations (Table 3.1). Careful review of field forms did not indicate the presences of floral material in any exterior hearths. It is possible that ovens are present and were simply missed in the course of sampling. Hearths are present in the northern section of the house only in the postcontact. The central section also lacks strictly precontact hearths, however five were identified in levels that crossover between precontact and postcontact.

Table 3.4 summarizes the thickness and estimated hypothetical measures for all Meier features[1]. A summary of the method used in calculating these is presented in Chapter 3. Of all measurements based on field notes from Meier, only width appears to be normally distributed based on a Kolmogorov-Smirnov Z test for all features (Z = 8.11, p = .527, where a significance value of less than .05 indicates a non-normal distribution). However, a Shapiro-Wilk and a Kolmogorov-Smirnov test with a significance correction contradicted this result. An examination of histograms for the measurements revealed width to have a bimodal distribution (Figure 3.6). Length and diagonal both have long right tails, and depth is somewhat random in its distribution. When hearths and dumps were looked at separately, all measurements for both types were normally distributed using a nonparametric Kolmogorov-Smirnov Z test. Again, however, this is questionable, with Shaprio-Wilk contradicting these results. Examination of histograms suggests slightly bimodal distributions.

This pattern was essentially reproduced for hypothetically derived measurements when a one sample Kolmogorov-Smirnov test was used. When hearths and dumps were looked at together, hypothetical length, hypothetical width, and hypothetical diagonal appear to be normally distributed. When looking at hearths alone, hypothetical area measurements also appear to be normally distributed. All hypothetical measurements for

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[1] Estimated hypothetical measurements (along with actual thickness) will generally be used in summary tables. As noted in Chapter 3, field measurements often only captured a portion of a feature's actual size. The hypothetical measurements are more directly comparable.

Table 3.2. Summary Statistics for Field Measurements by Site and Feature Type in Meters.

Site	Type	Measure	N	Mean	Standard Deviation	Coefficient of Variation	Median	Min	Max
Cathlapotle	Dump	Length	40	.59	.30	.50	.48	.16	1.42
		Width	40	.35	.21	.60	.30	.07	1.00
		Depth	40	.16	.13	.81	.12	.02	.65
	Hearth	Length	80	.74	.40	.54	.69	.13	2.00
		Width	80	.45	.27	.60	.40	.04	1.20
		Depth	80	.15	.14	.91	.13	.02	.85
	Oven	Length	11	.88	.34	.38	.82	.22	1.40
		Width	11	.52	.23	.44	.45	.20	.82
		Depth	11	.24	.10	.39	.27	.09	.43
Meier	Dump	Length	18	.61	.39	.65	.56	.08	1.60
		Width	18	.41	.22	.53	.38	.12	1.00
		Depth	18	.10	.11	1.07	.07	.02	.50
	Hearth	Length	30	.67	.47	.70	.55	.15	2.00
		Width	30	.41	.23	.56	.36	.12	1.00
		Depth	30	.16	.11	.68	.13	.05	.45
Combined	Dump	Length	58	.60	.33	.55	.51	.08	1.60
		Width	58	.37	.21	.58	.31	.07	1.00
		Depth	58	.14	.12	.88	.11	.02	.65
	Hearth	Length	110	.72	.42	.58	.63	.13	2.00
		Width	110	.44	.26	.59	.40	.04	1.20
		Depth	110	.15	.13	.84	.13	.02	.85
	Oven	Length	11	.88	.34	.38	.82	.22	1.40
		Width	11	.52	.23	.44	.45	.20	.82
		Depth	11	.24	.10	.39	.27	.09	.43

N = number of features of each type

Table 3.3. Number of Hearths and Dumps at Meier by Temporal Component and Association.

		Component					
		Crossover	Postcontact		Precontact		Total
Association		Hearth	Dump	Hearth	Dump	Hearth	
Central	Count	5	2	4	0	0	11
	%	45.45	18.18	36.36	.00	.00	100.00
Exterior	Count	1	0	0	3	3	7
	%	14.29	.00	.00	42.86	42.86	100.00
Midden	Count	0	0	0	0	1	1
	%	.00	.00	.00	.00	100.00	100.00
North	Count	0	8	6	4	0	18
	%	.00	44.44	33.33	22.22	.00	100.00
South	Count	2	1	8	0	0	11
	%	18.18	9.09	72.73	.00	.00	100.00

Table 3.4. Summary Statistics of Feature Thickness and Estimated Hypothetical Measurements from Meier.

Type	Measure	N	Mean	Standard Deviation	Coefficient of Variation	Median
Dump	Thickness	18	.10	.11	1.07	.07
	Hypothetical Length	18	.74	.46	.62	.58
	Hypothetical Width	18	.57	.32	.56	.52
	Hypothetical Diagonal	18	.96	.51	.54	.75
	Hypothetical Diagonal Area	18	.91	.85	.93	.44
	Hypothetical Length Area	18	.58	.66	1.15	.26
	Hypothetical Square Area	18	.50	.46	.93	.27
	Hypothetical Diagonal Volume	18	.10	.13	1.24	.04
	Hypothetical Length Volume	18	.07	.10	1.52	.02
	Hypothetical Square Volume	18	.05	.06	1.16	.02
	Hypothetical Diag. Cone Volume	18	.03	.04	1.24	.01
	Hypothetical Length Cone Volume	18	.02	.03	1.52	.01
	Hypothetical Square Cone Volume	18	.02	.02	1.16	.01
Hearth	Thickness	30	.16	.11	.68	.13
	Hypothetical Length	30	.77	.47	.61	.62
	Hypothetical Width	30	.59	.40	.68	.47
	Hypothetical Diagonal	30	1.00	.60	.60	.83
	Hypothetical Diagonal Area	30	1.05	1.31	1.24	.54
	Hypothetical Length Area	30	.63	.78	1.25	.30
	Hypothetical Square Area	30	.61	.80	1.31	.32
	Hypothetical Diagonal Volume	30	.23	.39	1.71	.06
	Hypothetical Length Volume	30	.13	.22	1.64	.04
	Hypothetical Square Volume	30	.13	.25	1.84	.04
	Hypothetical Diag. Cone Volume	30	.08	.13	1.71	.02
	Hypothetical Length Cone Volume	30	.04	.07	1.64	.01
	Hypothetical Square Cone Volume	30	.04	.08	1.84	.01
Total	Thickness	48	.14	.11	.80	.10
	Hypothetical Length	48	.76	.46	.61	.61
	Hypothetical Width	48	.58	.37	.63	.49
	Hypothetical Diagonal	48	.98	.56	.57	.79
	Hypothetical Diagonal Area	48	1.00	1.15	1.15	.49
	Hypothetical Length Area	48	.61	.73	1.20	.29
	Hypothetical Square Area	48	.57	.69	1.21	.29
	Hypothetical Diagonal Volume	48	.18	.33	1.78	.06
	Hypothetical Length Volume	48	.11	.18	1.70	.04
	Hypothetical Square Volume	48	.10	.20	1.94	.03
	Hypothetical Diag. Cone Volume	48	.06	.11	1.78	.02
	Hypothetical Length Cone Volume	48	.04	.06	1.70	.01
	Hypothetical Square Cone Volume	48	.03	.07	1.94	.01

Area measurements in m^2. Volume measurements in m^3. Methodology for estimating hypothetical measurements described in Chapter 3.

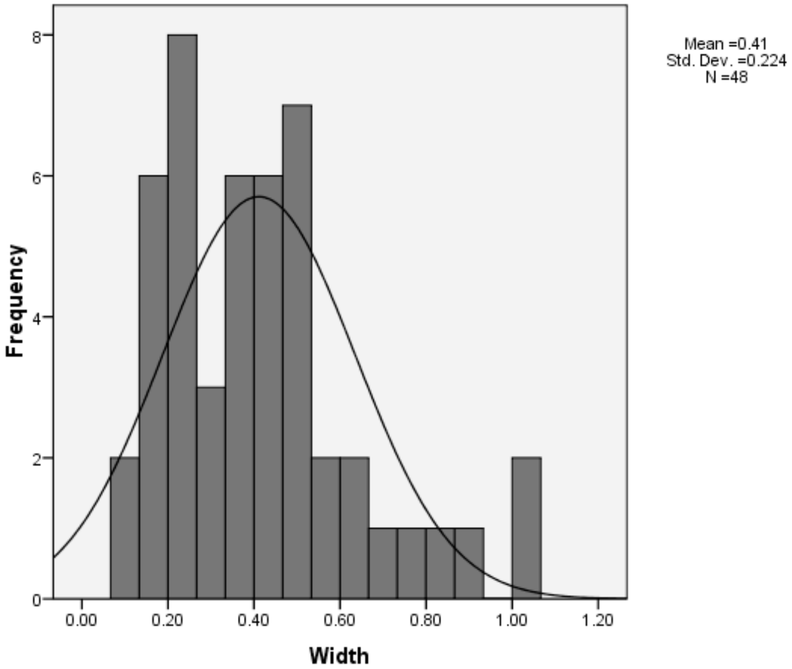

Figure 3.6. Histogram of feature width for all features at Meier with frequencies by number of excavation units.

dumps appear normally distributed. When significance correction was used and/or a Shapiro-Wilk test, the results tended to show non-normal distributions. Thus, while some of the measurements were at least statistically normally distributed, enough were either marginally normally distributed or not at all that it seemed prudent to generate Log10 transformations of the measurements. These transformations did indeed successfully normalize measurements for hearths and dumps separately and when considered together.

There was no significant[2] difference in measurements between hearths and dumps at Meier with the exception of feature thickness or depth. A Mann-Whitney U test showed significant differences between hearth and dump thickness using actual measurements (Z =- 2.38, *p* = .017). A t-test run on log10 transformed measures also showed significant differences (t = -2.58, *p* = .011). Interestingly, a non-parametric two-sample Kolmogorov-Smirnov test run on actual measurements contradicted these results (Z = 1.155, *p* = .139). Examination of histograms and boxplots shows that the determining factors in this were one or two (in the case of log transformed values) dump outliers which altered the overall distribution. One of these features (F 318) is an irregularly shaped concentration of ash, clay, and charcoal in unit S 3-5 / E 18-20. Although diminutive in size, it is unusually thick. The feature probably extended somewhat lower than its given measurements, which coincide with the lowest excavation depth for the unit. At lower elevations this feature runs along one wall of a pit feature that also terminates somewhat lower than the lowest excavation depth for the unit. As Feature 318 starts somewhat higher than the pit feature and at its far western side, it is possible that a portion of the dump simply slumped over into the pit giving the feature its unusual vertical dimension. At the other extreme is Feature 366, a shallow lens of ash, charcoal, and shell. This feature is located in unit N 6-8 / E 14-16, the far northwest corner of the house. The feature is located in an area where there is evidence

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[2] In this report there are many instances where large groups of variables are being tested. Reporting complete results of these tests would be unwieldy often without actually adding value. To streamline reporting of the results I have often resorted to summarizing multiple test results with a few words. When I do this the language used is precise. I use the word *significant* specifically in the statistical sense of the word referring to *p* values of equal to or less than .05. For clarity, the word *significant* will not be used in the sense of important or unusual ever.

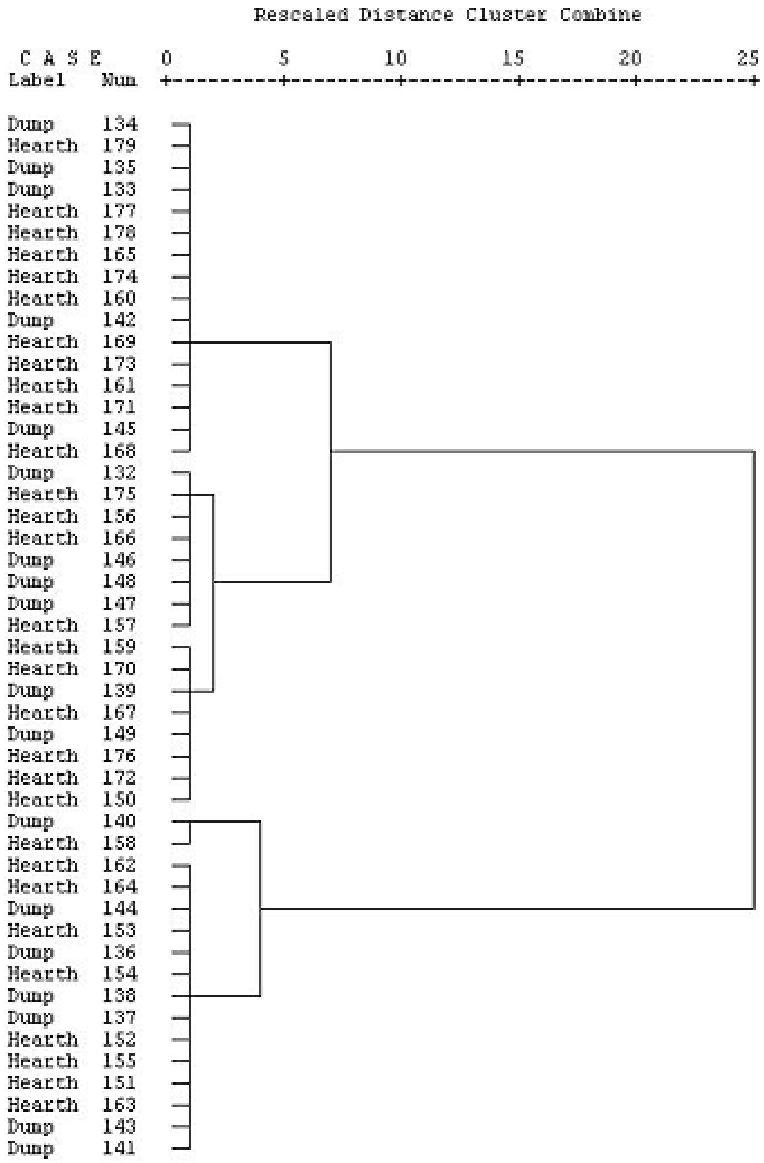

Figure 3.7. Dendrogram based on Ward's method hierarchical cluster analysis of Meier log10 transformed measurements of hearths and dumps.

of the north house wall being moved at least once. The unit has two other dump features at approximately the same unit depth. It is possible Feature 366 is a remnant of a larger feature (possibly along with one or both of these other dump features) that was disturbed by wall resetting leaving only an edge of the dump. This would account for its relatively narrow profile.

A simple cluster analysis, using log10 transformed linear measurements and volumes, was computed to see if Meier hearths and dumps group in any fashion. Hearths and dumps were treated as being the same in initial investigations then considered separately. Ward's method and average-link analysis were used to test for grouping and outliers. These two methods emphasize different aspects of group behavior with the former attempting to draw out differences between group and the latter similarities.

Ward's method produced slightly cleaner results in this case than the average-link algorithm (Figure 3.7). An examination of a dendro-

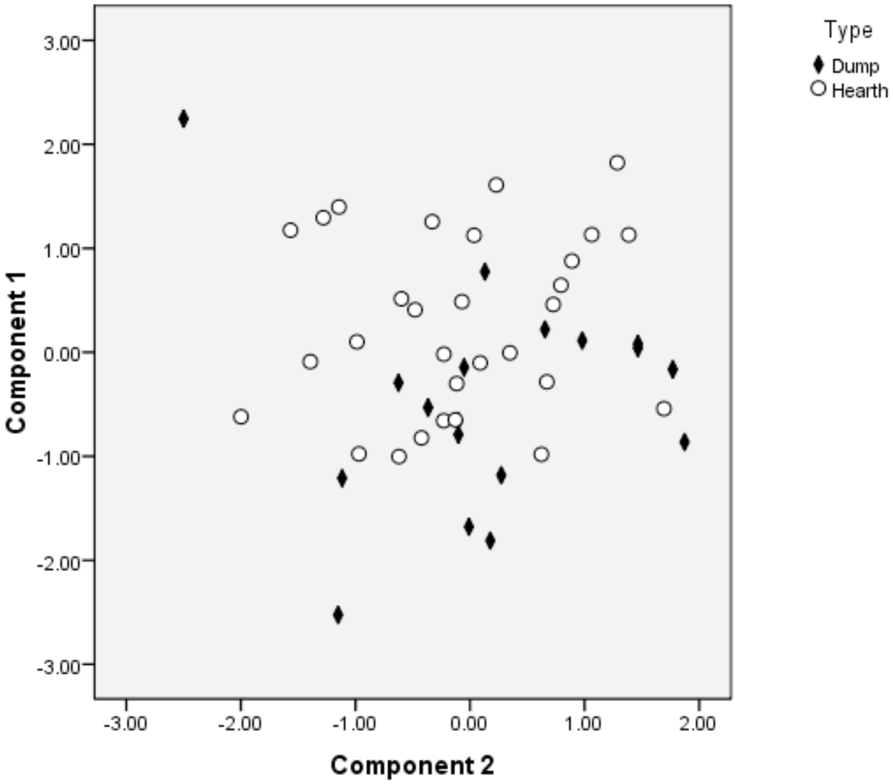

Figure 3.8. Principle component analysis based on log10 measurements with markers representing feature type.

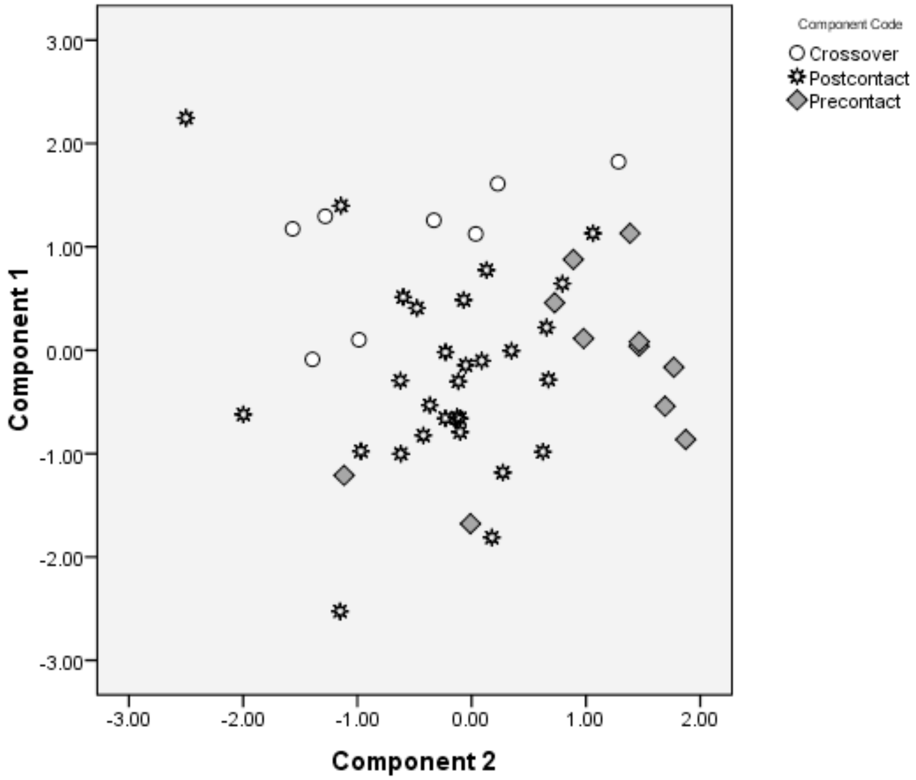

Figure 3.9. Principle component analysis based on log10 measurements with markers representing temporal component.

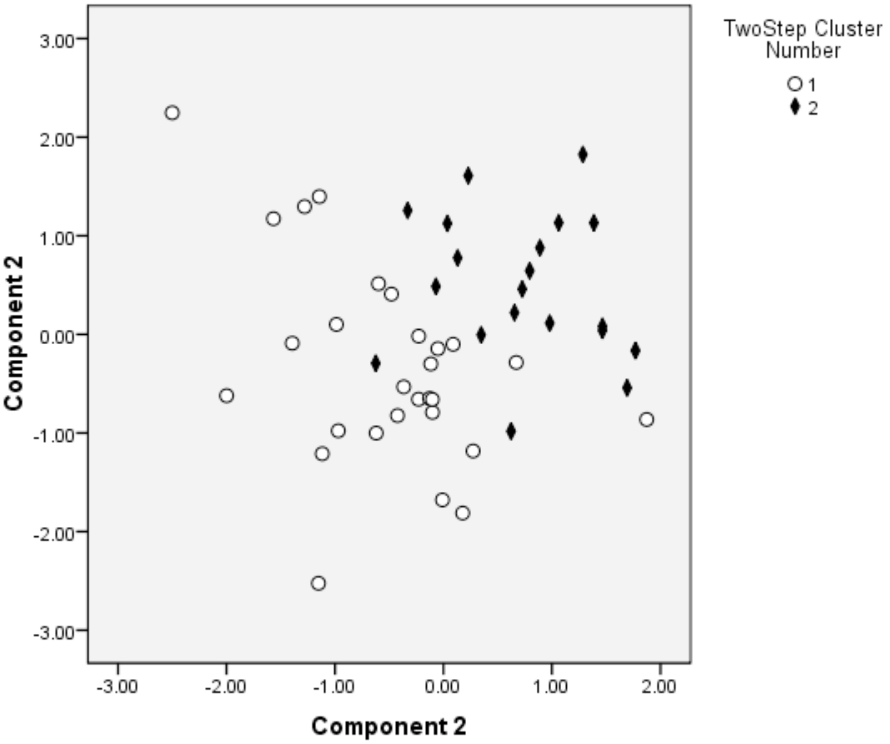

Figure 3.10. Principle component analysis based on log10 measurements with markers representing results of two-step cluster analysis.

gram showed no obvious outliers with two larger clusters and five sub-clusters. The algorithm produced several possible solutions creating between three and five groupings. A three cluster solution produced clusters with equal numbers of cases. Solutions with four and five clusters indicated two possible outliers, Features 292 and 366. An examination of a dendrogram produced using an average-linkage method also indicated these two features are possible outliers. Feature 366 is discussed above. Feature 292 is a hearth with an unusually short length measurement which may be a portion of a larger nearby hearth (F 303), but which has been disturbed by some process. However, the exclusion of these two features had little apparent effect on subsequent tests, and they are therefore left in for the remainder of this section.

A principle component analysis with varimax rotation was conducted using all Log10 transformed measures for all features combined. Two components produced by the test captured 92.6% of variance. Feature thickness was heavily weighted on the first component. Hypothetical volume measures were weighted on the second component.

The PCA was able to separate out dumps and hearths fairly well, with dumps largely limited to lower right portion of a scattergram based on the first two components (Figure 3.8). More importantly, temporal components were largely separated out into three groups (Figure 3.9). Within this pattern features that occupy both precontact and postcontact levels (crossover) tend to align with postcontact features.

A two-step cluster analysis was carried out using all categorical variables and all continuous data. The final solution produced two clusters. Only Interior/Exterior of the categorical variables had a significant impact on the final result. Of the continuous variables, only length was not part of the final solution. When graphed against the first two components of the PCA (Figure 3.10), one finds cluster 2 occupies approximately the same portion of the graph as the precontact features in Figure 3.9.

When compared against temporal components, the discriminant analysis, using only log-transformed measurements, built a model – based on a 65% sample of features – in which 78.8%

Table 3.5. Summary Statistics of Estimated Hypothetical Volumes for all Meier Features by Temporal Component.

Component	Measure	N	Mean	Standard Deviation	Coefficient of Variation	Median
Crossover	Hyp. Diagonal Volume	8	.31	.38	1.22	.14
	Hyp. Length Volume	8	.17	.24	1.42	.06
	Hyp. Square Volume	8	.17	.23	1.35	.05
	Hyp. Diag. Cone Volume	8	.10	.12	1.22	.04
	Hyp. Length Cone Volume	8	.06	.08	1.42	.02
	Hyp. Square Cone Volume	8	.06	.08	1.35	.02
Postcontact	Hyp. Diagonal Volume	29	.09	.13	1.38	.05
	Hyp. Length Volume	29	.06	.09	1.50	.03
	Hyp. Square Volume	29	.05	.07	1.36	.02
	Hyp. Diag. Cone Volume	29	.03	.04	1.38	.02
	Hyp. Length Cone Volume	29	.02	.03	1.50	.01
	Hyp. Square Cone Volume	29	.02	.02	1.36	.01
Precontact	Hyp. Diagonal Volume	11	.32	.54	1.67	.19
	Hyp. Length Volume	11	.19	.28	1.52	.10
	Hyp. Square Volume	11	.20	.34	1.72	.12
	Hyp. Diag. Cone Volume	11	.11	.18	1.67	.06
	Hyp. Length Cone Volume	11	.06	.09	1.52	.03
	Hyp. Square Cone Volume	11	.07	.11	1.72	.04
Total	Hyp. Diagonal Volume	48	.18	.33	1.78	.06
	Hyp. Length Volume	48	.11	.18	1.70	.04
	Hyp. Square Volume	48	.10	.20	1.94	.03
	Hyp. Diag. Cone Volume	48	.06	.11	1.78	.02
	Hyp. Length Cone Volume	48	.04	.06	1.70	.01
	Hyp. Square Cone Volume	48	.03	.07	1.94	.01

Measurements in m . Methodology for estimating hypothetical measurements discussed in Chapter 3. N = number of features within a component.

of sampled features were placed into the correct component. 66.7% of unselected features were correctly grouped when the model was applied to them. Cross-validation produced models that correctly identified features 57.6% of the time.

A t-test was carried out to look for what measurements might explain this clustering. Only log transformed measurements were used. Significant differences between precontact and postcontact were found in hypothetical area measurements and square volumes (*df* = 38, $p < .05$). In general, precontact features, when all were combined, tended to be larger than those in postcontact levels (Table 3.5).

A second pattern also emerged in the course of exploring the data in this way. Features in the northern section of the Meier house tend to group with those in the central section of the house, while those features in the southern section of the house tended to group with exterior hearths. This is evident when looking at the grouping formed using a two-step cluster analysis and PCA (Figures 3.11 and 3.12). Exterior and southern features tended to be larger in all dimensions than northern and, to a lesser extent, central features (Table 3.6).

A discriminant analysis also points to this spatial pattern. Using all cases, the analysis generated a model in which 66.7% of the features were grouped into the correct house location, with 47.9% of cases correctly grouped using cross-validation. These numbers dipped slightly when

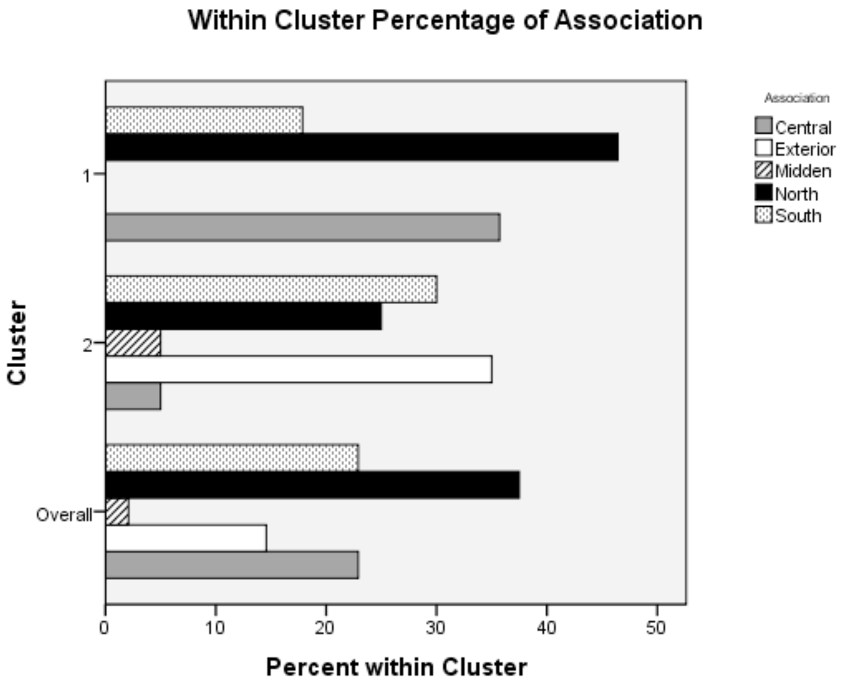

Figure 3.11. Bar chart showing percentage of features from each Meier site association grouped into two groups as defined by a two-step cluster analysis.

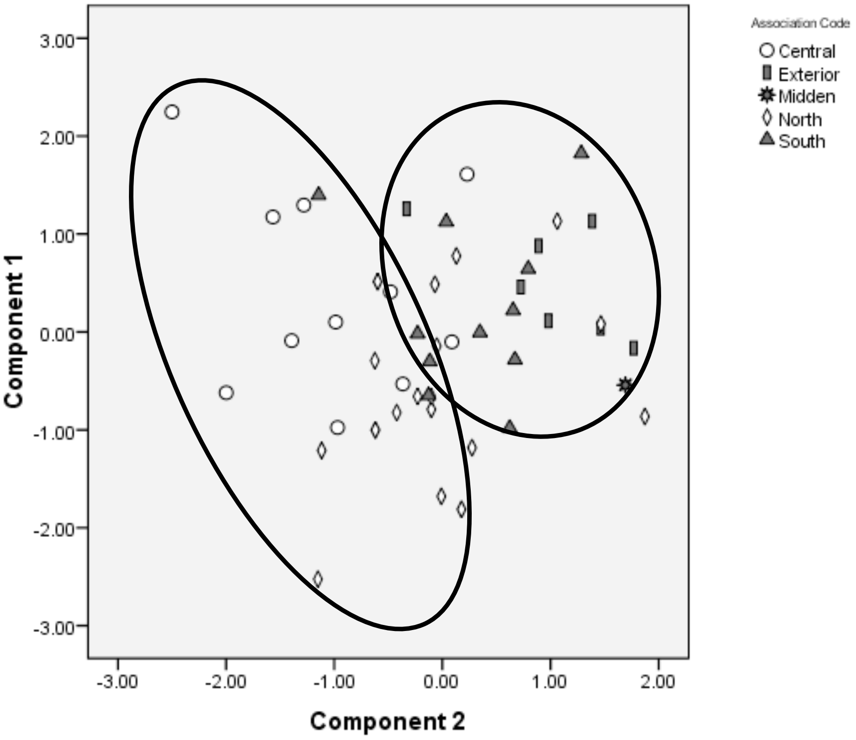

Figure 3.12. First two components of PCA based on log transformed measures marked by house association. Circles around north-central group and south-exterior group.

Table 3.6. Summary Statistics of Estimated Hypothetical Volumes for all Meier Features by Association.

Association	Statistic	N	Hyp. Diagonal Volume	Hyp. Length Volume	Hyp. Square Volume	Hyp. Diag. Cone Volume	Hyp. Length Cone Volume	Hyp. Square Cone Volume
Central	Mean	11	.13	.08	.07	.04	.03	.02
	Std. Dev.		.29	.20	.17	.10	.07	.06
Exterior	Mean	7	.49	.28	.30	.16	.09	.10
	Std. Dev.		.63	.32	.40	.21	.11	.13
Midden	Mean	1	.09	.05	.06	.03	.02	.02
	Std. Dev.		.	.	.	.	.	.
North	Mean	18	.09	.06	.04	.03	.02	.01
	Std. Dev.		.15	.11	.07	.05	.04	.02
South	Mean	11	.20	.10	.12	.07	.03	.04
	Std. Dev.		.23	.09	.14	.07	.03	.05
Total	Mean	48	.18	.11	.10	.06	.04	.03
	Std. Dev.		.33	.18	.20	.11	.06	.07

Measurements in m^3. Methodology for estimating hypothetical measurements presented in Chapter 3.

a 65% sample was used to create the model. In this case 63.6% of sampled cases were correctly grouped, 46.7% of cases that were left out during the creation of the model, and only 30.3% were correctly grouped using cross-validation. This implies that while there is some underlying structure present, it is not particularly robust. However, a graph of the first two discriminant functions does appear to support the idea that north/central house features group together and south/exterior house features group (Figure 3.13).

In summary, at Meier various analyses point to three possible conclusions. First, hearths and dumps are largely similar in size. Second, a difference can be identified between precontact and postcontact periods, with precontact features generally being larger than postcontact. Third, features in northern and central sections of the house tend to group together while southern and exterior features form a second group. Northern and central features tended to be smaller than southern and exterior features. These patterns can be seen in broad strokes when plotting groups based on a Ward's method cluster analysis against PCA Components 1 and 2. In Figure 3.14 cluster 1 covers approximately the same territory as the second cluster as determined by the two-step cluster analysis. These features are located either in the southern section of the house or in exterior units. Features in cluster 2 are all interior hearths, and all but one are either in the northern or central section. Features in cluster 3 are all interior and seem to be evenly mixed between house sections.

Cathlapotle

Table 3.7 summarizes basic statistics for thickness and estimated hypothetical measurements at Cathlapotle for hearth and related features. It is important to note one of the main differences between Cathlapotle and Meier is the presence of ovens at Cathlapotle. All ovens were found in units outside the houses at the site except for one small oven in house 4. Initial exploration of the measurements of Cathlapotle features showed,

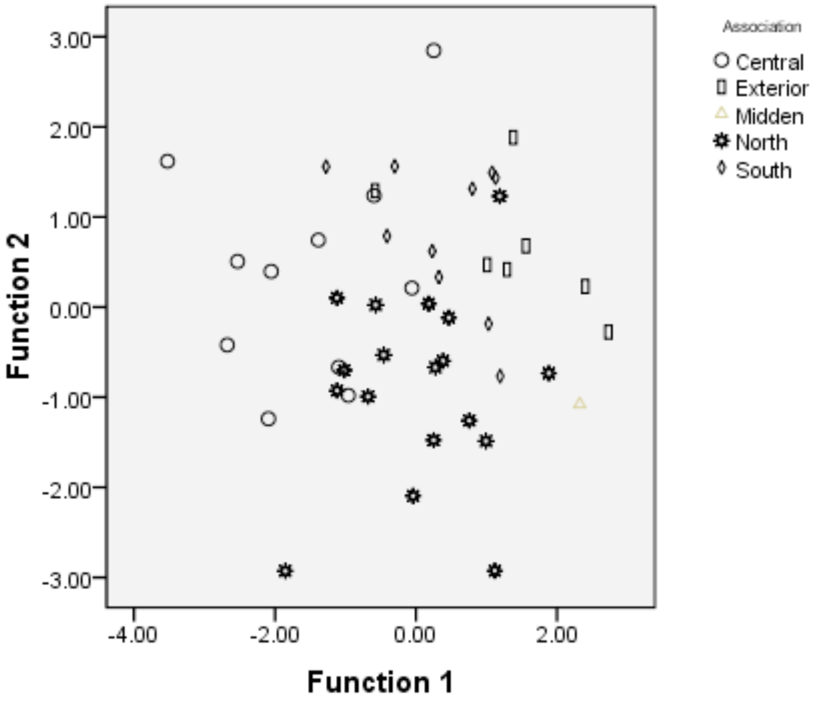

Figure 3.13. Plot of first two functions of discriminant analysis based on log transformed measurements of features from Meier showing group centroids (as defined by the DA).

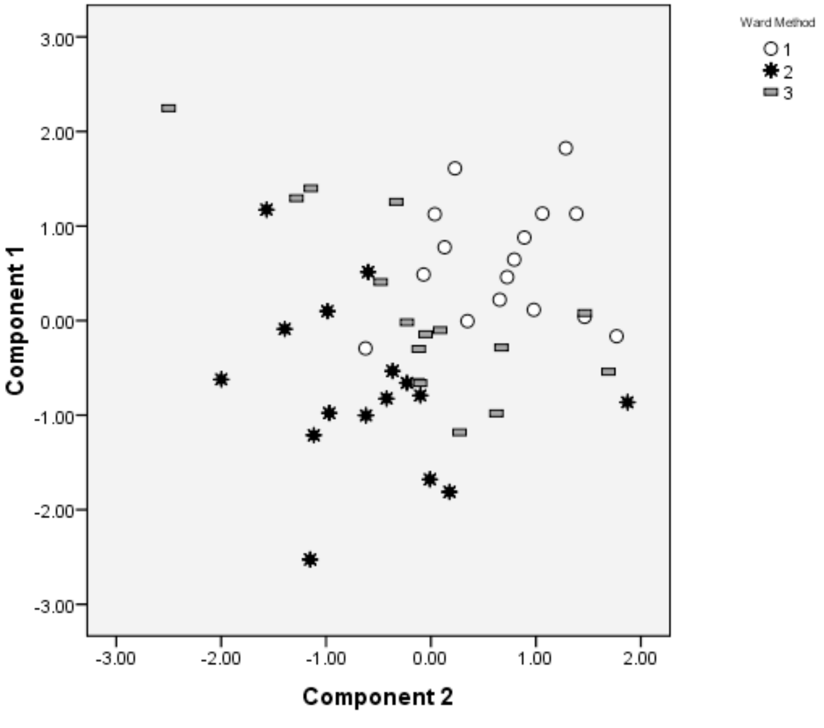

Figure 3.14. Components 1 and 2 based on PCA of all log transformed measurements marked by a three group solution Ward's method cluster analysis for Meier features.

Table 3.7. Summary Statistics of Thickness and Estimated Hypothetical Measurements of Cathlapotle Features.

Type	Measure	N	Mean	Standard Deviation	Coefficient of Variation	Median
Dump	Thickness	40	.16	.13	.81	.12
	Hypothetical Length	40	.72	.45	.62	.60
	Hypothetical Width	40	.50	.35	.70	.42
	Hypothetical Diagonal	40	.89	.55	.62	.77
	Hypothetical Diagonal Area	40	.85	1.10	1.29	.46
	Hypothetical Length Area	40	.56	.74	1.31	.28
	Hypothetical Square Area	40	.49	.66	1.36	.25
	Hyp. Diagonal Volume	40	.14	.25	1.82	.05
	Hyp. Length Volume	40	.08	.15	1.73	.04
	Hyp. Square Volume	40	.08	.16	1.90	.03
	Hyp. Diag. Cone Volume	40	.05	.08	1.82	.02
	Hyp. Length Cone Volume	40	.03	.05	1.73	.01
	Hyp. Square Cone Volume	40	.03	.05	1.90	.01
Hearth	Thickness	80	.15	.14	.91	.13
	Hypothetical Length	80	.85	.46	.54	.81
	Hypothetical Width	80	.61	.37	.60	.55
	Hypothetical Diagonal	80	1.06	.56	.53	1.06
	Hypothetical Diagonal Area	80	1.13	1.16	1.03	.88
	Hypothetical Length Area	80	.73	.76	1.04	.52
	Hypothetical Square Area	80	.65	.70	1.07	.40
	Hyp. Diagonal Volume	80	.19	.27	1.42	.10
	Hyp. Length Volume	80	.12	.18	1.43	.06
	Hyp. Square Volume	80	.11	.16	1.47	.05
	Hyp. Diag. Cone Volume	80	.06	.09	1.42	.03
	Hyp. Length Cone Volume	80	.04	.06	1.43	.02
	Hyp. Square Cone Volume	80	.04	.05	1.47	.02
Oven	Thickness	11	.24	.10	.39	.27
	Hypothetical Length	11	1.00	.34	.34	1.02
	Hypothetical Width	11	.78	.27	.35	.81
	Hypothetical Diagonal	11	1.27	.42	.33	1.32
	Hypothetical Diagonal Area	11	1.40	.72	.51	1.36
	Hypothetical Length Area	11	.87	.47	.54	.82
	Hypothetical Square Area	11	.85	.44	.52	.86
	Hyp. Diagonal Volume	11	.34	.26	.77	.22
	Hyp. Length Volume	11	.21	.17	.80	.15
	Hyp. Square Volume	11	.21	.16	.77	.14
	Hyp. Diag. Cone Volume	11	.11	.09	.77	.07
	Hyp. Length Cone Volume	11	.07	.06	.80	.05
	Hyp. Square Cone Volume	11	.07	.05	.77	.04

Area measurements in m . Volume measurements in m . Methodology for estimating hypothetical measurements described in Chapter 3. N = number of features.

(Table continues on Page 174)

Table 3.7 (cont.). Summary Statistics of Thickness and Estimated Hypothetical Measurements of Cathlapotle Features.

Type	Measure	N	Mean	Standard Deviation	Coefficient of Variation	Median
Combined	Thickness	131	.16	.13	.83	.13
	Hypothetical Length	131	.82	.45	.54	.80
	Hypothetical Width	131	.59	.36	.61	.50
	Hypothetical Diagonal	131	1.03	.55	.54	.92
	Hypothetical Diagonal Area	131	1.07	1.12	1.05	.67
	Hypothetical Length Area	131	.69	.73	1.06	.50
	Hypothetical Square Area	131	.62	.67	1.09	.34
	Hyp. Diagonal Volume	131	.19	.27	1.43	.08
	Hyp. Length Volume	131	.12	.17	1.42	.05
	Hyp. Square Volume	131	.11	.16	1.47	.05
	Hyp. Diag. Cone Volume	131	.06	.09	1.43	.03
	Hyp. Length Cone Volume	131	.04	.06	1.42	.02
	Hyp. Square Cone Volume	131	.04	.05	1.47	.02

Area measurements in m . Volume measurements in m . Methodology for estimating hypothetical measurements described in Chapter 3. N = number of features.

not surprisingly, that most actual and hypothetical measurements were not normally distributed. A log10 transformation effectively normalized the distribution.

Interestingly, measurements for ovens were largely normally distributed. However, this may be the result of a relatively small sample of ovens (N = 11). In fact, one-sample Kolmogorov-Smirnov tests showed that measurements for oven features also largely met the required shape for a uniform distribution.

There is an increase in the number of hearths at Cathlapotle inside houses relative to those identified in exterior contexts from the precontact to the postcontact. Although the number of exterior hearths was similar in the precontact and postcontact (N = 17 and 13 respectively), the number of interior hearths more than doubled in the postcontact (N = 30, N = 14 in the precontact) A standard chi-square test found these differences to be significant ($X^2 = 6.013$, df = 2, p = .049). Hearths found in crossover contexts stayed approximately constant (exterior N = 4, interior N = 2).

Comparisons of feature measurements to individual site characteristics produced mixed results. A t-test based on all log measurements showed significant differences in size for all measurements when comparing dumps and ovens. When comparing hearths and ovens, again all measurements were significantly different. In both situations, ovens were always larger relative to dumps and hearths (Table 3.7). There was not a significant difference in measurements between hearths and dumps.

When grouping test variables by temporal component, features in the precontact tended to be larger than postcontact. Mann-Whitney U tests showed significant differences between precontact and postcontact periods for hypothetical measurements and some of the actual measurements when all features were combined as a single category. However, this does not hold when features are split out so only like features within paired temporal components were compared against each other (e.g. only dumps comparing precontact and postcontact).

Finally, T-tests were conducted to compare interior and exterior features. Hearths were significantly larger within houses, although ovens and dumps did not vary in size across contexts. Differences in hearths are attributable to presence of small, possibly limited use, ephemeral hearths

Table 3.8. Summary Statistics for Estimated Hypothetical Volumes Comparing Interior and Exterior Features at Cathlapotle.

Type	Interior/ Exterior	Statistic	Hyp. Diagonal Volume	Hyp. Length Volume	Hyp. Square Volume	Hyp. Diag. Cone Volume	Hyp. Length Cone Volume	Hyp. Square Cone Volume
Dump	Exterior	N	16	16	16	16	16	16
		Mean	.13	.07	.08	.04	.02	.03
		Standard Deviation	.25	.15	.16	.08	.05	.05
		Coefficient of Variation	1.97	1.97	2.01	1.97	1.97	2.01
		Median	.03	.02	.02	.01	.01	.01
	Interior	N	24	24	24	24	24	24
		Mean	.15	.09	.09	.05	.03	.03
		Standard Deviation	.26	.15	.16	.08	.05	.05
		Coefficient of Variation	1.77	1.64	1.88	1.77	1.64	1.88
		Median	.07	.04	.03	.02	.01	.01
Hearth	Exterior	N	34	34	34	34	34	34
		Mean	.12	.07	.07	.04	.02	.02
		Standard Deviation	.21	.12	.14	.07	.04	.04
		Coefficient of Variation	1.73	1.55	1.84	1.73	1.55	1.84
		Median	.07	.05	.03	.02	.02	.01
	Interior	N	46	46	46	46	46	46
		Mean	.24	.16	.13	.08	.05	.04
		Standard Deviation	.29	.20	.17	.10	.07	.06
		Coefficient of Variation	1.24	1.28	1.28	1.24	1.28	1.28
		Median	.15	.09	.08	.05	.03	.03

Ovens are omitted. Volume measurements in m . Methodology for estimating hypothetical measurements described in Chapter 3.

outside of the house (Table 3.8). When all features were grouped together as a single category, however, there were no significant differences in size by location.

Clustering analyses produced no noticeable patterns. PCA, cluster, and two-step cluster produced results that generally sorted features according to size (Figure 3.15). PCA produced three factors the first of which was associated with the log transformed hypothetical two dimensional area measurements. The second was entirely associated with thickness, and the third with log transformed actual measurements. Hierarchical cluster analysis split groups out entirely based on size. No relation could be found between clusters and either temporal component or type.

In summary, relationships between feature structure and other site characteristics were less distinct at Cathlapotle than Meier. Several points can be made, however. Features were generally

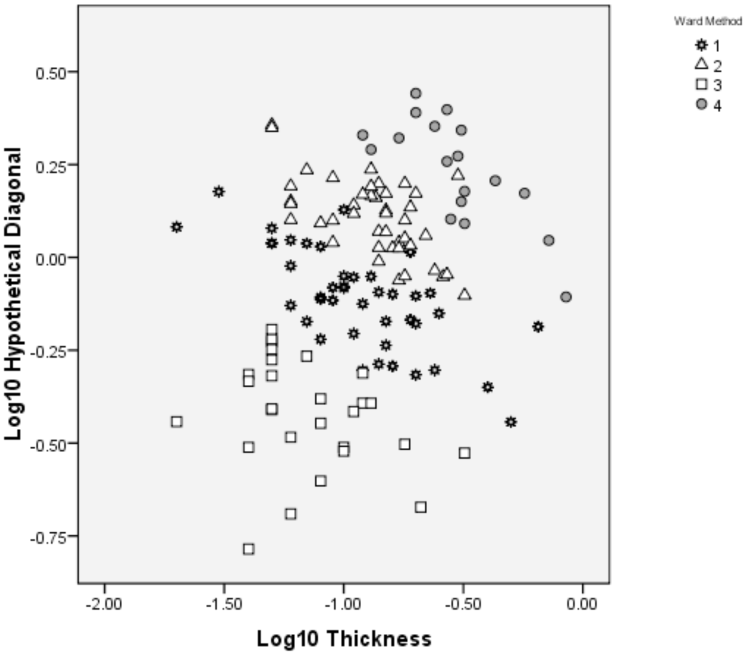

Figure 3.15. Cathlapotle features graphed by size marked by hierarchical cluster number.

larger inside dwellings than outside. Hearths were significantly larger inside the houses. Interior hearths were also more numerous in the postcontact than in the precontact. This was driven by the presence of small hearths outside the houses that were probably only used for a short period. There was a weak relationship between size and temporal component. Also ovens tended to have greater volumes than hearths or dumps, as was expected for features designed for mass processing events.

Combined Cathlapotle and Meier Features

These sites, as noted in Chapter 1, were occupied during approximately the same time period. As such, each site comprises a sample of a larger target population of features that exist within the Wapato Valley (Orton 2000). This section allows the opportunity for direct comparison of features between sites. Further, by combining the sites' features, one can look for patterning at a higher scale. Finally, although beyond the scope of this report, through combining the data I am attempting to create a starting point for defining variation in feature size for the Wapato Valley and Northwest Coast as a whole.

Table 3.9 shows summary statistics for features from both sites combined (Tables 3.8 and 3.9 show summary statistics for hearth and dump features by site). Combining the features from the two sites had little impact on how the various measurements were distributed. In most cases, actual measurements were not normally distributed. Using log transformed values did produce a normal distribution. For simplicity, log10 transformed measurements will be used for all analyses.

T-tests of feature measurements were run for several parameters. First a direct comparison of both sites for all features types combined showed that there were no significant differences between the sites. Comparing feature types from Cathlapotle against the same feature types at Meier also generally produced no significant results for hearths. However, dumps at Cathlapotle were significantly thicker than those at Meier ($t = 2.293$, $df = 56$, $p = .026$). Again, note, there are no ovens at Meier.

Combining features from both sites and comparing types (e.g. combining hearths from Meier and Cathlapotle and comparing them to dumps from both sites) produced mixed results. There were no significant differences in size between hearths and dumps. Hearths and ovens

Table 3.9. Summary Statistics for Features With Both Sites Combined.

Type		N	Mean	Standard Deviation	Coefficient of Variation	Median
Dump	Thickness	58	.14	.12	.88	.11
	Hypothetical Length	58	.73	.45	.62	.60
	Hypothetical Width	58	.52	.34	.65	.45
	Hypothetical Diagonal	58	.91	.53	.59	.76
	Hypothetical Diagonal Area	58	.87	1.03	1.18	.45
	Hypothetical Length Area	58	.57	.71	1.25	.28
	Hypothetical Square Area	58	.49	.60	1.23	.26
	Hyp. Diagonal Volume	58	.13	.22	1.73	.05
	Hyp. Length Volume	58	.08	.13	1.69	.03
	Hyp. Square Volume	58	.07	.14	1.83	.03
	Hyp. Diag. Cone Volume	58	.04	.07	1.73	.02
	Hyp. Length Cone Volume	58	.03	.04	1.69	.01
	Hyp. Square Cone Volume	58	.02	.04	1.83	.01
Hearth	Thickness	110	.15	.13	.84	.13
	Hypothetical Length	110	.83	.46	.55	.80
	Hypothetical Width	110	.60	.38	.62	.51
	Hypothetical Diagonal	110	1.04	.57	.55	.95
	Hypothetical Diagonal Area	110	1.11	1.20	1.08	.71
	Hypothetical Length Area	110	.70	.76	1.09	.50
	Hypothetical Square Area	110	.64	.72	1.13	.38
	Hyp. Diagonal Volume	110	.20	.31	1.53	.08
	Hyp. Length Volume	110	.13	.19	1.49	.05
	Hyp. Square Volume	110	.12	.19	1.61	.04
	Hyp. Diag. Cone Volume	110	.07	.10	1.53	.03
	Hyp. Length Cone Volume	110	.04	.06	1.49	.02
	Hyp. Square Cone Volume	110	.04	.06	1.61	.01
Oven	Thickness	11	.24	.10	.39	.27
	Hypothetical Length	11	1.00	.34	.34	1.02
	Hypothetical Width	11	.78	.27	.35	.81
	Hypothetical Diagonal	11	1.27	.42	.33	1.32
	Hypothetical Diagonal Area	11	1.40	.72	.51	1.36
	Hypothetical Length Area	11	.87	.47	.54	.82
	Hypothetical Square Area	11	.85	.44	.52	.86
	Hyp. Diagonal Volume	11	.34	.26	.77	.22
	Hyp. Length Volume	11	.21	.17	.80	.15
	Hyp. Square Volume	11	.21	.16	.77	.14
	Hyp. Diag. Cone Volume	11	.11	.09	.77	.07
	Hyp. Length Cone Volume	11	.07	.06	.80	.05
	Hyp. Square Cone Volume	11	.07	.05	.77	.04

Area measurements in m . Volume measurements in m . Methodology for estimating hypothetical measurements described in Chapter 3.

Table 3.10. T-test Results Comparing Hearth and Oven Features with Cathlapotle and Meier Features Combined Based On Hypothetical Area and Volume Measurements.

Measure	t-test for Equality of Means t	df	Sig. *
Log10 Hypothetical Diagonal Area	-1.476	119.00	.143
Log10 Hypothetical Length Area	-1.422	119.00	.158
Log10 Hypothetical Square Area	-1.633	119.00	.105
Log10 Hypothetical Diagonal Volume	-2.411	119.00	**.017**
Log10 Hypothetical Length Volume	-2.373	119.00	**.019**
Log10 Hypothetical Square Volume	-2.545	119.00	**.012**
Log10 Hypothetical Diag Cone Volume	-2.411	119.00	**.017**
Log10 Hypothetical Length Cone Volume	-2.373	119.00	**.019**
Log10 Hypothetical Square Cone Volume	-2.545	119.00	**.012**

* Two-tailed significance with values >.05 in bold.

showed significant differences in volume measurements, but two dimensional measurements were not significantly different (Table 3.10). Dumps and ovens were significantly different for all measurements. In all cases Cathlapotle features tended to be larger than those at Meier.

Using temporal component as a grouping variable also produced mixed results. In general when comparing sites there were no significant differences between crossover features and either postcontact or postcontact features when all features were combined. The exception to these results was thickness measurements which were significant for both groupings, with crossover being thickest followed by precontact and then postcontact. Precontact features were, conversely, significantly larger than postcontact features for most actual and hypothetical measurements except, oddly enough, thickness. This suggests that the greatest difference between precontact and precontact features was area. This pattern is seen at Meier and to a lesser extent at Cathlapotle.

In several groups of tests presented thus far statistically significant results have been identified for measurements based on hypothetical approximations of total feature size when measurements based on field notes have not been significant for the given test. As noted earlier (see Chapter 3) part of the systematic process I am trying to follow requires reviewing possible patterns from various angles. In this case the pattern of hypothetical measurements being significant when actual measurements are not calls into question how these measurements were created. I doubt, however, that there is any systematic bias involved for three reasons. First, the hypothetical measurements were created without regard to any other facts other than how the features fit onto the site plan. In essence, the measurements were calculated “blind” to all other information. Second, this highlighting of hypothetical variables was not present when t-tests and Mann-Whitney U tests were rerun using a number of samples generated by a bootstrap. If there was a serious problem with the hypothetical measurements, one would expect it to arise more consistently in simulated samples. Finally, in an attempt to test the pattern in a slightly different way, I ran Mann-Whitney U and two-sample Kolmogorov-Smirnov Z tests on the actual and hypothetical measurements which had not been log transformed. For all pairs the results were essentially the same as the t-tests (although width was often flagged as being significantly different). With this in mind, it would appear that there are actual differences between precontact and postcontact features when they are grouped in this way.

Parsing the grouping parameters in various ways led to several patterns. Again, on a large scale there are few distinctions between sites, temporal components, and feature types. However, several differences were present. Grouping features by type and comparing them by temporal component did show significant differences between precontact hearths and ovens on Mann-

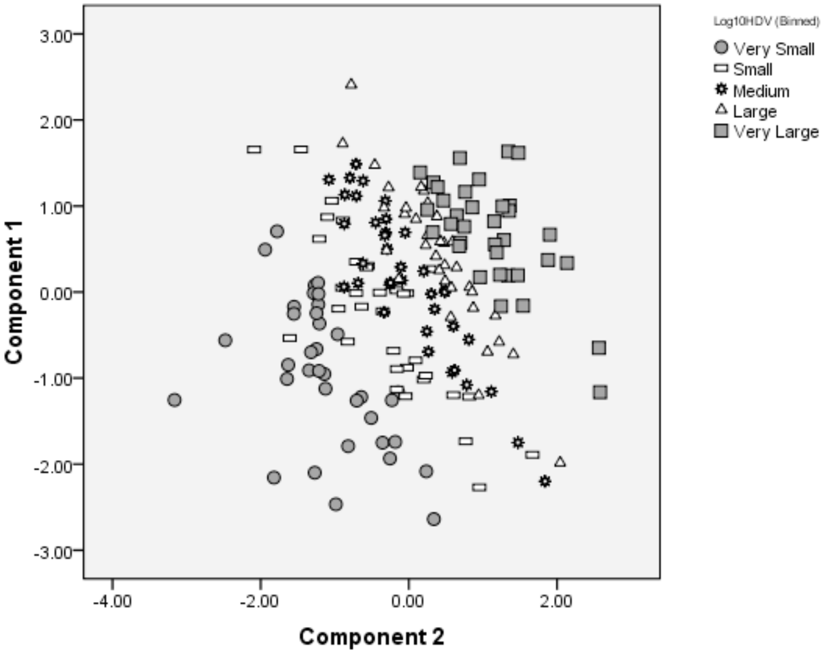

Figure 3.16. Components 1 and 2 of a PCA based on all log transformed measurements marked by hypothetical diagonal cylindrical volume split into five bins.

Whitney U and t-tests. Measurements for dumps and ovens tended to be significantly different for precontact, crossover, and, although less consistently so, postcontact contexts. In both of these comparisons ovens were larger than the feature against which they were compared. Hearths and dumps were largely only significantly different for crossover levels and then often only if equal variance was not assumed, which was not always the case. In general, the most likely measurement to be significantly different in comparisons was thickness, often showing a significant difference when no other measure in the comparison was. Ovens tended to always be larger than either hearths or dumps. Precontact features tended to be larger than postcontact or crossover features.

There are, however, many measurements to track in these tests. It was not unusual in the course of running various tests for a single measurement to produce a significant result when no others did. In order to discover some larger patterns exploratory analysis was conducted.

Initial exploration using PCA (with varimax rotation and without) and hierarchical cluster analysis (average-link and Ward's methods) essentially grouped the features, with all features included in analysis, by size. PCA without rotation broke out two components, with component 1 accounting for 84.34% of the variability and component 2 an additional 8.04%. Component 2 was associated entirely with the thickness measure, with all other measures being associated with component 1. PCA with varimax rotation evened the total variance explained out to 52.26% and 40.11% for each component respectively. With rotation component 1 was associated with length, width, diagonal and area measurements and component 2 with depth and volume measurements. However, there was no apparent association with any site characteristic. Dividing the log transformed hypothetical diagonal cylindrical volume (Log10HDV) into 5 even groups and graphing those groups against components 1 and 2 indicated that the PCA was splitting the data largely based on size (Figure 3.16).

Thus, while there is a pattern present on a very broad scale, in this case the pattern is essentially meaningless in terms of fulfilling the expectations of my hypotheses. However, one of the goals of unsupervised data explorations is to refine the dataset through identification of outliers. With this in mind I performed a cluster analysis.

Table 3.11. Summary Statistics for Dump Features by Site.

Site	Measure	N	Mean	Standard Deviation	Coefficient of Variation	Median
Cathlapotle	Thickness	40	.16	.13	.81	.12
	Hypothetical Length	40	.72	.45	.62	.60
	Hypothetical Width	40	.50	.35	.70	.42
	Hypothetical Diagonal	40	.89	.55	.62	.77
	Hypothetical Diagonal Area	40	.85	1.10	1.29	.46
	Hypothetical Length Area	40	.56	.74	1.31	.28
	Hypothetical Square Area	40	.49	.66	1.36	.25
	Hyp. Diagonal Volume	40	.14	.25	1.82	.05
	Hyp. Length Volume	40	.08	.15	1.73	.04
	Hyp. Square Volume	40	.08	.16	1.90	.03
	Hyp. Diag. Cone Volume	40	.05	.08	1.82	.02
	Hyp. Length Cone Volume	40	.03	.05	1.73	.01
	Hyp. Square Cone Volume	40	.03	.05	1.90	.01
Meier	Thickness	18	.10	.11	1.07	.07
	Hypothetical Length	18	.74	.46	.62	.58
	Hypothetical Width	18	.57	.32	.56	.52
	Hypothetical Diagonal	18	.96	.51	.54	.75
	Hypothetical Diagonal Area	18	.91	.85	.93	.44
	Hypothetical Length Area	18	.58	.66	1.15	.26
	Hypothetical Square Area	18	.50	.46	.93	.27
	Hyp. Diagonal Volume	18	.10	.13	1.24	.04
	Hyp. Length Volume	18	.07	.10	1.52	.02
	Hyp. Square Volume	18	.05	.06	1.16	.02
	Hyp. Diag. Cone Volume	18	.03	.04	1.24	.01
	Hyp. Length Cone Volume	18	.02	.03	1.52	.01
	Hyp. Square Cone Volume	18	.02	.02	1.16	.01
Combined	Thickness	58	.14	.12	.88	.11
	Hypothetical Length	58	.73	.45	.62	.60
	Hypothetical Width	58	.52	.34	.65	.45
	Hypothetical Diagonal	58	.91	.53	.59	.76
	Hypothetical Diagonal Area	58	.87	1.03	1.18	.45
	Hypothetical Length Area	58	.57	.71	1.25	.28
	Hypothetical Square Area	58	.49	.60	1.23	.26
	Hyp. Diagonal Volume	58	.13	.22	1.73	.05
	Hyp. Length Volume	58	.08	.13	1.69	.03
	Hyp. Square Volume	58	.07	.14	1.83	.03
	Hyp. Diag. Cone Volume	58	.04	.07	1.73	.02
	Hyp. Length Cone Volume	58	.03	.04	1.69	.01
	Hyp. Square Cone Volume	58	.02	.04	1.83	.01

Area measurements in m . Volume measurements in m . Methodology for estimating hypothetical measurements described in Chapter 3.

Table 3.12. Summary Statistics for Hearth Features.

Site	Measure	N	Mean	Standard Deviation	Coefficient of Variation	Median
Cathlapotle	Thickness	80	.15	.14	.91	.13
	Hypothetical Length	80	.85	.46	.54	.81
	Hypothetical Width	80	.61	.37	.60	.55
	Hypothetical Diagonal	80	1.06	.56	.53	1.06
	Hypothetical Diagonal Area	80	1.13	1.16	1.03	.88
	Hypothetical Length Area	80	.73	.76	1.04	.52
	Hypothetical Square Area	80	.65	.70	1.07	.40
	Hyp. Diagonal Volume	80	.19	.27	1.42	.10
	Hyp. Length Volume	80	.12	.18	1.43	.06
	Hyp. Square Volume	80	.11	.16	1.47	.05
	Hyp. Diag. Cone Volume	80	.06	.09	1.42	.03
	Hyp. Length Cone Volume	80	.04	.06	1.43	.02
	Hyp. Square Cone Volume	80	.04	.05	1.47	.02
Meier	Thickness	30	.16	.11	.68	.13
	Hypothetical Length	30	.77	.47	.61	.62
	Hypothetical Width	30	.59	.40	.68	.47
	Hypothetical Diagonal	30	1.00	.60	.60	.83
	Hypothetical Diagonal Area	30	1.05	1.31	1.24	.54
	Hypothetical Length Area	30	.63	.78	1.25	.30
	Hypothetical Square Area	30	.61	.80	1.31	.32
	Hyp. Diagonal Volume	30	.23	.39	1.71	.06
	Hyp. Length Volume	30	.13	.22	1.64	.04
	Hyp. Square Volume	30	.13	.25	1.84	.04
	Hyp. Diag. Cone Volume	30	.08	.13	1.71	.02
	Hyp. Length Cone Volume	30	.04	.07	1.64	.01
	Hyp. Square Cone Volume	30	.04	.08	1.84	.01
Combined	Thickness	110	.15	.13	.84	.13
	Hypothetical Length	110	.83	.46	.55	.80
	Hypothetical Width	110	.60	.38	.62	.51
	Hypothetical Diagonal	110	1.04	.57	.55	.95
	Hypothetical Diagonal Area	110	1.11	1.20	1.08	.71
	Hypothetical Length Area	110	.70	.76	1.09	.50
	Hypothetical Square Area	110	.64	.72	1.13	.38
	Hyp. Diagonal Volume	110	.20	.31	1.53	.08
	Hyp. Length Volume	110	.13	.19	1.49	.05
	Hyp. Square Volume	110	.12	.19	1.61	.04
	Hyp. Diag. Cone Volume	110	.07	.10	1.53	.03
	Hyp. Length Cone Volume	110	.04	.06	1.49	.02
	Hyp. Square Cone Volume	110	.04	.06	1.61	.01

Area measurements in m . Volume measurements in m . Methodology of estimating hypothetical measurements described in Chapter 3. N = number of features

Hierarchical cluster analysis also broke the dataset into groups based on size. However, an examination of a dendrogram produced by an average-link analysis identified four possible outliers. These were removed and the PCA was redone. This produced an additional component, which, when varimax rotation was applied, split the variance across the three components fairly evenly with total variance explained reaching 95.89%. A hierarchical cluster analysis was again done on the data. Again, the results were largely size based, with no other obvious associations. Graphing of component 1 and 2 with features marked by feature types did have the effect of moving ovens into one portion of the graph, but this is to be expected given the above results of the t-tests. Although ovens did group, they were still entirely surrounded by other features, perhaps indicating that while individual measurements were significantly different statistically, on the whole they were still not particularly unusual. Removal of one additional possible outlier also had no effect on the basic pattern or lack thereof.

Discriminant analysis was only partially successful at splitting out groups. Using all features combined from both sites, the DA created a model that correctly placed features into temporal component 53.1% of the time and 50.3% under cross-validation. Using a 70% sample improved the situations slightly for the basic model with 56.8% correctly classified, 48.1% of unselected cases correctly identified, and 48% of cross-validated grouped cases correctly identified.

The DA was less successful at grouping based on feature type. Using a 70% random sample, the model correctly classified 44.8% of cases, but only 29.6% of unselected cases and 32% of selected cross-validated cases.

In summary, features at both sites were of similar size. Ovens tend to be the largest overall class of features. Significance based tests (Kolmogorov-Smirnov, Mann-Whitney U, and t-tests) produced mixed results when looking at temporal periods with which features were associated. Crossover features were thicker than either precontact or postcontact individually. Precontact features tended to be larger based on a range of measurements than postcontact features. Despite the presence of some significant differences in feature measurements, unsupervised data exploration largely failed at uncovering any meaningful patterning. It is therefore not surprising that discriminant analysis was also largely unsuccessful at sorting features into groupings based on site characteristics.

Combined Dumps Only

Table 3.11 shows summary statistics for dump features. A total of 58 dumps were identified at Cathlapotle and Meier. No hypothetical measurements were normally distributed, and only length, width, and diagonal actual measurements were normally distributed. Again, log transformations successfully normalized these distributions and will be used in all analyses.

T-tests indicated there was little significant difference in measurements of dump features at the sites, with the exception noted above of thickness. Cathlapotle dumps tended to be slightly larger and have greater variation in size than those at Meier.

Comparing temporal periods with features from both sites combined did identify a few measurements that were significantly different. However, there was no apparent pattern to these flagged measurements. Many of the instances where values were highlighted were significant only if equal variance was not assumed. Both an ANOVA test and non-parametric Kruskal-Wallis H test found only the log transformed thickness measure, which was not found to be significantly different in any t-test, to have unequal variance. Ultimately, only width, hypothetical width, and hypothetical square area were significantly different, and only when comparing postcontact to precontact. These results were essentially meaningless as width was greater in postcontact and length in precontact. Further, when only those features within a temporal period were compared against each other by site, no significant differences were identified (there are no dumps occupying crossover levels at Meier).

Average-link cluster analysis identified one possible outlier (Feature 366 from Meier). Ward's method also singled this feature out, but it was included within a larger cluster as opposed to treating it as its own cluster in the average-link analysis. Initial exploration was conducted with this feature included in the mix, then a second set of tests were run with it removed to gauge the impact of the feature. A PCA split the data into three components that accounted for 95.57% of the variation. No particular patterning was evident in the results, although Feature 366 was again highlighted as a outlier.

With this in mind, the feature was removed and the tests rerun. During this process a second outlier was identified. This feature (Feature 359 from Cathlapotle) was also removed, and the process repeated.

Removing these features only marginally improved the ability to identify patterns. A PCA produced three components accounting for 95.18% of variance. Using a 65% sample as the basis of the PCA produced almost identical results. In both cases, outside of sorting features on the basis of size, there did not seem to be any particular visual correlation with any site characteristic such as temporal component or location within the sites.

The strongest result obtained in exploratory analysis was using DA with the edited dataset to model site based on measurements. Using a 65% sample produced a fairly robust model in which 81.1% of selected cases were successfully grouped by site. 68.4% of unselected cases correctly grouped, and 70.3% of cases were correctly grouped using cross-validation. The spread of factor weights suggests that dumps at Meier tended to have greater area and be less thick.

In summary, overall there is very little significant variation in dumps when compared to various site characteristics. Dumps at Meier tended to be slightly smaller than those at Cathlapotle, which also had greater variation is dump size. Discriminant analysis had some success at sorting dumps by site, but this result was not robust in terms of finding similar results using other clustering techniques.

Combined Hearths Only

Table 3.12 provides summary statistics for hearth features. The hearths, when both sites were combined, showed the same pattern in their distributions as has been seen thus far, which is not particularly surprising. In general, actual and hypothetical measurements were not normally distributed. Taking a log transformation successfully normalized the distribution.

T-tests were run comparing measurements based on site, temporal period, and interior versus exterior location. In general, no significant differences were identified. Meier hearths were more varied in terms of size than those at Cathlapotle. However, the median of almost all measurements (except thickness which was equal) tended to be larger at Cathlapotle than Meier. The only difference that was noted as significant was between all combined hearth features from both sites when comparing precontact and postcontact, with precontact features being larger than their postcontact counterparts for most measurements.

Hierarchical cluster analysis did not suggest any outliers. Both Ward's method and average-link produced multiple clusters, with Ward's method producing the "cleanest" groupings. Both methods produced one cluster composed almost entirely of postcontact features. Within this cluster of postcontact features were two subclusters, in the case of Ward's method, and four subclusters in the case of average-link. The question of where to divide the dendrograms produced by cluster analysis is a tricky one. For all analysis produced thus far, I have used results based on a range of solutions or trimmings. In this specific case, there appeared to be two obvious large clusters: one larger of mixed temporal component features (Cluster 1) and one smaller almost exclusively composed of postcontact features (Cluster 2).

PCA split out two components totaling 93.16% of variance explained. A rotated solution associated component 1 with length, width, and area measurements (both actual and hypothetical) and component 2 with thickness and volume measurements. Again, component scores for each measurement generally increased with increases in associated measurements. Plotting clusters produced by a two group solution Ward's method cluster analysis highlights how these postcontact features were sorted out (Figure 3.17).

Discriminant analysis identified this pattern also, although less dramatically. Using a 65% sample, the DA produced a model which successfully identified temporal component for a given

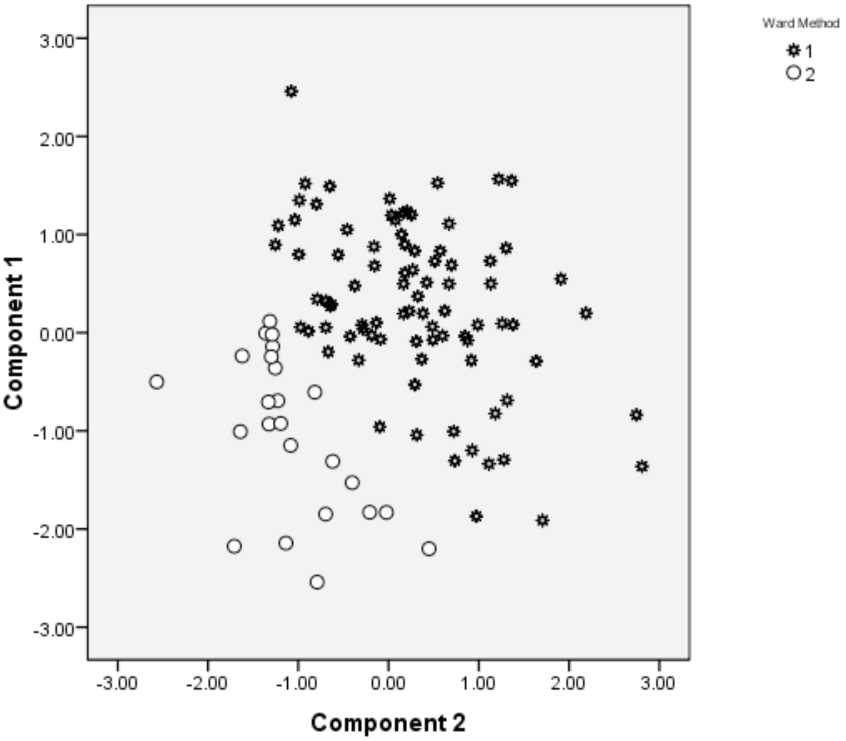

Figure 3.17. PCA components 1 and 2 marked by a two cluster solution Ward's method hierarchical cluster analysis.

feature 62% of the time. Under this model, 48.7% of unselected cases were successfully grouped, and 56.3% of cases were correctly attributed under cross-validation. Thus, while there is a relationship between size and temporal component, there is enough variation remaining (probably entirely residing in the first cluster described above) to make it rather difficult to create a model that absolutely separates the time periods.

Overall, however, there is a difference between precontact and postcontact hearth features. Meier hearths tended to be smaller and more varied in size than those at Cathlapotle but not significantly so. T-tests showed postcontact hearths tend to be significantly smaller than their precontact counterparts for most measurements. Unsupervised data exploration produced similar results, sorting out postcontact features based on size. However, cluster analysis and PCA further refined this pattern by suggesting that rather than there being an absolute distinction between the two periods, some postcontact features were mixed in with precontact features.

Summary of Results of Analyses of Feature Measurements

A number of patterns emerged when looking at hearth and related features in terms of measurements. Overall, features at both sites were largely similar in size, although dumps and hearths at Meier are slightly smaller. Dumps at Cathlapotle tended to be more varied than those at Meier. Conversely, Meier hearths tended to be more varied in size than those at Cathlapotle. However, neither dumps nor hearths were *significantly* different in size between sites. Along this line, hearths and dumps were similar in size, but ovens were significantly larger than either. At Meier, spatial patterning can be seen within the house, with smaller hearths located at the north end of the house. Exploratory data analysis tended to group southern and exterior Meier features together while central and northern features formed a second grouping. F size can be associated with number of people using these features, this may suggest northern and central hearths were limited in who could use them and southern and exterior were more generally accessible to members of the household. Temporally, there is a clear difference between precontact and postcontact features, with precontact features being the larger of the two. Although present at Cathlapotle when all features were combined, this pattern is seen most clearly when looking at Meier alone or when looking at combined hearths specifically from both sites.

Table 3.13. NISP from Cathlapotle and Meier Units with Hearths and Related Features.

Time		Cathlapotle		Meier		Total	
Taxa	Common Name	NISP	%NISP	NISP	%NISP	NISP	%NISP
Aplodontia rufa	**Mountain Beaver**	92	1.36	2	.09	94	1.06
Canidae	Dog	23	.34	35	1.62	58	.65
Castor canadensis	**Beaver**	259	3.84	99	4.58	358	4.02
Cervidae	Cervidae (antler)	73	1.08	0	.00	73	.82
Cervus elaphus	**Elk**	2873	42.57	313	14.49	3186	35.76
Equus caballus	Horse	3	.04	0	.00	3	.03
Erethizon dorsatum	Porcupine	0	.00	1	.05	1	.01
Felis concolor	**Cougar**	7	.10	4	.19	11	.12
Lepus americanus/ Sylvilagus sp.	**Rabbit**	31	.46	8	.37	39	.44
Lutra canadensis	**River Otter**	47	.70	15	.69	62	.70
Lynx sp.	**Bobcat**	20	.30	9	.42	29	.33
Martes pennanti	**Fisher**	2	.03	11	.51	13	.15
Mustela sp.	**Mink**	22	.33	43	1.99	65	.73
Odocoileus sp.	**Deer**	2926	43.35	1400	64.81	4326	48.56
Ondatra zibethicus	**Muskrat**	78	1.16	91	4.21	169	1.90
Ovis aries	Domestic Sheep	1	.01	0	.00	1	.01
Ovis canadensis	Bighorn Sheep	1	.01	0	.00	1	.01
Pinnipedia	Seal	55	.81	9	.42	64	.72
Procyon lotor	**Raccoon**	154	2.28	85	3.94	239	2.68
Sciuridae/ Tamiasciurus douglasii	Squirrel	0	.00	1	.05	1	.01
Testudinidae	Turtle	1	.01	6	.28	7	.08
Ursus americanus	**Bear**	76	1.13	28	1.30	104	1.17
Vulpes vulpes	Fox	5	.07	0	.00	5	.06
Total		6749	100.00	2160	100.00	8909	100.00

* *Sylvilagus bachmani* is present only at Meier. *Sylvilagus floridamus* and *Lepus americanus* are present only at Cathlapotle. When faunal data are combined, three taxa are grouped into one taxon.

** Bold font indicates taxa used as bases for some exploratory analyses (referred to in text as “edited samples”). These tend to be species that have the greatest impact on the first few dimensions of the results of many of these tests. It will be specifically noted in the text and/or graph titles (if applicable) when the complete dataset is not being used.

Table 3.14. Summary Statistics for Meier Taxa NISP, Unit NISP, and Richness by Excavation Unit.

Taxa	N	Unit Mean	Standard Deviation	Coefficient of Variation	Unit Median
NISP	25	86.40	76.10	.88	62.00
Richness	25	7.40	3.35	.45	7.00
Mt. Beaver	25	.08	.28	3.46	.00
Dog	25	1.40	2.52	1.80	1.00
Beaver	25	3.96	3.68	.93	3.00
Elk	25	12.52	11.46	.92	9.00
Porcupine	25	.04	.20	5.00	.00
Cougar	25	.16	.47	2.96	.00
Rabbit	25	.32	1.07	3.34	.00
River Otter	25	.60	.82	1.36	.00
Bobcat	25	.36	.76	2.10	.00
Fisher	25	.44	1.39	3.15	.00
Mink	25	1.72	1.99	1.16	1.00
Deer	25	56.00	50.36	.90	46.00
Muskrat	25	3.64	3.21	.88	3.00
Seal	25	.36	.76	2.10	.00
Raccoon	25	3.40	4.18	1.23	2.00
Squirrel	25	.04	.20	5.00	.00
Turtle	25	.24	.60	2.49	.00
Bear	25	1.12	1.86	1.66	.00

N = Number of analytical units.

Table 3.15. Summary Statistics for Meier Taxa NISP, Unit NISP, and Richness Broken into Temporal Components by Analytical Unit.

	Postcontact					Precontact				
	N	Unit Mean	Standard Deviation	Coefficient of Variation	Unit Median	N	Unit Mean	Standard Deviation	Coefficient of Variation	Unit Median
NISP	13	121.23	83.37	0.69	101.00	12	48.67	45.44	0.93	27.50
Richness	13	9.08	2.87	0.32	8.00	12	5.58	2.94	0.53	6.00
Mt. Beaver	13	0.15	0.38	2.51	0.00	12	0.00	0.00		0.00
Dog	13	1.77	2.98	1.68	1.00	12	1.00	1.95	1.95	0.50
Beaver	13	5.69	3.30	0.58	4.00	12	2.08	3.20	1.54	1.00
Elk	13	17.46	12.43	0.71	15.00	12	7.17	7.61	1.06	6.00
Porcupine	13	0.08	0.28	3.46	0.00	12	0.00	0.00		0.00
Cougar	13	0.15	0.38	2.51	0.00	12	0.17	0.58	3.39	0.00
Rabbit	13	0.15	0.56	3.70	0.00	12	0.50	1.45	2.89	0.00
River Otter	13	0.85	0.80	0.94	1.00	12	0.33	0.78	2.36	0.00
Bobcat	13	0.69	0.95	1.37	0.00	12	0.00	0.00		0.00
Fisher	13	0.77	1.88	2.44	0.00	12	0.08	0.29	3.61	0.00
Mink	13	2.00	1.96	0.98	1.00	12	1.42	2.07	1.45	0.50
Deer	13	79.38	55.91	0.70	74.00	12	30.67	27.87	0.91	17.50
Muskrat	13	4.31	3.12	0.72	4.00	12	2.92	3.29	1.13	2.00
Seal	13	0.62	0.96	1.55	0.00	12	0.08	0.29	3.61	0.00
Raccoon	13	5.00	4.90	0.98	4.00	12	1.67	2.39	1.43	0.50
Squirrel	13	0.08	0.28	3.46	0.00	12	0.00	0.00		0.00
Turtle	13	0.31	0.63	2.03	0.00	12	0.17	0.58	3.39	0.00
Bear	13	1.77	2.28	1.29	1.00	12	0.42	0.90	2.14	0.00

N = Number of analytical units.

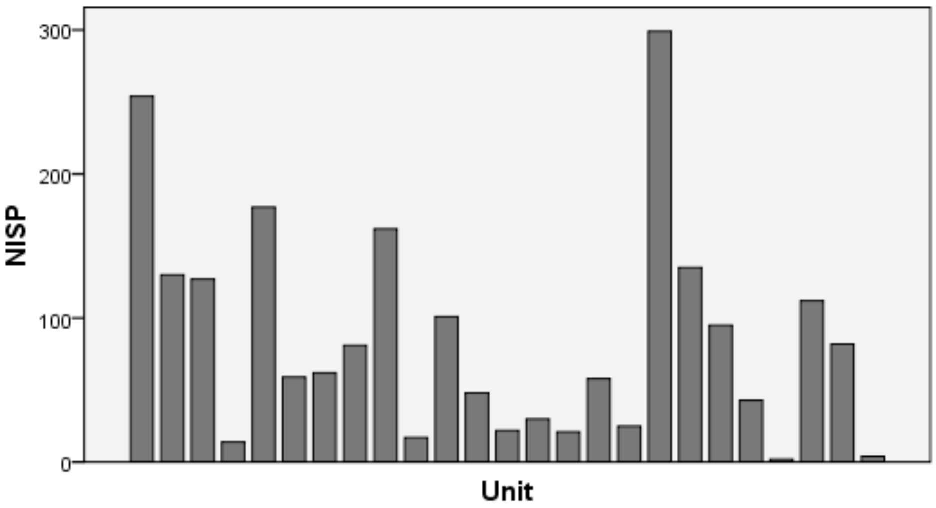

Figure 3.18. Total unit NISP by analytical unit at Meier.

CHAPTER 5
RESULTS: FAUNAL ANALYSES

Introduction

This chapter presents results of analyses of the faunal assemblages associated with the features discussed in the last chapter. Note that the fauna under consideration here is limited to mammalian taxa (with the exception of turtles). This chapter will show first that there are distinct differences between sections of the Meier house. Second, spatially Cathlapotle appears to be more generalized in how taxa are dispersed across the site. Third, in exploratory data analyses precontact and postcontact analytical units separate clearly at both sites. And fourth, although there is an increase in deer and elk elements in terms of accumulation rates of NISP in the postcontact, the ratio of deer to elk is essentially the same in both components at both sites.

Faunal elements recovered at an archaeological site can be a clear marker of production. They are the direct evidence of what was being produced much as hearth features are the direct evidence of how production and where production happened. Variation in production, reflected in faunal remains, shows the basic ebbs and flows of household demand over time and space. Variation in production also potentially reflects upon what a household finds economically advantageous to expend energy. At Cathlapotle and Meier production associated with fauna can be related to both fulfilling of household needs and how these households took part in the changing economic situation of the late eighteenth and early nineteenth centuries. As such, they tell a second and complimentary story to that told by the features that were used to process them.

I focused on largely mammalian remains previously analyzed by Dr. R. Lee Lyman (University of Missouri-Columbia). A total of 15,114 faunal elements were identified at Cathlapotle and Meier. Of these 8,909 specimens were found in units with hearth and related features (Table 3.13, Appendices A through F provide additional summary statistics for the assemblages). Deer (*Odocoileus sp.*) and elk (*Cervus elephus*) dominate the assemblages (Table 3.13). Deer make up 43% and 65% of the assemblages at Cathlapotle and Meier respectively. Elk make up 43% and 15% of the assemblages at Cathlapotle and Meier. Note that while the 15% representation of deer at Meier seems relatively low, the next most common species, beaver (*Castor canadensis*), only accounts for 4.6% of the assemblage. At the other end of the spectrum, there are several taxa with only a single element at a site.

The goal of much of exploratory analysis is to find basic patterns (see Chapter 3 for discussion of exploratory and significance-based sta-

Table 3.16. Summary Statistics for Diversity and Evenness Measures from Meier.

Component	Measure	N	Unit Mean	Standard Deviation	Coefficient of Variation	Unit Median
Postcontact	D	13	.4642	.0708	.1526	.4463
	H'	13	1.2037	.1845	.1533	1.1988
	H' Log10	13	.5228	.0801	.1533	.5206
	Shannon Scaled	13	.3839	.0588	.1533	.3823
	1-D	13	.5358	.0708	.1322	.5537
	E 1-D	13	.6084	.0763	.1254	.6309
	1/D	13	2.1997	.3269	.1486	2.2405
	E 1/D	13	.2596	.0702	.2706	.2743
	J'	13	.5603	.0789	.1407	.5381
	Simpson Estimate	13	.4568	.0723	.1582	.4432
	Simpson Scaled	13	.5601	.0740	.1322	.5788
	E_{VAR}	13	.3599	.0856	.2379	.3300
Precontact	D	12	.4905	.1139	.2323	.4273
	H'	12	1.0136	.3201	.3158	1.0774
	H' Log10	12	.4402	.1390	.3157	.4679
	Shannon Scaled	12	.3233	.1021	.3157	.3436
	1-D	12	.5095	.1139	.2236	.5727
	E 1-D	12	.6880	.1598	.2323	.6985
	1/D	12	2.1260	.4145	.1950	2.3415
	E 1/D	12	.4880	.2564	.5255	.4024
	J'	12	.6800	.1569	.2307	.6554
	Simpson Estimate	12	.4253	.1709	.4018	.3996
	Simpson Scaled	12	.5327	.1191	.2236	.5988
	E_{VAR}	12	.5360	.2185	.4077	.4325
Combined	D	25	.4768	.0929	.1949	.4380
	H'	25	1.1125	.2709	.2435	1.1988
	H' Log10	25	.4831	.1176	.2435	.5206
	Shannon Scaled	25	.3548	.0864	.2435	.3823
	1-D	25	.5232	.0929	.1776	.5620
	E 1-D	25	.6466	.1275	.1972	.6612
	1/D	25	2.1643	.3655	.1689	2.2830
	E 1/D	25	.3692	.2149	.5819	.2925
	J'	25	.6178	.1346	.2178	.6152
	Simpson Estimate	25	.4417	.1275	.2886	.4228
	Simpson Scaled	25	.5470	.0972	.1776	.5875
	E_{VAR}	25	.4444	.1834	.4126	.4006

N = number of analytical units for each component.

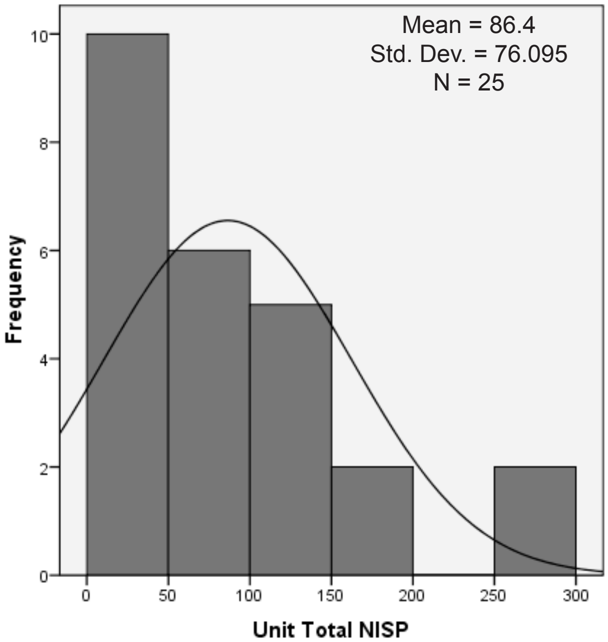

Figure 3.19. Histogram of total unit NISP with frequencies by analytical unit.

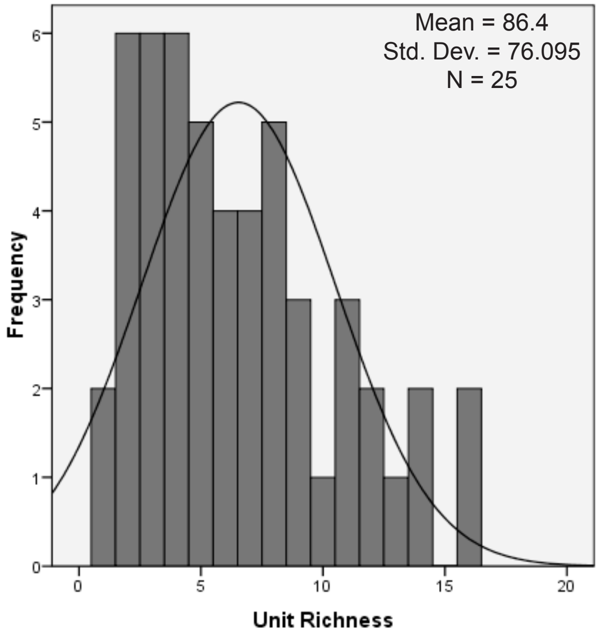

Figure 3.20. Histogram of unit richness with frequencies by analytical unit.

tistical procedures used). "Noise" in the results caused by variables that are not important to the basic pattern can obscure that pattern. For example, assuming for a moment that there is a clear pattern to how elk production was distributed across Cathlapotle, several taxa with very few elements in some excavations units could shift the results enough to obscure or, more likely, weaken the basic pattern. A number of different strategies were attempted to overcome these differences in distributions. One technique which proved generally productive was to use a subset of the data suggested by several principle component and discriminant analyses. These essentially ended up sorting out more common taxa.

More importantly, taxa that were probably highly sought after during the early contact period for exchange in the fur trade tended to be in this subset. When this grouping is used it will be explicitly stated and will generally refer to these as an edited sample or dataset.

Ultimately, the goal is to compare the results of faunal analysis with the results of feature structure analysis in Chapter 4. For example, assuming for a moment that a pattern is identified in the faunal remains at Meier, it can then be compared against those patterns noted using feature size as the basis of analysis. If similar patterns are present, they would tend to reinforce each other in terms of accepting or rejecting hypotheses.

Meier

Twenty-five 2m excavation units from Meier were the focus of this study. These were further broken down into precontact and postcontact AU's (N = 12 and 13 respectively). Tables 3.14 and 3.15 show excavation unit NISP means and related statistics for all species identified at Meier. Deer and elk dominate the assemblage. In both the precontact and postcontact, deer and elk account for more than 79% of the total NISP (postcontact N = 1576, precontact N = 584, Appendix A). When deer and elk are removed analytical unit means drop to 10.83 for precontact and 24.38 in the postcontact.

Figures 3.18 through 3.20 show basic distributions of NISP and richness at Meier. One sample Kolmogorov-Smirnov tests were run for all taxa to determine distribution for each species across all units. These tests indicated most taxa were not normally distributed between units. Those that were normally distributed included beaver, elk, mink, deer, muskrat and raccoon. A regression analysis showed richness and NISP were highly correlated with an R = .841 (p <

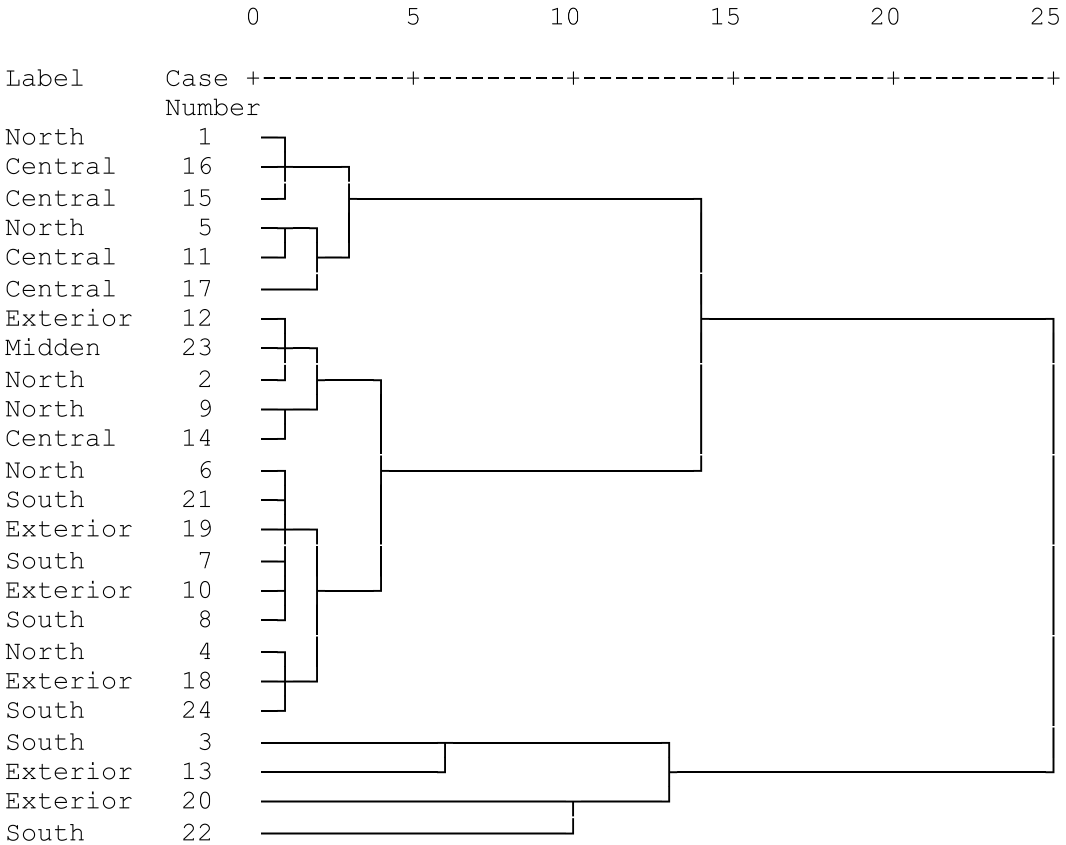

Figure 3.21. Dendrogram based on average-link cluster analysis using diversity and evenness measures. Richness not included because of differences in scale.

.001) when using NISP as an independent variable and richness as the dependent. Only unit S 3-5 / E18-20, an interior central unit with a large dump, had a lower richness than expected based on the regression model using a 95% confidence interval. However, when using volume excavated as a predictor, the unit was not unusual. In fact, no unit's richness was outside a 95% confidence interval when using volume as the independent variable. Volume and richness were related (R = .441, $p < .001$), as were volume and NISP (R = .414, $p = .001$). Removing deer and elk from consideration had little impact on the previous results, although unit S 3-5 / E 18-20 was no longer an outlier. The low R^2 values suggest that excavation bias will not have a large impact on the models created using exploratory analysis.

Hierarchical cluster analysis was used to begin looking for possible outliers and get an initial impression of possible grouping patterns. Depending on the variables used (all counts, normally distributed counts, NISP per m [density], diversity measures, etc.) there appears to be some grouping along two general lines. First, lowest level groupings showed distinct precontact and postcontact clusters. However, these clusters were mixed with one another at higher trimmings. Second, central and northern units tend to group together and southern and exterior units tend to group together (Figure 3.21).

Richness, diversity, and evenness measures were somewhat contradictory. Table 16 summarizes these measures. Beginning with simple richness or the raw number of taxa present in each unit, there is a significant difference between precontact (mean = 5.58) and postcontact (mean = 9.08) (Mann-Whitney U = 34.0, Wilcoxon W = 112.0, $p = 0.016$). Evenness was also significantly different, with three measures having $p < .05$ as calculated using a t-test. This may be related to an

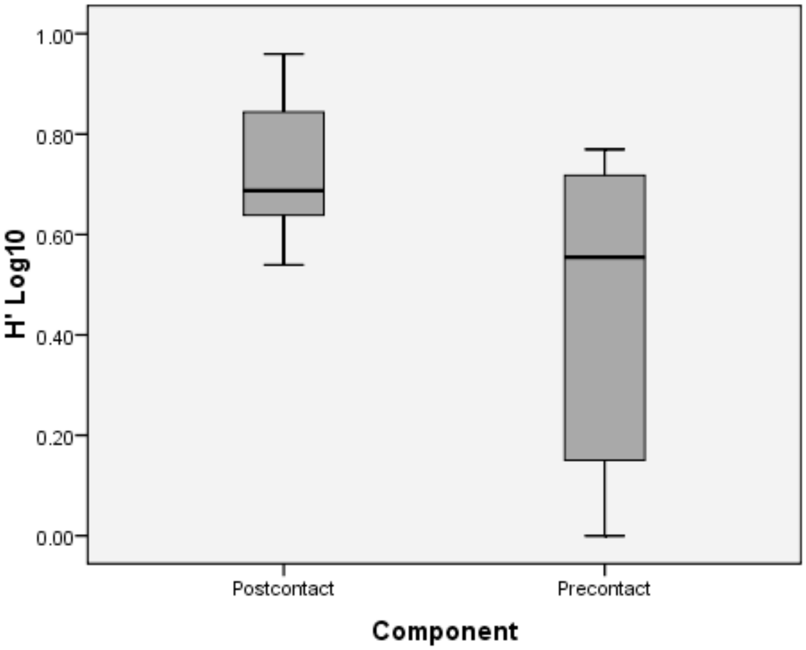

Figure 3.22. Boxplot of distribution of H' Log10 scores at Meier with deer and elk removed. Shaded box represents values within 25th to 75th percentiles. Whiskers represent values within 1.5 box lengths. Central bar represents median.

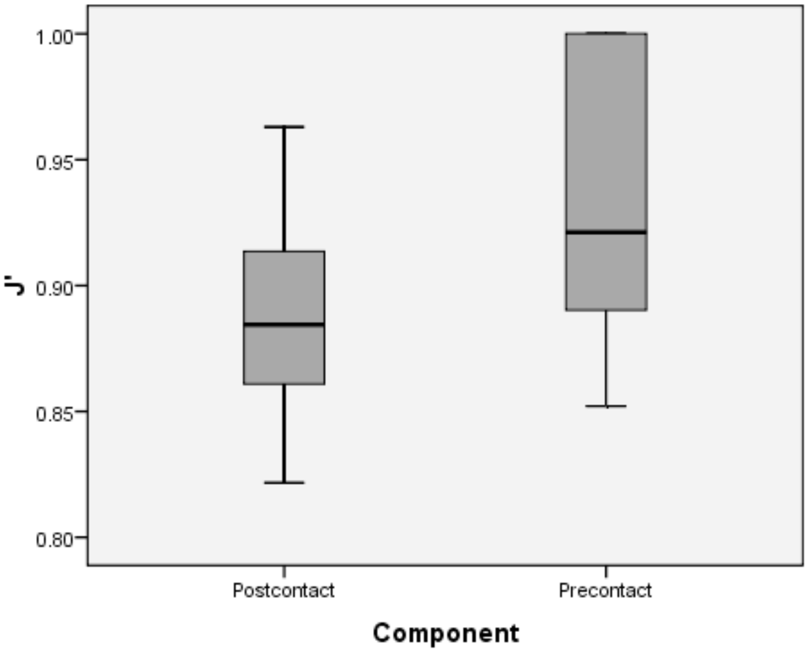

Figure 3.23. Boxplot of distribution of J' scores at Meier with deer and elk removed northern section. Shaded box represents values within 25th to 75th percentiles. Whiskers represent values within 1.5 box lengths. Central bar represents median.

increased presence of deer and elk in the postcontact sample. While a t-test basted on NISP suggested significant differences (Deer: t = 2.720, *df* = 23, *p* = .012; Elk: t = 2.470, *df* = 23, *p* =.021) between precontact and postcontact, the result may be viewed as suspect as distributions for the species were normal for only the postcontact component (and then only marginally so). However, more conservative non-parametric tests also produced significant results, with both deer and elk having significant values below the .05 level on a Mann-Whitney U test. It is interesting to note that the ratio of deer to elk did not change significantly (t = -.561, *df* = 23, *p* =.580).

However, the above must be qualified by noting that there were differences in the size of the sample based on excavation volume (postcontact volume = 40.75 m , precontact volume = 24.64 m , postcontact AU mean = 3.13 m , precontact AU mean = 2.05m). When NISP is normalized for precontact and postcontact by dividing by AU volume producing a density measure, a Mann-Whitney U did not find a significant difference between components although it was rather close (Mann-Whitney U = 45.00, Z = -1.8, *p* = .077). There were, however, significant differences in mean AU accumulation rates (determined by dividing by 350 for precontact and 40 for postcontact) of NISP and richness (*p* < .001). When only AU's with less than 3m^3 of volume (precontact N = 10, postcontact N = 7) were considered (creating a small test where volume sampled was not a consideration) the difference in accumulation rate of NISP between precontact and postcontact was still significant (Mann-Whitney U < .001, Z = -3.416, *p* < .001). The same is true for richness (Mann-Whitney U < .001, Z = -3.442, *p* < .001). For both there was an increase in the postcontact. Thus, while several postcontact AU's with large amounts of excavated volume may be skewing tests based on absolute values, there is still change in how fast faunal elements were accumulating in the two periods with a much more rapid rate in the postcontact.

One of the dangers of a number of diversity measures is the influence of taxa with unusually large numbers of representatives. This seems to be the case at Meier, where despite the above,

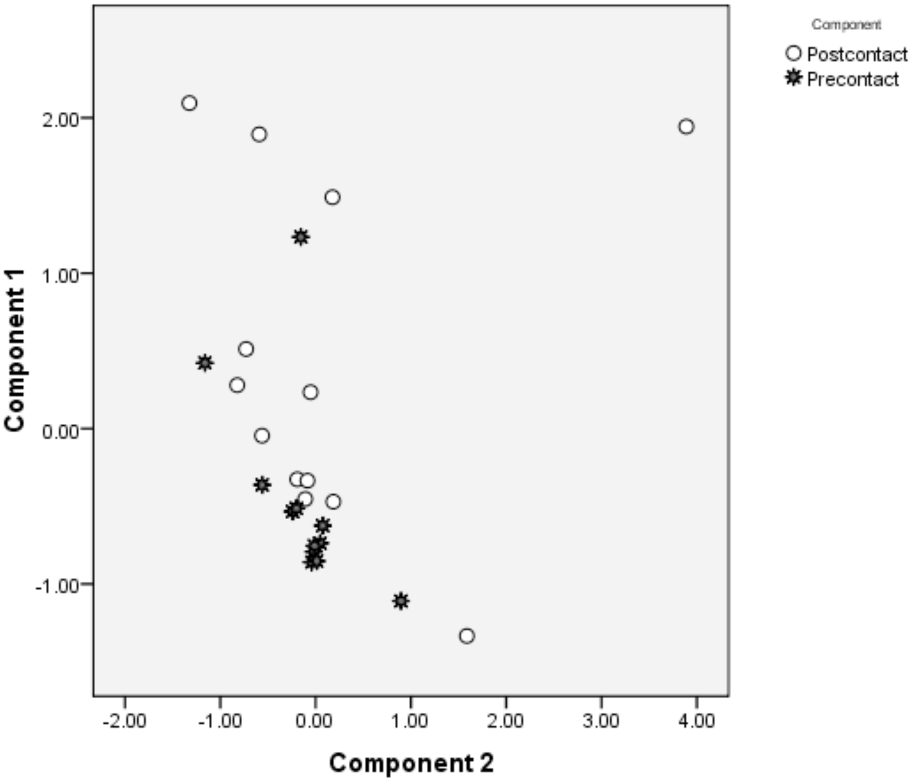

Figure 3.24. Components 1 and 2 of PCA based on NISP of all taxa with markers indicating temporal component.

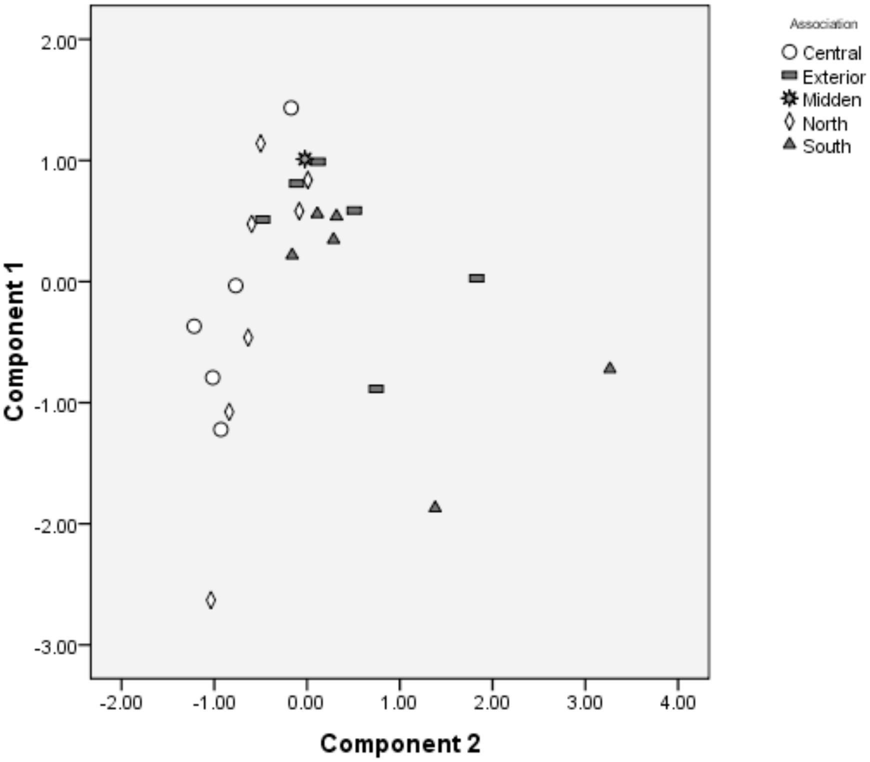

Figure 3.25. Components 1 and 2 of PCA based on diversity measures with markers indicating location.

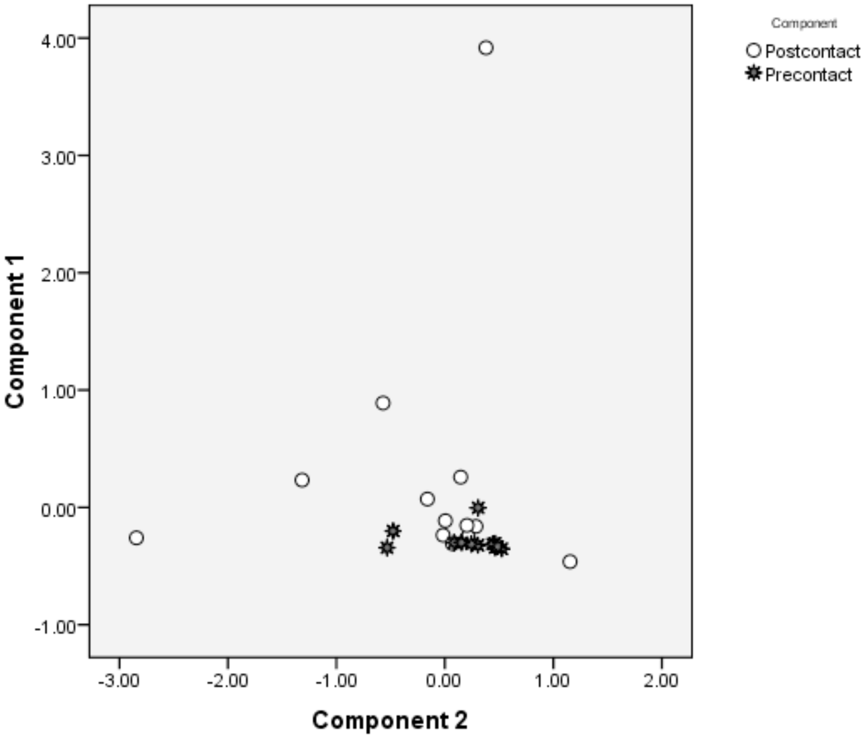

Figure 3.26. First two components of a correspondence analysis based on NISP of most common taxa at Meier.

actual heterogeneity measures (which should in principle combine the richness and evenness measures) did not see significant differences between precontact and postcontact AU's. This was again the result of the influence of deer and elk on the measures. When deer and elk were removed from consideration and diversity measures were recalculated, virtually all measures showed significant differences between precontact and postcontact. Precontact AU's tended to be more even and less diverse across the site. However, there was also a greater variation between precontact AU's (Figures 3.22 and 3.23).

It is interesting to note that when AU's containing only dumps (N=8) are removed from consideration, the differences between precontact and postcontact become much less obvious, with no measures being significantly different. This suggests that much of the variation is stored in those AU's which contain only dumps. Dumps are, to some extent, miniature middens. As such, there is a greater chance for a wider variety of items to accumulate as multiple cleanings are brushed off into them and before they are themselves removed to a main house midden.

The central portion of the house is characterized by the highest NISP and richness (see Appendix G for diversity and evenness measure summary statistics by association).

In the interior of the house, this is followed fairly closely in both aspects by the northern section. Finally, despite having the largest grouping of hearths overall, the southern section has far lower NISP and richness. When AU's with just dumps are excluded, the northern section becomes the dominant in terms of NISP and richness, followed by central, then south. This low richness combined with low NISP has a tendency to make the southern section measure more even. With all AU's this is seen in significant differences in Mann-Whitney U and two sample Kolmogorov-Smirnov test scores between northern and southern sections of the house in evenness measures, with northern units being less even. However, when dumps are removed, some of these differ-

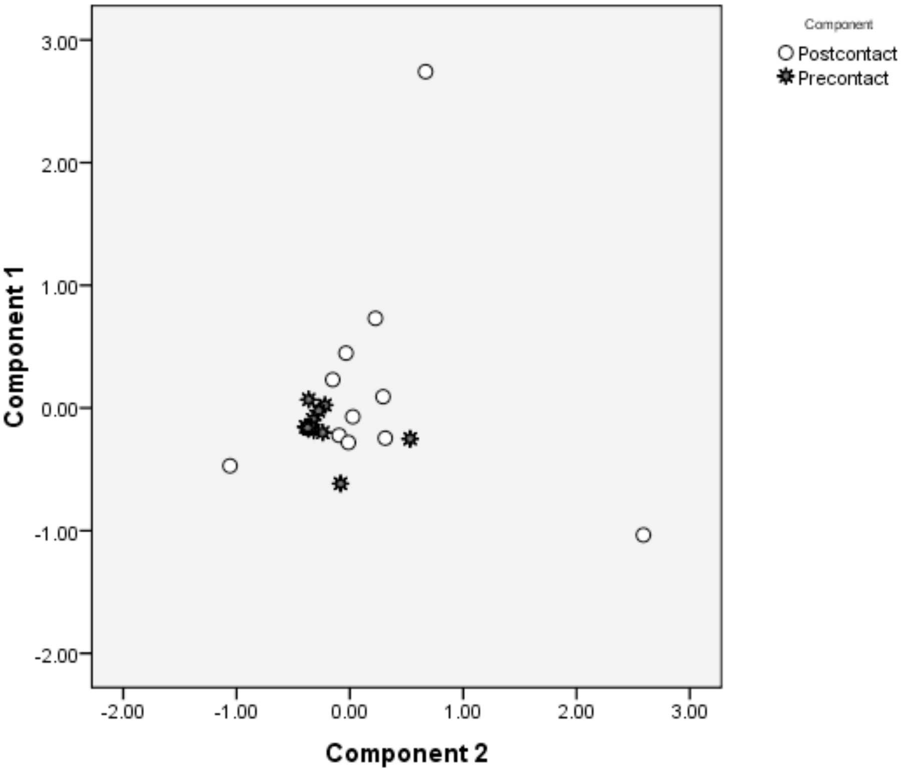

Figure 3.27. First two CA components based on NISP for all taxa at Meier with units N 0-2/E 18-20 and S 3-5/E 18-20 removed.

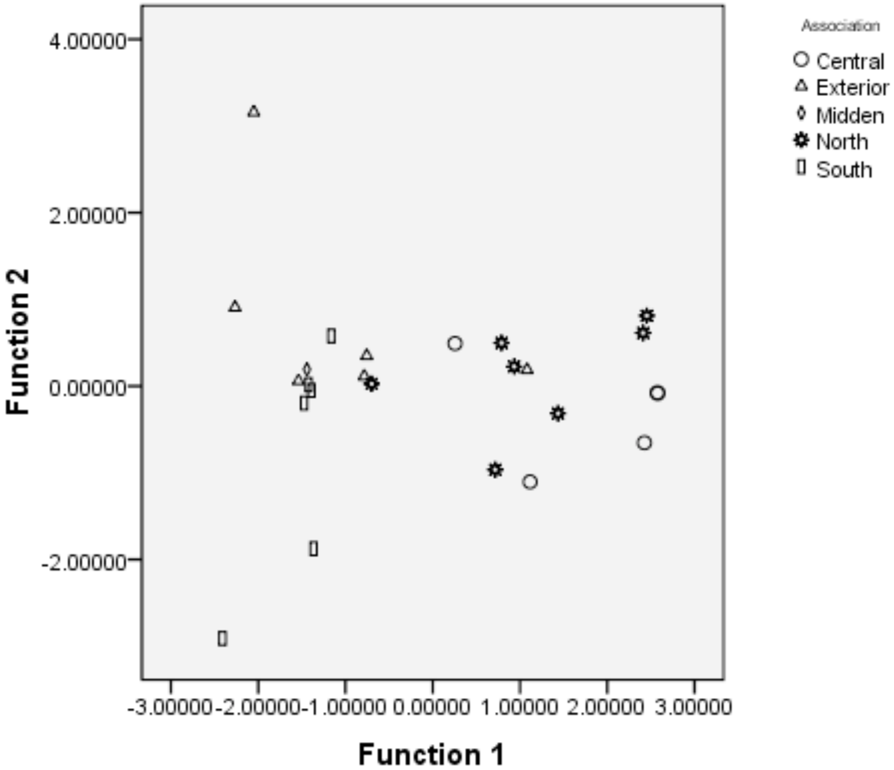

Figure 3.28. Discriminant Analysis using only evenness measures for all Meier analytical units.

ences lessen, again suggesting that a fair amount of the diversity in the sample is contained therein. On the other hand, the significant differences remained in terms of evenness between the central and the southern units. The difference again is related to the distribution of elk and deer, with their relative numbers exaggerated in the central units compared to other taxa. When deer and elk are removed, the differences between central and southern units become less obvious in terms of evenness, but more so in overall diversity with significant differences present.

In general, when comparing interior sections of the house using diversity measures, the central and northern sections are similar to each other, having a greater number of taxa present and greater variation in how NISP is spread over those taxa than southern AU's. This pattern is most evident with deer and elk removed from consideration. Under all circumstances, southern AU's tend to be more even.

Using NISP for all taxa as the basis for a PCA, the analysis created five components, with none accounting for more than 42% of the variation. Graphing the first two components one begins to see differences between precontact and postcontact (Figure 3.24). The rotated component matrix associates Component 1 with bear and beaver. Component 2 is associated with fisher, squirrel, turtle and bobcat. Using diversity measures as the basis for the PCA showed some patterning in location (Figure 3.25) and a similar pattern in terms of temporal component. Component 1 is associated with diversity indices and Component 2 with evenness measures.

Initial correspondence analysis identified two outlier AU's, one each in the northern and central units characterized by high NISP for elk and the presence of cougar. Removing these cases and rerunning the analysis tended to make patterning more evident without actually changing the pattern (i.e. separating clusters further apart without changing the basic relation of one cluster to the other). CA tended to group variation into a relatively small area as defined by the first two components. The test was less successful at sorting out locations within the house, although the northern

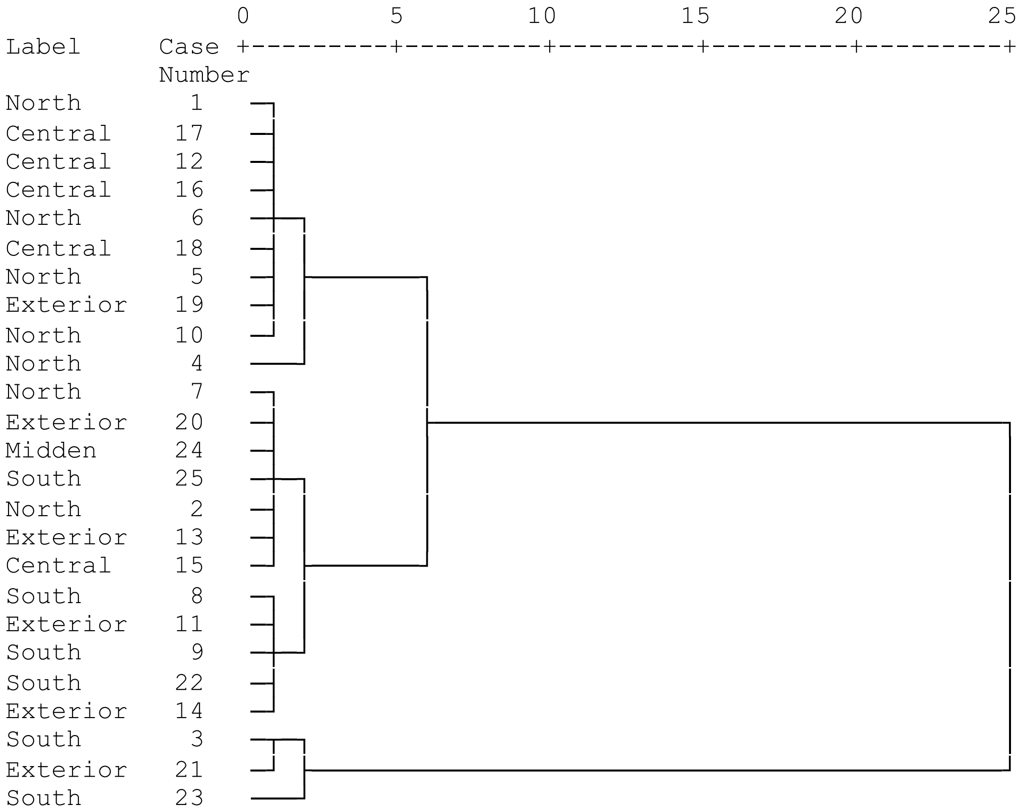

Figure 3.29. Dendrogram based on Ward’s method hierarchical cluster analysis using only evenness measures for Meier.

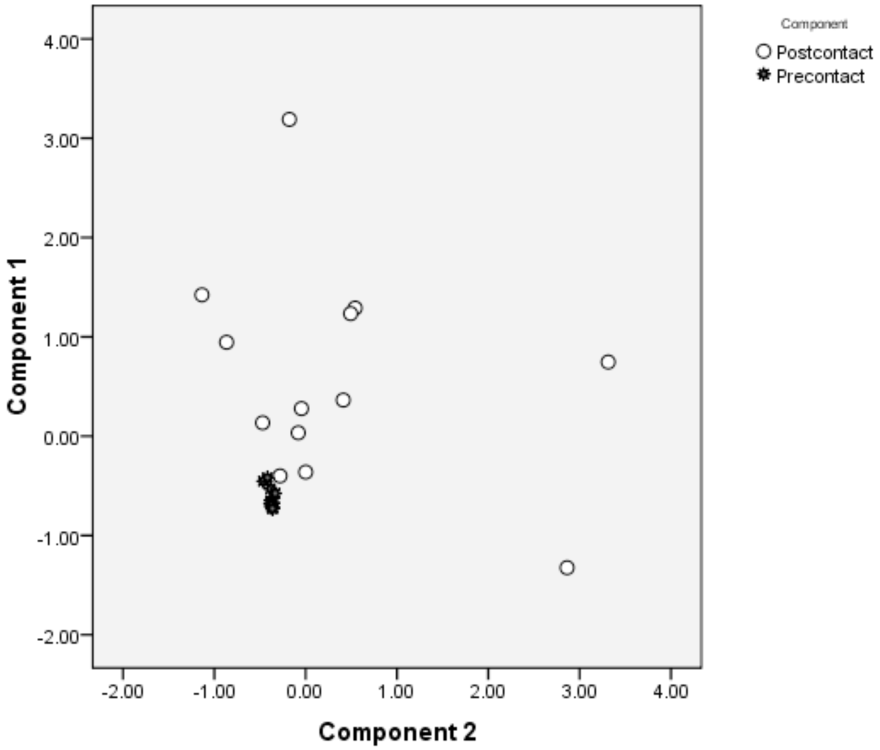

Figure 3.30. First two components of a PCA based on time corrected NISP derived from discriminate analyses with markers by component at Meier.

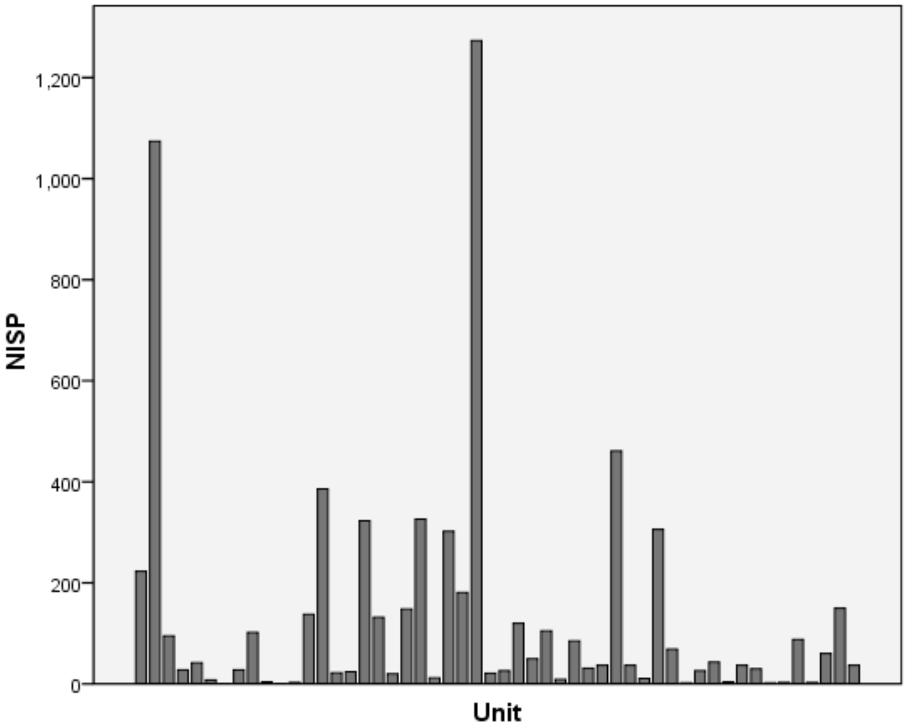

Figure 3.31. Total NISP by analytical unit at Cathlapotle.

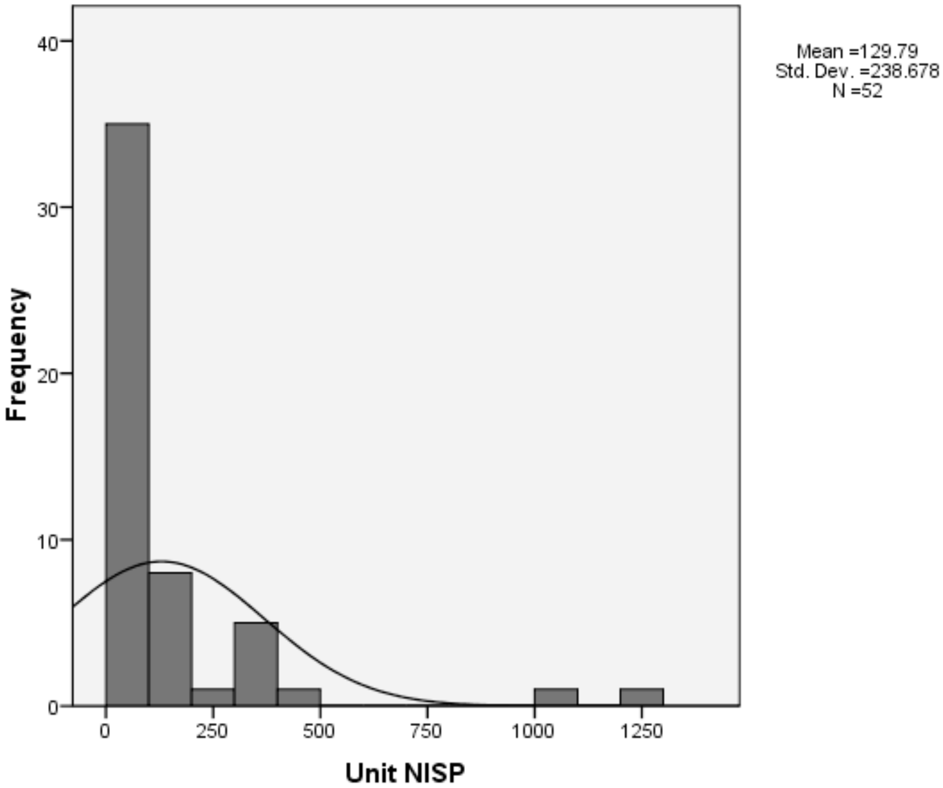

Figure 3.32. Histogram of total NISP with frequencies by analytical unit.

and central AU's showed greater variation. The analysis did point out a consistent pattern of precontact AU's forming a tight cluster indicating relative similarity. Postcontact AU's spread out from this relatively homogeneous cluster showing greater variation (Figures 3.26 and 3.27).

When discriminant analysis is used to build models of the data in such a way that cases with unknown characteristics can be placed, what quickly becomes apparent is that while there is order at Meier, it is a somewhat fragile order. This has already been seen in the tests for significant differences based on diversity measures: when there is a slight alteration in the data, a relationship that was significant suddenly becomes not and *vice versa*.

For example, when one uses raw NISP values to build a model that groups cases by association within and around the house (i.e. North, South, Exterior, etc.), the success rate for the basic model in allocating AU's used to build the model can go as high as 100%. However, this extremely high rate of success begins to fall apart when cases are dropped out of consideration. When using the complete sample to build the model, under cross-validation the success rate for correctly grouping cases drops to 36%. A model based on a 65% sample only correctly grouped 30% of unselected AU's and the success rate under cross-validation drops to 13.3%.

These apparent failures of the models do have value, however. For instance, when the same test is run with deer and elk left out of consideration, the success rate for grouping those sampled AU's in the model is 93.3%. AU's left out of the initial model are correctly grouped 40% of the time. The success rate for placing AU's under cross-validation is 33.3%. While this is better than when elk and deer are left in the model, it is still not overly impressive. What is important to note is where those incorrectly grouped AU's are be-

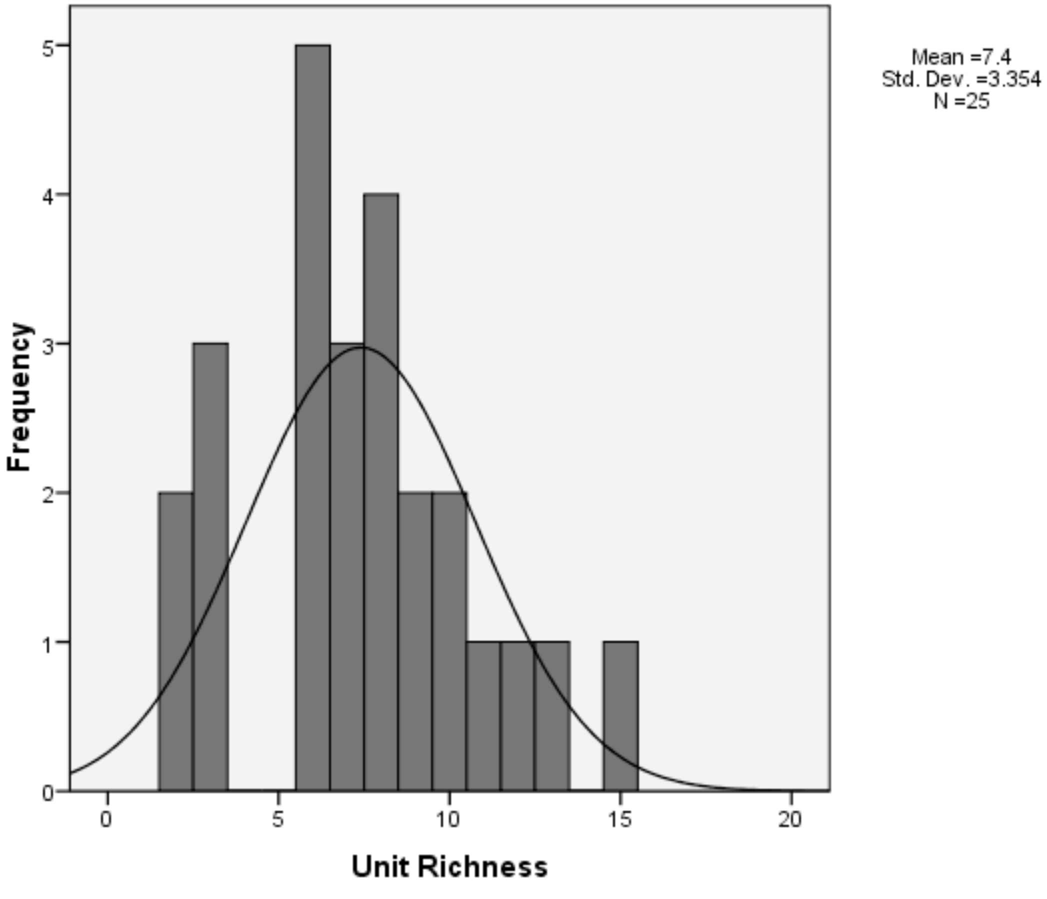

Figure 3.33. Histogram of richness with frequencies by analytical unit.

Table 3.17. Summary Statistics for Cathlapotle Taxa NISP, Unit NISP, and Richness by Analytical Unit.

Taxa	N	Unit Mean	Standard Deviation	Coefficient of Variation	Unit Median
NISP	52	129.79	238.68	1.84	37.00
Richness	52	6.54	3.97	.61	6.00
Mt. Beaver	52	1.77	4.59	2.59	.00
Dog	52	.44	1.60	3.64	.00
Beaver	52	4.98	9.03	1.81	2.00
Elk	52	55.25	108.07	1.96	12.00
Horse	52	.06	.31	5.13	.00
Cougar	52	.13	.53	4.04	.00
Rabbit	52	.60	1.16	1.93	.00
River Otter	52	.90	2.45	2.72	.00
Bobcat	52	.38	.72	1.89	.00
Fisher	52	.04	.19	4.85	.00
Mink	52	.42	1.23	2.92	.00
Deer	52	56.27	98.23	1.75	19.50
Muskrat	52	1.50	3.33	2.22	.00
Domestic Sheep	52	.02	.14	6.95	.00
Bighorn Sheep	52	.02	.14	6.95	.00
Seal	52	1.06	2.12	2.00	.00
Raccoon	52	2.96	9.07	3.07	.00
Turtle	52	.02	.14	6.95	.00
Bear	52	1.46	3.47	2.37	.00
Fox	52	.10	.50	4.95	.00

N = number of analytical units.

ing placed. For units that should have been placed with the central house section and were not, all were placed with northern AU’s. The reverse is also true with all AU’s that should have been placed within the northern section of the house, but were not, placed in the central portion. This would tend to reinforce the idea that central and northern AU’s are similar and distinctly dissimilar from southern AU’s. When only normally distributed taxa are used to build the model, the model tends to confuse southern and exterior AU’s.

This pattern reemerges when one uses diversity measures as the building blocks of the discriminant analysis. Once again initial success rates tended to be high (86.7% for a 65% sample of cases using all measures). However, the models invariably fell much shorter under cross-validation and at placing cases not in the original sample.

A closer examination of the structure of the models showed that often actual heterogeneity measures were not being included in the final model and evenness measures were. This again pointed to the differences noted above between portions of the site. An examination of units plotted against the first two functions of the model again highlighted the relations between parts of the site (Figure 3.28). A hierarchical cluster analysis using only evenness measures would seem to confirm this relationship (Figure 3.29).

Evenness was again the main point for differentiating precontact and postcontact. In initial tests most diversity measures failed to be entered into the discriminant analysis.

When just evenness measures were used to build the model, success rates were relatively high with 86.7% of selected cases being correctly

Table 3.18. Summary Statistics for Cathlapotle Taxa NISP, Unit NISP, and Richness Broken into Temporal Components by Analytical Unit.

	Postcontact					Precontact				
	N	Unit Mean	Standard Deviation	Coefficient of Variation	Unit Median	N	Unit Mean	Standard Deviation	Coefficient of Variation	Unit Median
NISP	33	97.52	121.93	1.25	37.00	19	#####	360.21	1.94	37.00
Richness	33	6.18	3.75	0.61	5.00	19	7.16	4.38	0.61	7.00
Mt. Beaver	33	0.79	1.67	2.12	0.00	19	3.47	7.07	2.04	0.00
Dog	33	0.24	0.50	2.09	0.00	19	0.79	2.57	3.26	0.00
Beaver	33	4.09	5.08	1.24	2.00	19	6.53	13.46	2.06	2.00
Elk	33	41.82	55.75	1.33	12.00	19	78.58	163.28	2.08	10.00
Horse	33	0.09	0.38	4.27	0.00	19	0.00	0.00		0.00
Cougar	33	0.09	0.38	4.27	0.00	19	0.21	0.71	3.40	0.00
Rabbit	33	0.85	1.37	1.61	0.00	19	0.16	0.38	2.34	0.00
River Otter	33	0.58	1.32	2.28	0.00	19	1.47	3.66	2.49	0.00
Bobcat	33	0.42	0.66	1.58	0.00	19	0.32	0.82	2.56	0.00
Fisher	33	0.03	0.17	5.80	0.00	19	0.05	0.23	4.58	0.00
Mink	33	0.33	1.11	3.36	0.00	19	0.58	1.43	2.46	0.00
Deer	33	43.24	57.09	1.32	20.00	19	78.89	143.85	1.82	19.00
Muskrat	33	0.64	1.22	1.91	0.00	19	3.00	5.00	1.67	0.00
Domestic Sheep	33	0.03	0.17	5.80	0.00	19	0.00	0.00		0.00
Bighorn Sheep	33	0.00	0.00		0.00	19	0.05	0.23	4.58	0.00
Seal	33	0.94	2.05	2.18	0.00	19	1.26	2.28	1.81	1.00
Raccoon	33	1.18	2.60	2.21	0.00	19	6.05	14.33	2.37	1.00
Turtle	33	0.00	0.00		0.00	19	0.05	0.23	4.58	0.00
Bear	33	1.00	2.28	2.28	0.00	19	2.26	4.87	2.16	0.00
Fox	33	0.00	0.00		0.00	19	0.26	0.81	3.10	0.00

N= Number of analytical units for each component.

classified, 50% of unselected cases, and 60% of cases under cross-validation. Postcontact AU's were more likely to be misplaced into the precontact group than the reverse.

Finally, those taxa that were highlighted as being important to the creation of the DA above were used for another PCA to examine differences in precontact and postcontact. In order to normalize for the vast differences in the amount of time elements had to accumulate, time corrected counts were created for each taxa. This was done simply by dividing NISP by number of years represented by each time interval (350 years for precontact or 40 years postcontact) creating a working accumulation rate. This PCA created three components with components 1 and 2 accounting for 85% of variation. Figure 3.30 shows the results with precontact AU's being tightly grouped and postcontact spreading out from this center position.

In summary, there are two relations seen at Meier. First, northern and central AU's are more similar to each other than to other units. Conversely, southern and exterior AU's tend to group together. Northern and central sections tend to be more rich and less even than southern section. This may point to elites at the northern end of the house having access to rarer species. Second, there is a change from precontact to postcontact, with precontact AU's tending to be more even. There is a significant increase in elk and deer abundance in the postcontact period, but the overall ratio of deer to elk did not change significantly. Methodologically, an interesting pattern emerged during exploratory analysis: analyses based on diversity and evenness measures tended to highlight differences in space while analyses based on NISP tended to highlight differences in time at the site.

Table 3.19. Summary Statistics for Diversity and Evenness Measures from Cathlapotle.

Component	Measure	N	Unit Mean	Standard Deviation	Coefficient of Variation	Unit Median
Postcontact	D	33	.4184	.1276	.3051	.3865
	H'	33	1.0696	.3117	.2914	1.0986
	H' Log10	33	.4645	.1354	.2914	.4771
	Shannon Scaled	33	.3411	.0994	.2914	.3504
	1-D	33	.5816	.1276	.2195	.6135
	E 1-D	33	.7991	.1290	.1614	.7763
	1/D	33	2.5335	.5358	.2115	2.5871
	E 1/D	33	.5646	.2875	.5091	.5499
	J'	33	.7287	.1935	.2656	.6958
	Simpson Estimate	33	.3097	.1401	.4523	.3333
	Simpson Scaled	33	.6080	.1334	.2195	.6414
	E_{VAR}	33	.5281	.3079	.5830	.3974
Precontact	D	19	.4425	.1733	.3917	.4097
	H'	19	1.0967	.3821	.3484	1.2025
	H' Log10	19	.4763	.1660	.3484	.5223
	Shannon Scaled	19	.3498	.1219	.3484	.3835
	1-D	19	.5575	.1733	.3109	.5903
	E 1-D	19	.7393	.1303	.1762	.7340
	1/D	19	2.5020	.7351	.2938	2.4407
	E 1/D	19	.4774	.2580	.5404	.4000
	J'	19	.6718	.1598	.2378	.6196
	Simpson Estimate	19	.3720	.1471	.3954	.3799
	Simpson Scaled	19	.5828	.1812	.3109	.6171
	E_{VAR}	19	.4525	.2285	.5049	.4130
Combined	D	52	.4272	.1448	.3389	.3977
	H'	52	1.0795	.3357	.3109	1.1247
	H' Log10	52	.4688	.1458	.3110	.4884
	Shannon Scaled	52	.3443	.1071	.3109	.3587
	1-D	52	.5728	.1448	.2528	.6023
	E 1-D	52	.7772	.1314	.1691	.7523
	1/D	52	2.5220	.6092	.2415	2.5144
	E 1/D	52	.5328	.2777	.5212	.4920
	J'	52	.7079	.1824	.2577	.6859
	Simpson Estimate	52	.3325	.1444	.4344	.3589
	Simpson Scaled	52	.5988	.1514	.2528	.6297
	E_{VAR}	52	.5005	.2815	.5625	.4052

N= Number of analytical units for each component.

Table 20. Results of Mann-Whitney U Test Comparing Temporal Components for Cathlapotle Richness, NISP, Density, and Accumulation Rate.

Component	Statistic	NISP	Richness	NISP Density	Richness Density	NISP AR *	Richness AR *
Postcontact	N	33	33	33	33	33	33
	Mean	97.52	6.18	26.83	2.06	2.44	.15
	St.Dev.	121.93	3.75	31.81	1.26	3.05	.09
	Median	37.00	5.00	15.75	1.78	.93	.13
Precontact	N	19	19	19	19	19	19
	Mean	185.84	7.16	42.60	2.53	.53	.02
	St.Dev.	360.21	4.38	63.10	1.31	1.03	.01
	Median	37.00	7.00	20.75	2.33	.11	.02
Mann-Whitney U Test	Mann-Whitney U	286.00	274.00	258.00	245.00	162.00	6.00
	Wilcoxon W	847.00	835.00	819.00	806.00	352.00	196.00
	Z	-.523	-.753	-1.055	-1.302	-2.880	-5.852
	Asymp. Sig. (2-tailed)	.601	.451	.292	.193	.004	.000

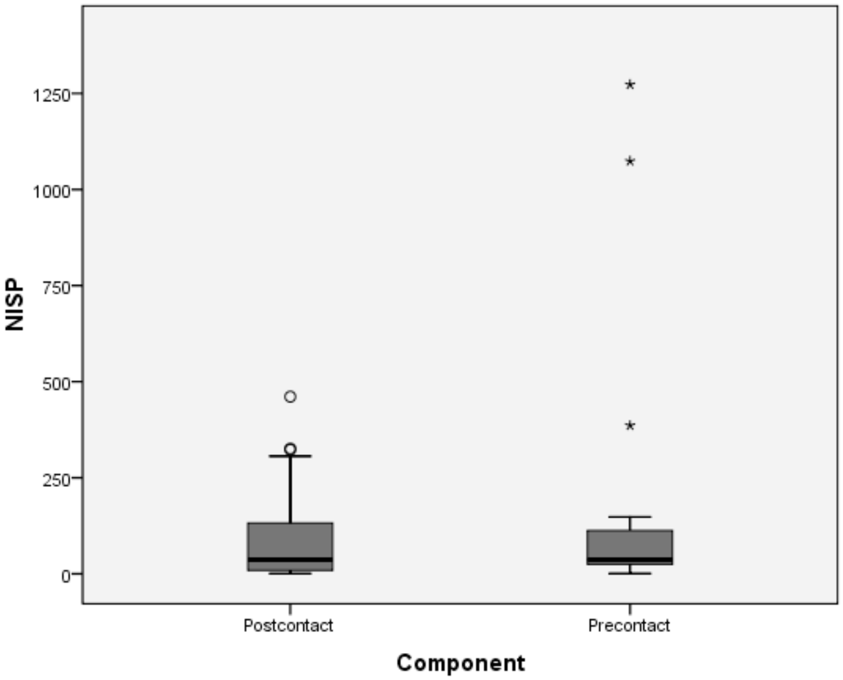

Figure 3.34. Boxplot of Cathlapotle comparing frequency of NISP by excavation unit for precontact and postcontact components. Shaded box represents values within 25th to 75th percentiles. Whiskers represent values within 1.5 box lengths. Points represent outlier AU's. Central bar represents median.

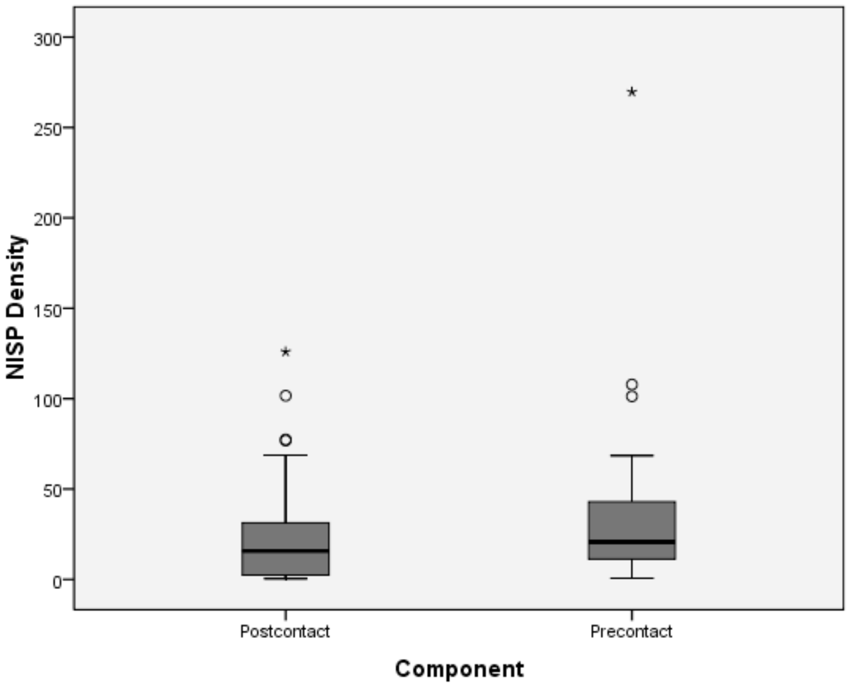

Figure 3.35. Boxplot of Cathlapotle comparing NISP density (NISP/m^3) by excavation unit for precontact and postcontact components. Shaded box represents values within 25th to 75th percentiles. Whiskers represent values within 1.5 box lengths. Points represent outlier AU's. Central bar represents median.

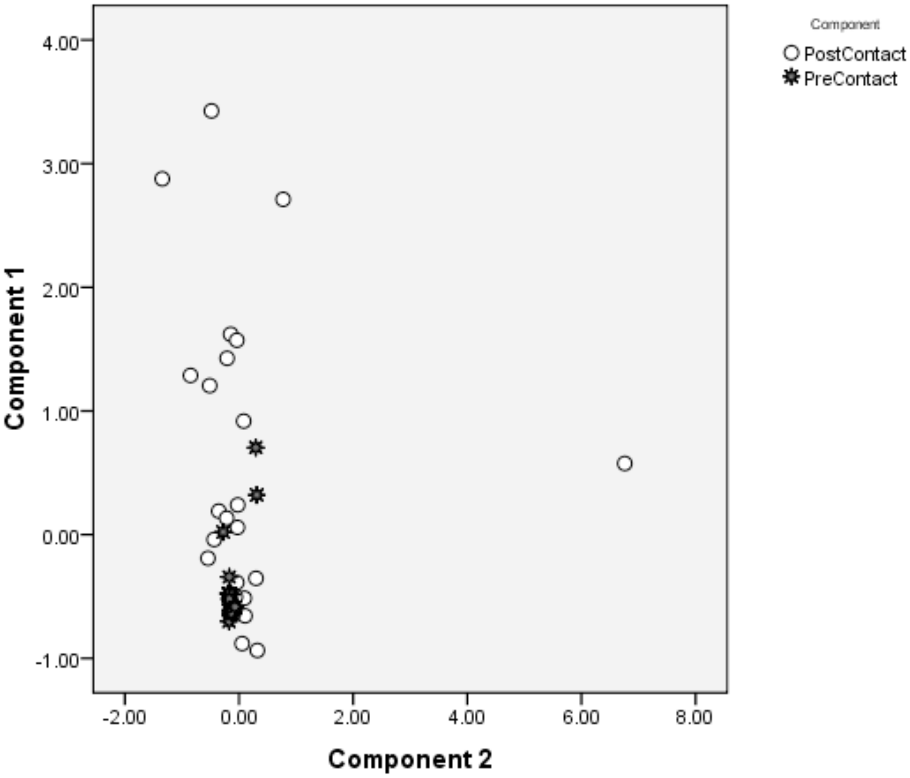

Figure 3.36. PCA components 1 and 2 based on time corrected NISP for all taxa.

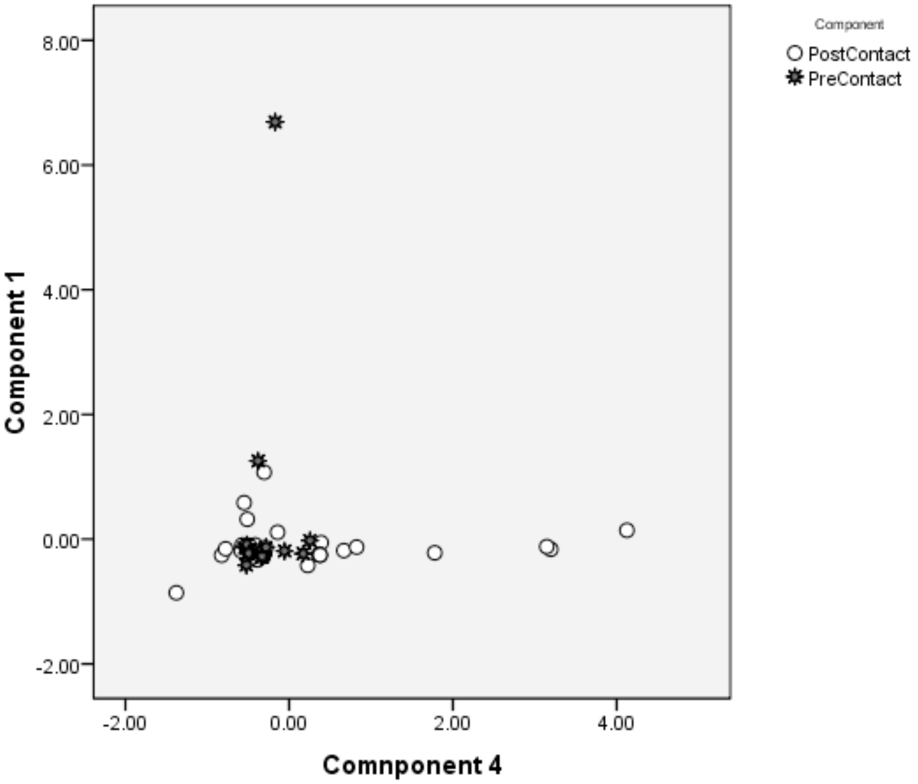

Figure 3.37. Components 1 and 4 of a PCA based on NISP with rare taxa (NISP < 2) removed.

Cathlapotle

Tables 3.17 and 3.18 show excavation unit NISP means and related statistics for all species identified at Cathlapotle as well as unit NISP and richness. Table 3.19 shows summary statistics for diversity and evenness measures at Cathlapotle. Normal distribution is a rare thing in units at Cathlapotle (for example, Figures 3.31 to 3.33). NISP for all taxa, combined and individually, densities, and diversity measures all had distributions that diverged significantly from normal. With this in mind, non-parametric tests were used as appropriate.

There was no relationship between volume and richness (R = .295). Nor was there a significant relation between volume and NISP (R = .291). This was also the case when the data set was split into precontact and postcontact components and when looking at only individual houses. A Mann-Whitney U test indicated that there was also no significant difference in the mean volumes for precontact and postcontact. This indicates that an excavation sample bias is not affecting the assemblage in terms of richness.

Regression analyses suggested two outliers. This is again confirmed when looking at boxplots of various aspects of the data set (Figure 3.34). These units, N 107-109 / W 98-100 and N 159-160 / W 103-107, are located in sheet middens associated with Houses 2 and 1 respectively. Features in these units all come from precontact levels. Unit N 107-109 / W 98-100 has two hearths at the bottom of a fairly deep excavation unit. Unit N 159-160 / W 1030-107 has several features occupying both precontact and postcontact. Both are characterized by very high NISP and richness. The large number of elements is largely the result of an unusual abundance of deer and elk. In fact, these two units have an unusually large number of deer and elk elements present relative to the entire site, not just the sample being dealt with here defined by the presence of hearth and related features. Neither of these units tended to stand out in a number of exploratory tests. Mann-Whitney U tests were run with and without them.

Because the data were skewed, non-para-

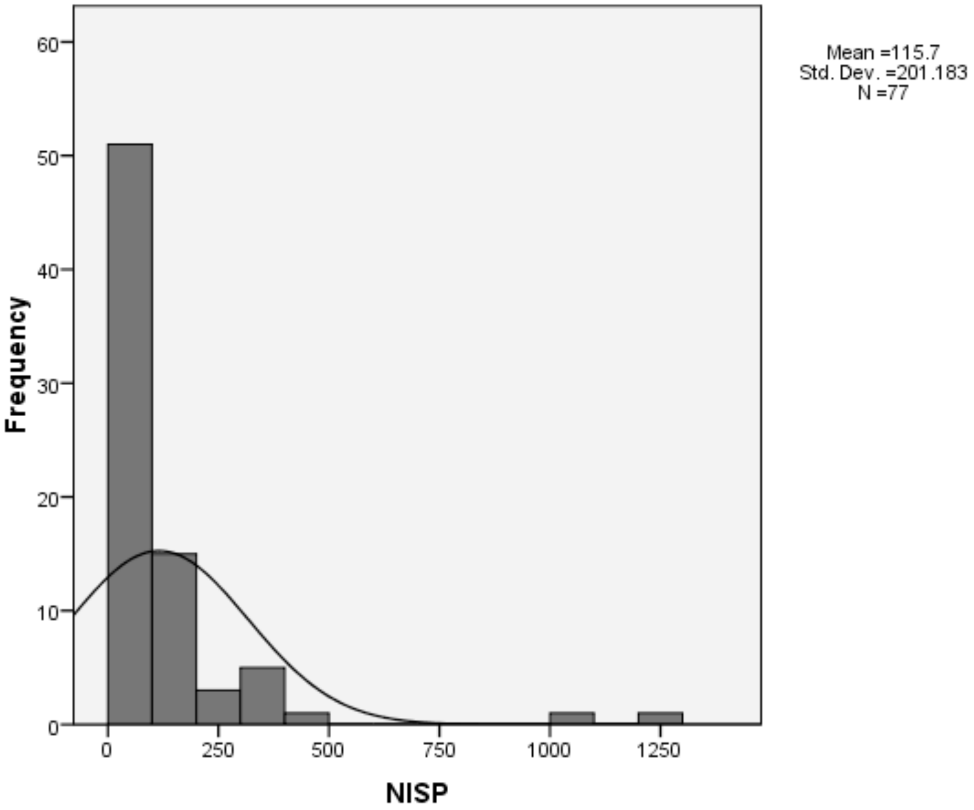

Figure 3.38. Histogram of distribution of total unit NISP, Cathlapotle and Meier assemblages combined, with frequencies by number of analytical units.

metric Mann-Whitney U tests were used to compare various characteristics of the site. There were, however, few significant differences to be noted. A few comparisons here and there had significant differences, but many of these were dependent on how the site was partitioned. For instance, when the site is split up into six broad areas using the houses and their associated middens as grouping variables, without differentiating interior or exterior spaces, the combined House 1 and its sheet midden have significantly fewer dog, bear and raccoon elements than House 2 and its sheet midden. Several other taxa were approaching the .05 significance level as well. However, the area for House 2 consists of only two AU's, one of which is one of the previously mentioned outliers. When this AU is removed, so just the interior House 2 unit is used for comparison, it does not have significant differences.

When looking at temporal components, there are, again, few significant differences seen in Mann-Whitney tests of means. There tended to be higher raw NISP frequencies in precontact AU's (mean NISP = 185.84) than postcontact (mean NISP = 97.52). Precontact AU's also tended to be richer (mean richness = 7.16) than postcontact AU's (mean richness = 6.18). Again, however, a Mann-Whitey U test did not find a significant difference between precontact and postcontact for either NISP or richness (*p* = .601 and .451 respectively). Postcontact AU's also tended to be more even than precontact (Table 3.19, Appendix H shows diversity and evenness measures by site associations for each component). Obviously, these precontact means are greatly influenced by the two outlier AU's. With these AU's are removed precontact means drop slightly below postcontact NISP and richness (revised precontact mean NISP = 69.95, mean richness = 6.12). When density (richness or NISP per m of excavated sediment) was used to normalize sample sizes the results were also not significant (Figure 3.35). However, accumulation rates of NISP were significantly different between precontact and postcontact. Table 3.20 summarizes these results.

Table 3.21. Normality Tests for Combined Dataset.

			Kolmogorov-Smirnov			Shapiro-Wilk		
Division	Subdivision	Measure	Statistic	df	Sig.	Statistic	df	Sig.
Combined								
	n/a	NISP	.284	77	.000	.528	77	.000
	n/a	Log10 NISP	.095	77	.084	.969	77	.059
	n/a	Richness	.097	77	.073	.952	77	.005
	n/a	Elk-Index	.087	77	.200	.961	77	.018
Site								
	Cathlapotle	NISP	.295	52	.000	.539	52	.000
	Meier		.146	25	.180	.881	25	.007
	Cathlapotle	Log10 NISP	.101	52	.200	.975	52	.336
	Meier		.133	25	.200	.927	25	.073
	Cathlapotle	Richness	.131	52	.025	.932	52	.005
	Meier		.138	25	.200	.962	25	.454
	Cathlapotle	Elk-Index	.109	52	.178	.947	52	.022
	Meier		.148	25	.163	.924	25	.062
Component								
	Postcontact	NISP	.178	46	.001	.832	46	.000
	Precontact		.382	31	.000	.448	31	.000
	Postcontact	Log10 NISP	.114	46	.165	.924	46	.005
	Precontact		.105	31	.200	.969	31	.493
	Postcontact	Richness	.112	46	.192	.955	46	.071
	Precontact		.141	31	.121	.928	31	.038
	Postcontact	Elk-Index	.118	46	.112	.965	46	.177
	Precontact		.089	31	.200	.950	31	.161
Interior/Exterior								
	Exterior	NISP	.329	28	.000	.515	28	.000
	Interior		.194	49	.000	.797	49	.000
	Exterior	Log10 NISP	.108	28	.000	.977	28	.772
	Interior		.097	49	.200	.946	49	.025
	Exterior	Richness	.132	28	.200	.936	28	.090
	Interior		.107	49	.200	.947	49	.028
	Exterior	Elk-Index	.107	28	.200	.955	28	.259
	Interior		.118	49	.084	.952	49	.045

A significance value less than .05 indicates a non-normal distribution.

When testing means between precontact and postcontact, only hare/rabbit (*Lepus americanus*/*Sylvilagus floridamus*) and bobcat (*Lynx sp.*) showed a significant difference in Mann-Whitey U tests (p = .034) when all AU'ss were considered, with bobcats falling just above this level (p = .055). When the two outlier AU's were removed, bobcats dropped beneath the .05 significance level (p = .031). These were the only taxa that showed significant differences in their distributions. Nor did any diversity measure show significant changes between precontact and postcontact.

Exploratory grouping tests had mixed results. Cluster analysis produced no obvious patterns. No transformations or trimming of the data

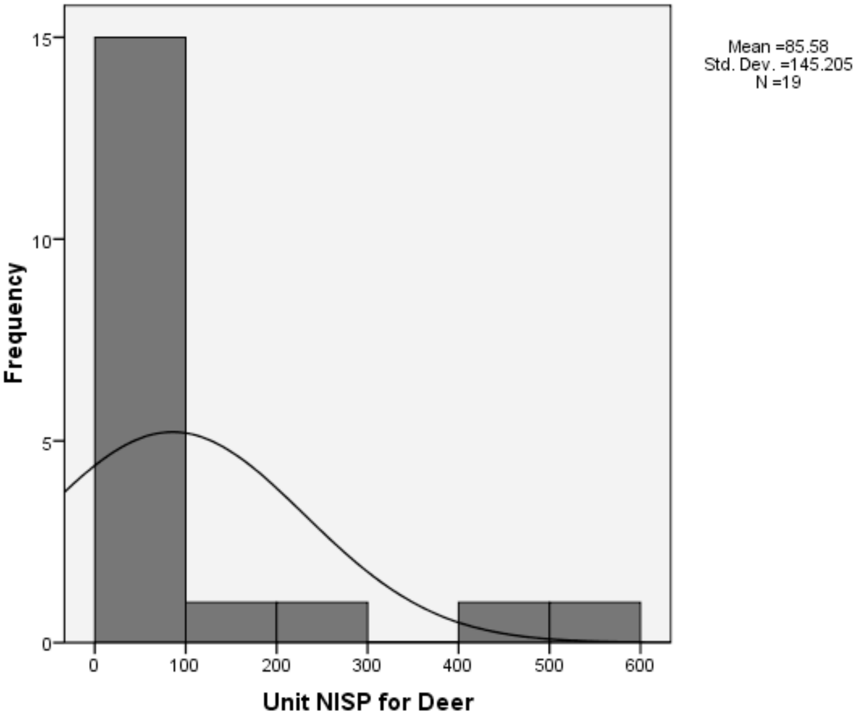

Figure 3.39. Histogram of NISP for deer found in interior contexts at Cathlapotle with frequencies by number of analytical units.

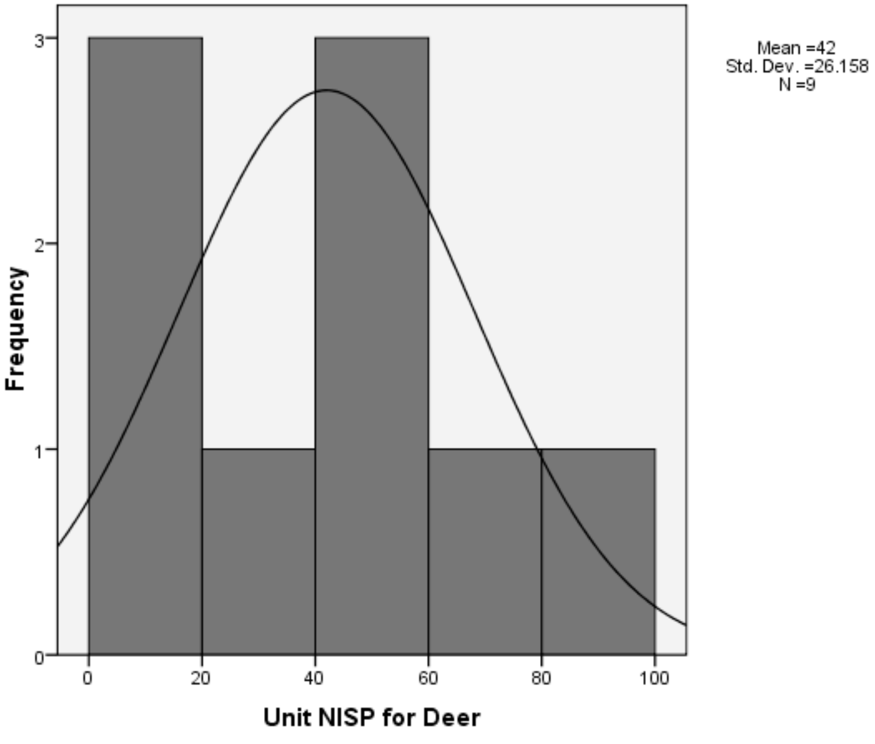

Figure 3.40. Histogram of NISP for deer found in interior contexts at Meier with frequencies by number of analytical units.

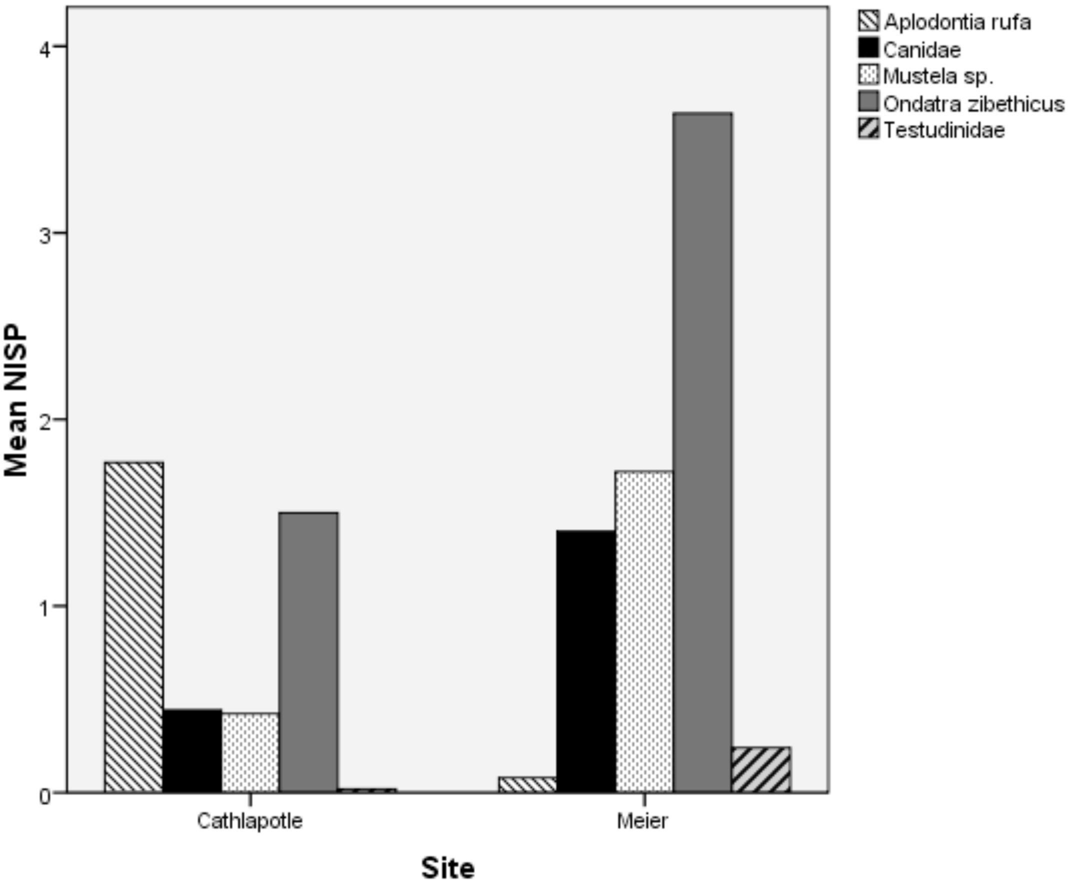

Figure 3.41. NISP for taxa with significant differences ($p < .05$) between sites based on a Mann-Whitney U test.

could produce groupings that translated to meaningful organization.

Principle component analysis, however, was more suggestive of underlying patterning in the data. While PCA at Meier tended to produce relatively few components, almost all tests (with the exception of a PCA based on diversity measures) produced more than four components. All tests, when components were plotted against one another, tended to show the same pattern, namely a rather tight group of precontact AU's, with postcontact AU's spreading away from this cluster. For example, Figure 3.36 shows the first two components of a PCA (with varimax rotation) based on accumulation rates for each taxon. The first two components account for about 40% of variation in the data. The first of these components is weighted heavily on, in order, elk, deer, bobcat, river otter, mountain beaver and beaver. The second component is associated with fishers and raccoons.

The general pattern of a tightly grouped precontact cluster with postcontact spread around it was fairly consistent. The only test that did not produce this pattern at some level was when diversity measures were used as the basis of the PCA, although oddly this particular test produced the fewest number of factors. Overall, the species mentioned above, with the addition of rabbits, were most often associated with this postcontact spread. The combination of species was not consistent however. For example, Figure 3.37 shows component 1 and 4 of a PCA based on NISP in which several unique taxa (such as sheep) have been removed. The total variance explained by these two components, after rotation, is 62.65%. The "spreading" component, component 4 in this case, is heavily associated with rabbits.

Discriminant analyses looking at temporal components were able to build models robust enough to succeed at least in part in placing cases

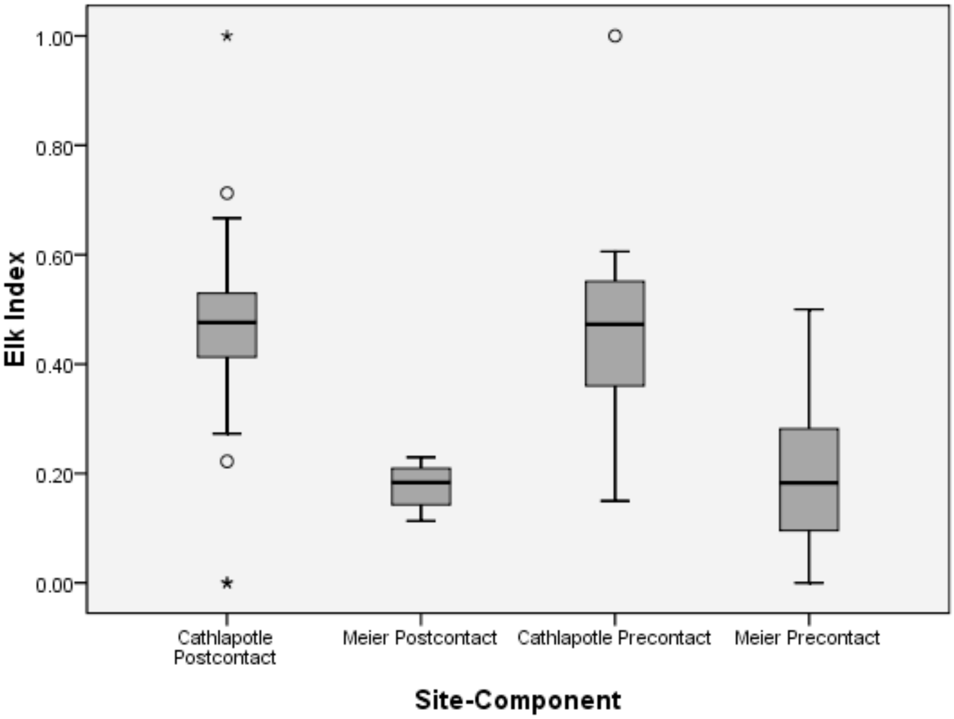

Figure 3.42. Boxplot of excavation unit elk-index values for site and component. Shaded box represents values within 25th to 75th percentiles. Whiskers represent values within 1.5 box lengths. Points represent outlier AU's. Central bar represents median.

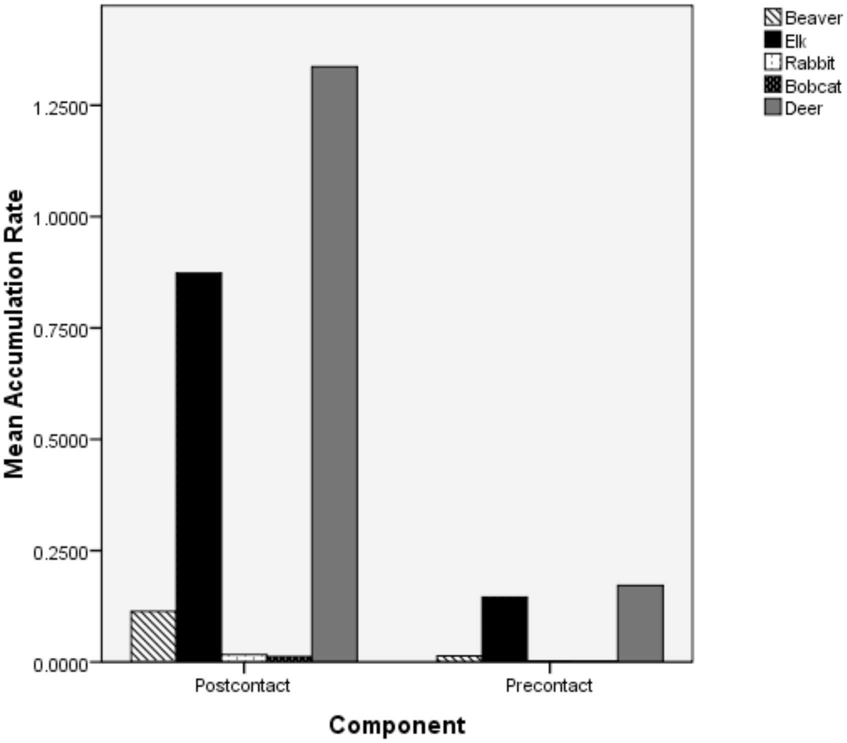

Figure 3.43. Precontact and postcontact accumulation rate means for species with significant differences between temporal components.

Table 3.22. Taxa with Significant Changes from Precontact Compared to Postcontact Based on Accumulation Rates.

Test	Beaver	Elk	Rabbit	Bobcat	Deer
Mann-Whitney U	348.00	240.00	558.00	493.00	267.50
Wilcoxon W	844.00	736.00	1054.00	989.00	763.50
Z	-3.84	-4.92	-2.09	-2.97	-4.63
Asymp. Sig. (2-tailed)	.00	.00	.04	.00	.00
Kolmogorov-Smirnov Z	2.76	2.63	1.40	1.59	2.81
Asymp. Sig. (2-tailed)	.00	.00	.04	.01	.00

that were not part of the original model. For example, a model based on diversity measures for a 65% sample correctly placed sampled AU's 81.8% of the time into the correct component. Under cross-validation 60.6% of AU's were correctly placed into precontact or precontact components. Of AU's that were not part of the original sample used to build the model, 57.9% were correctly placed. Precontact AU's were correctly grouped 66.6% of the time and postcontact AU's 50% of the time.

Using accumulation rates, the results were similar. The basic model correctly grouped 78.8% of the AU's into precontact or postcontact. 54.5% of AU's were correctly grouped under cross-validation. Of the unselected cases, 63.2% were correctly grouped. As above, for both cross-validation and placement of unselected AU's, the majority of incorrectly grouped AU's were postcontact mistakenly assigned as precontact. Removing deer and elk and rerunning the test slightly increased success of the initial model (81.8%) and cross-validation (57.6%) while slightly decreasing success at placing test AU's (57.9%).

The results of the PCA and DA suggest two things, first that there are some basic differences in the faunal characteristics of AU's containing hearth and related features between precontact and postcontact. For instance, the increase in accumulation rates of elk, deer, bobcat, river otter, mountain beaver and beaver was visible in PCA analysis. Second, this difference is somewhat subtle, and is seen more in the interactions of multiple taxa than through the direct influence of any one or two. This is seen most directly in how little difference removing deer and elk from the last discriminant analysis made. Further, as just noted, while PCA showed the influence of changing accumulation rates of several species, direct comparison of NISP of various species did not tend to produce significant results. No tests were successful at sorting unit locations within the site. This suggests a fair degree of uniformity between households and within households at the Cathlapotle.

Combined Cathlapotle and Meier Fauna

As with feature size, this section allows direct comparison of sites. Further, by treating these sites as a sample of a target population, the following analyses present the opportunity to begin exploring patterning at the higher scale of the Wapato Valley as a whole.

As before, the first step is looking at basic shape of distributions. Kolmogorov-Smirnov (with Lilliefors significance correction) and Shapiro-Wilk tests were used to determine distribution. Visual observation of histograms was used for confirmation when there was doubt about distributions. Not surprisingly, there is a mix of normal and less than normal distributions depending on how the dataset is subdivided. For instance, Table 3.21 summarizes the results for normality tests for several subdivisions of the dataset for NISP, log10 transformed NISP, richness, and elk-index. The log10 transformation was carried out on NISP simply because NISP was so skewed (Figure 3.38).

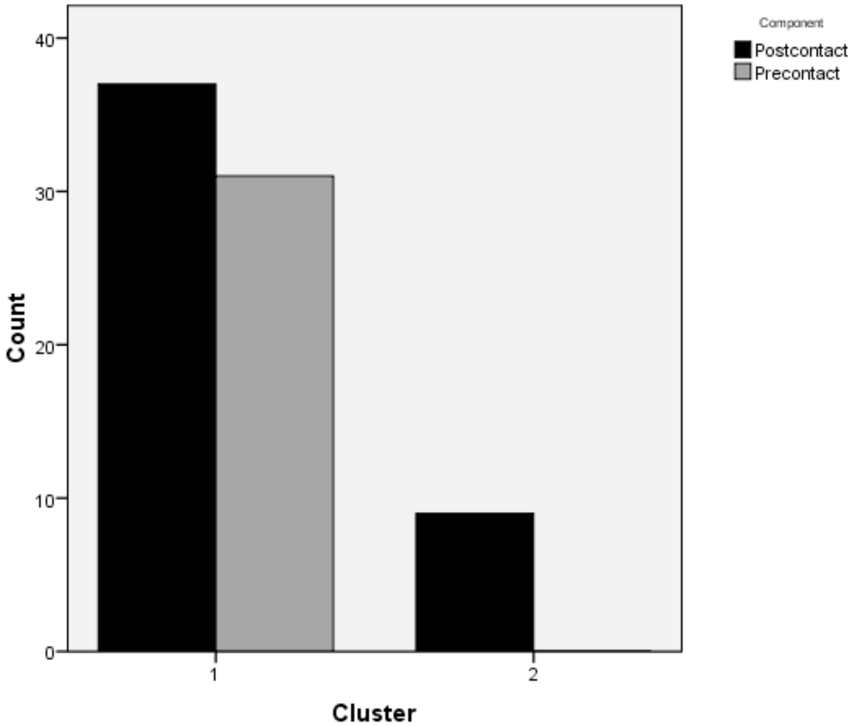

Figure 3.44. Ward's method hierarchical cluster analysis two cluster solution with Cluster 1 consisting of mixed precontact and postcontact AU's and Cluster 2 containing only postcontact AU's.

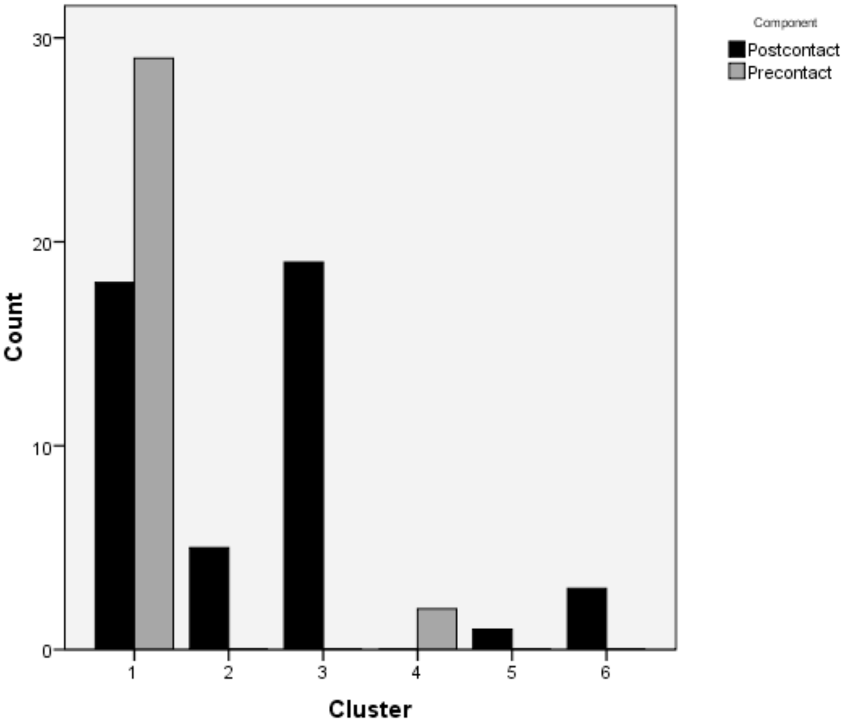

Figure 3.45. Ward's method hierarchical cluster analysis six cluster solution showing postcontact and precontact AU's separating in Clusters 2 through 6.

Table 3.23. Taxa with Significantly Different Means and/or Distributions Based on Mann-Whitney U and Two Sample Kolmogorov-Smirnov Tests Compared by Site/Temporal Component Treated as a Single Grouping Variable.

		Cathlapotle Postcontact	Meier Postcontact	Cathlapotle Precontact
Cathlapotle Postcontact	NISP			
	Accumulation Rate			
Meier Postcontact	NISP	Dog, Rabbit, River Otter, Mink Deer, Mustrat, Raccoon, Turtle		
	Accumulation Rate	Dog, Rabbit, River Otter, Mink, Deer, Muskrat, Raccoon, Turtle		
Cathlapotle Precontact	NISP	None	Beaver, Mink, Deer, Muskrat	
	Accumulation Rate	Elk, Rabbit, Deer	Dog, Beaver, Elk, River Otter, Mink, Deer, Muskrat, Raccoon, Bear(?)	
Meier Precontact	NISP	Elk, Muskrat	Beaver, Elk, Bobcat (?), Deer	Mountain Beaver (?), Elk, Seal
	Accumulation Rate	Beaver, Elk, Deer	Beaver, Elk, River Otter, Bobcat (?), Mink, Deer, Muskrat, Raccoon, Bear	Mountain Beaver (?), Elk, Seal

Taxa with question marks are borderline cases where calculated significance was either just above or just below the .05 level.

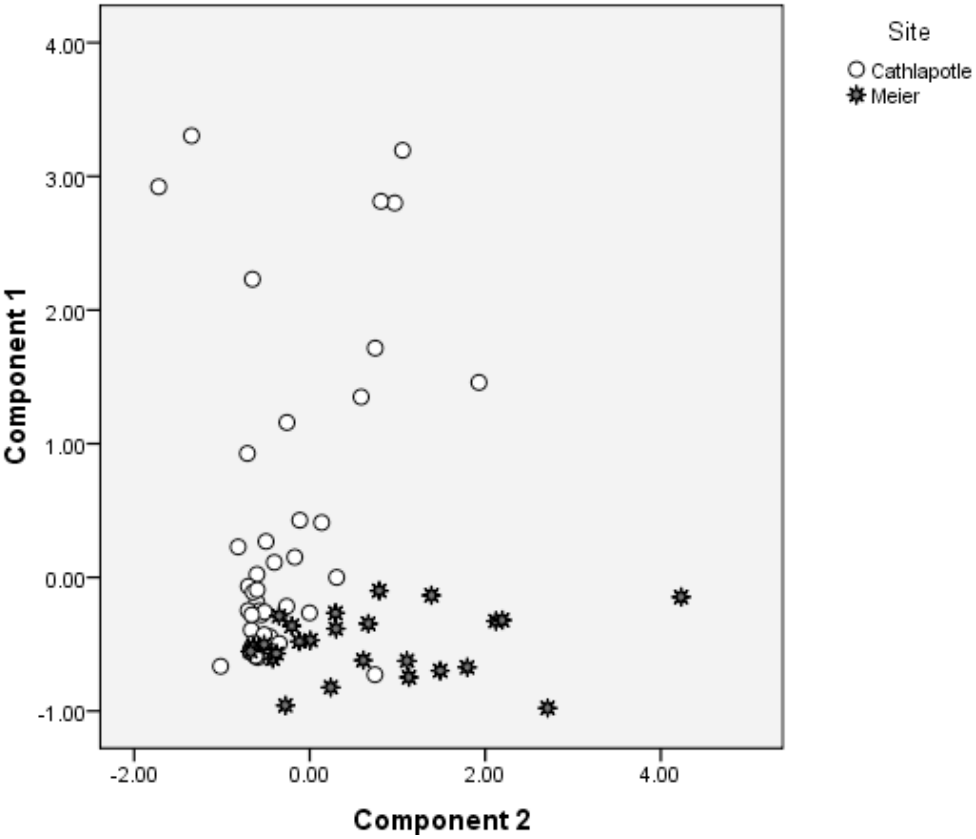

Figure 3.46. PCA components 1 and 2 based on NISP with markers by site.

No individual taxon was normally distributed. This did not change, as a rule, when the dataset was subdivided (for instance, when only looking at the distribution of NISP of deer by unit in interior contexts at Cathlapotle or Meier [Figures 3.39 and 3.40]). The exception to this was beavers, which became normally distributed when the sites were combined. Similarly with both sites' assemblages combined only the diversity measures E1/D and 1-D were normally distributed among all diversity measures. When the dataset was split by component, the diversity measure J' also became normally distributed for precontact AU's. In general, however, diversity measures were all skewed significantly. The two outlier AU's identified at Cathlapotle were still stand outs, but removing them had little effect on normality tests.

There was little sign of sample bias based on volume excavated with an R of less than .3 when Richness, NISP, and Log NISP when each was used as a dependent variable for a regression analysis. There was a relation between NISP and richness ($R^2 = .828$, $p < .001$). With three exceptions, all AU's were within 95% confidence intervals for the relation. The three outliers, two from Cathlapotle and one from Meier, were characterized by low richness values compared to their NISP (Cathlapotle) or very high richness values (Meier). Again, removing these AU's had no noticeable effect on distributions. As with all outliers, subsequent tests were run both with them included and excluded.

Mann-Whitney U and two-sample Kolmogorov-Smirnov tests showed relatively few significant differences in direct paired comparisons. When NISP for individual species was compared by site, mountain beaver, dog, mink, muskrat, and turtle showed significant Mann-Whitney U test differences. Mountain beaver are more numerous at Cathlapotle, dog, mink, muskrat, and turtle at Meier (Figure 3.41). When accumulation rates based in time are compared, rabbit and hare (combined) also become significantly different, with Cathlapotle having a much higher rate.

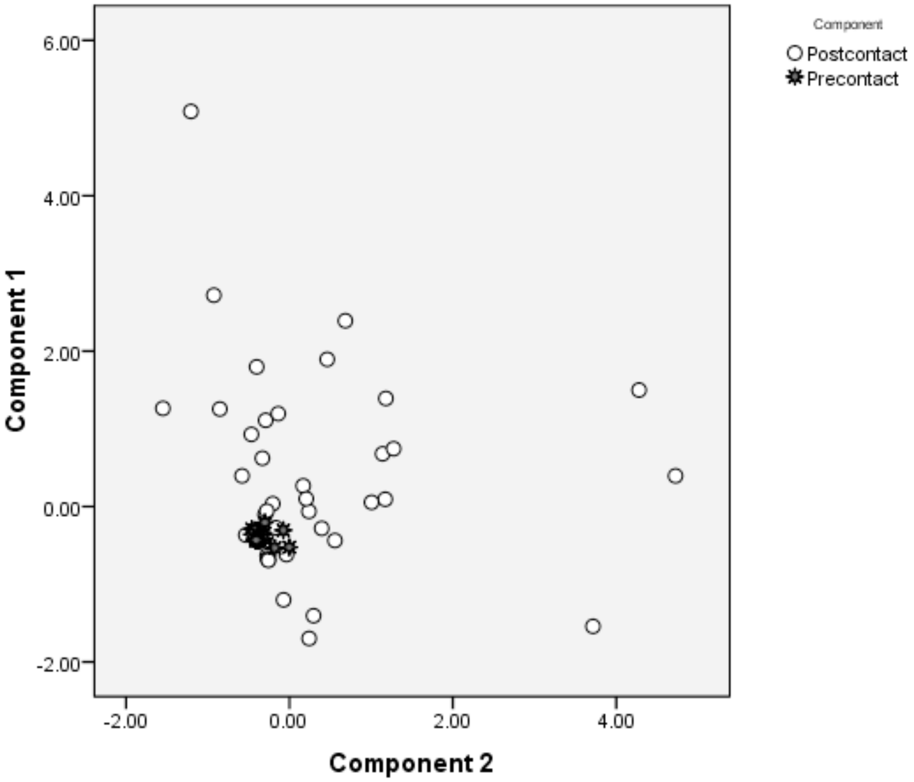

Figure 3.47. PCA components 1 and 2 based on accumulation rates of common taxa (NISP > 2) with markers by component.

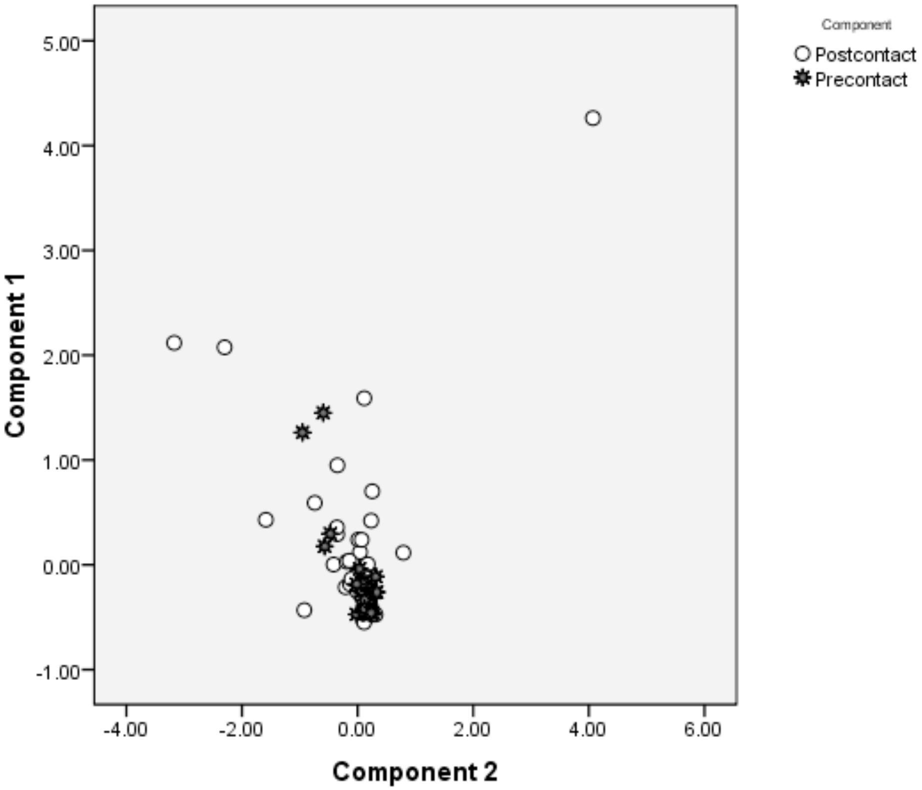

Figure 3.48. First two CA components based on NISP with markers by component.

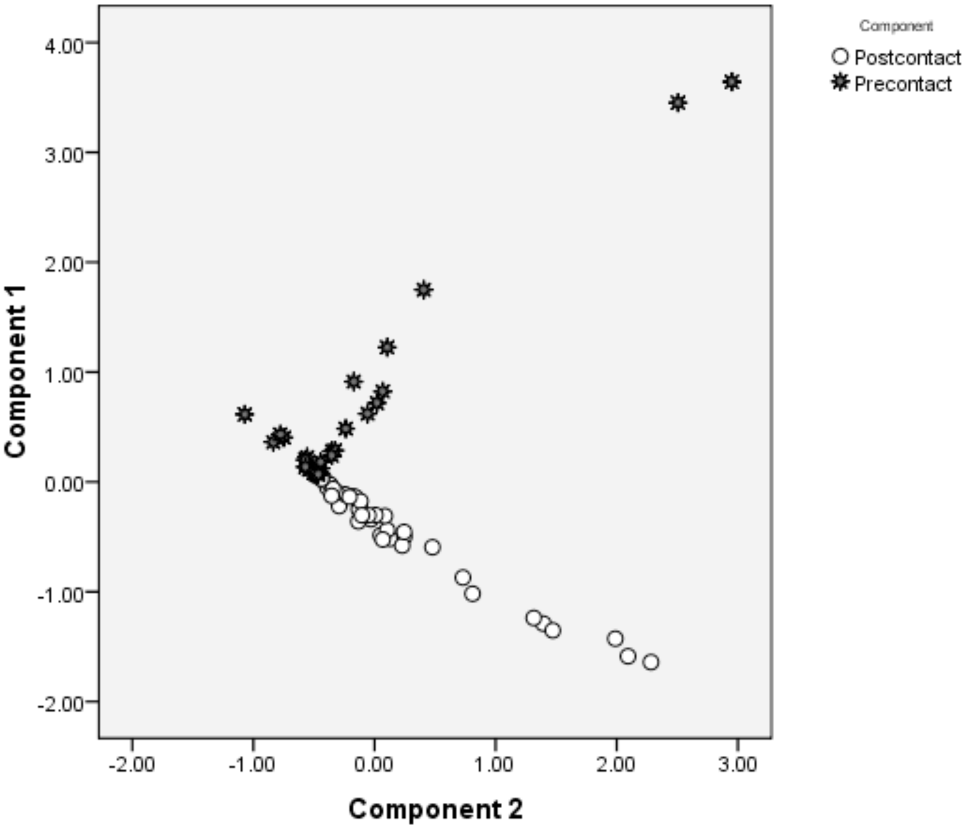

Figure 3.49. First two CA components based on accumulation rates.

Elk index values were a somewhat special case. There was a significant difference between sites for both Kolmogorov-Smirnov and Mann-Whitney U tests ($p < .001$ in both cases). However, there was no difference between precontact and postcontact at the sites individually when comparing temporal components. Despite an overall increase in deer and elk representation in the postcontact period at both sites, the ratios of deer to elk did not change. Means of the elk index (and a supplementary elk accumulation rate index) did not change at either site between precontact and postcontact (Figure 3.42). In order to explore this somewhat further, several additional ratios were calculated including deer-elk to total NISP, deer to elk accumulation rates, and a large mammal to total NISP. In general the pattern seen in the elk index was reproduced with significant differences in means between sites but not temporal components.

When NISP was used to compare components, only bobcat showed a significant difference. Nor were there any differences when using richness, total NISP, or log transformed NISP. However, accumulation rates for individual species showed significant differences for beaver, elk, rabbit, bobcat and deer (Table 3.22, Figure 3.43). All differences were associated with increases into the postcontact.

Whether using NISP and accumulation rates several species consistently had significantly different means and/or distributions. Table 3.23 shows taxa with significant ($p < .05$) results for site-component pairs. Deer, elk, and muskrat (in that order) appear most often. Differences for deer and elk are driven in no small part by several AU's with very high counts, especially at Cathlapotle in the precontact period. Removal of the two AU's with the highest NISP for deer and elk did not, however, change the results for any pair of comparisons. Muskrat differences are pushed by a very high mean at Meier in the postcontact and a very low mean at Cathlapotle. In paired comparisons, tests with Meier postcontact as one half of the pair tended have larger number of significant taxa.

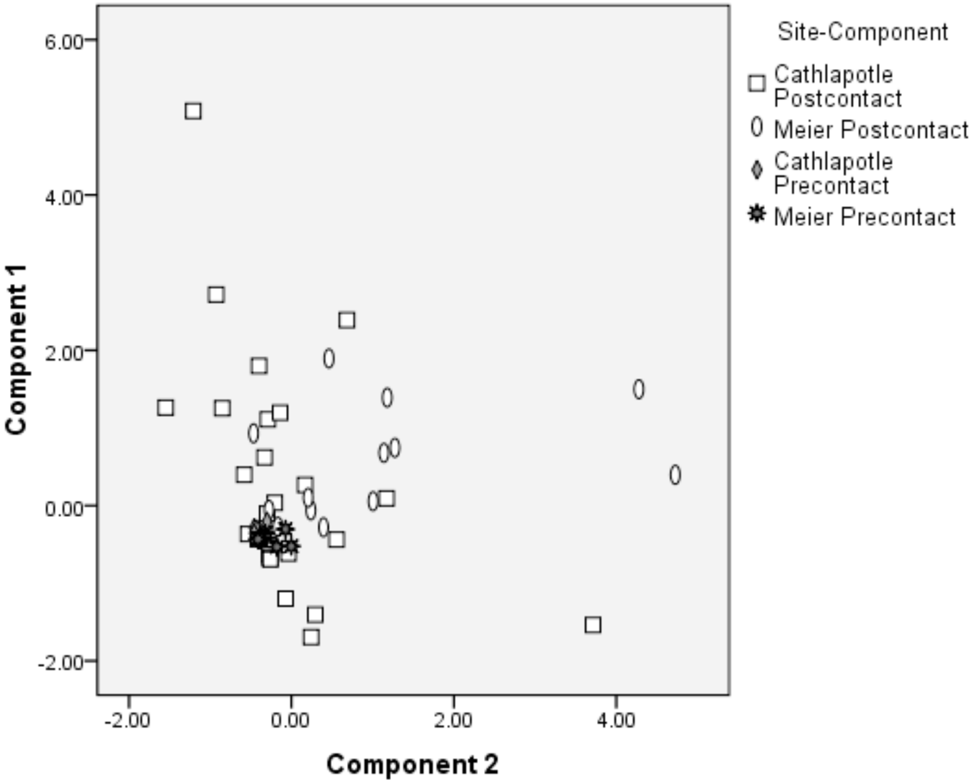

Figure 3.50. PCA components 1 and 2 based on accumulation rates.

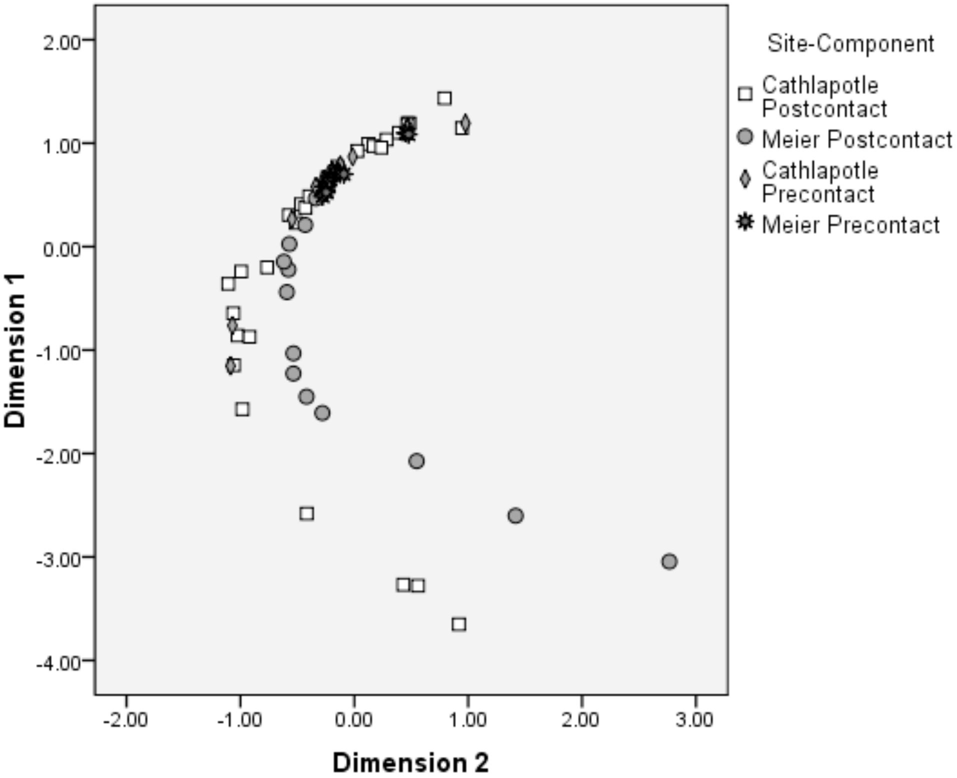

Figure 3.51. Multidimensional scaling dimensions 1 and 2 based on accumulation rates.

Table 3.24. PCA Components and Associated Species and Sites.

	Component					
	1	2	3	4	5	6
Associated Species	Elk, Mountain Beaver, Beaver, Seal	Deer, Mink, Muskrat, River Otter, Cougar	Fisher, Squirrel, Bobcat	Bear, Domestic Sheep	Horse, Rabbit	Dog
Associated Site	Cathlapotle	Meier	Meier	Cathlapotle	Cathlapotle	Meier

Table 3.25. Discriminant Analysis Groupings of Test Analytical Units by Percent.

	Percent Predicted Group			
Original Group	Cathlapotle Postcontact	Meier Postcontact	Cathlapotle Precontact	Meier Precontact
Cathlapotle Postcontact	20.00	.00	60.00	20.00
Meier Postcontact	16.70	83.30	.00	.00
Cathlapotle Precontact	.00	.00	80.00	20.00
Meier Precontact	.00	.00	40.00	60.00

Table 3.26. Discriminant Analysis Mean Groupings of Test Analytical Units by Percent.

	Percent Predicted Group			
Original Group	Cathlapotle Postcontact	Meier Postcontact	Cathlapotle Precontact	Meier Precontact
Cathlapotle Postcontact	31.09	10.70	32.69	24.74
Meier Postcontact	11.88	62.47	9.44	16.02
Cathlapotle Precontact	15.32	.02	52.13	32.57
Meier Precontact	20.55	.00	35.65	43.31

Based on 1000 bootstrap simulations.

Hierarchical cluster analysis was used as a first step in exploratory data analysis. Dendrograms produced by hierarchical cluster analysis tended to be complex and lacking in obvious patterning when all taxa and NISP were used. However, when using the edited sample of taxa (Table 3.13), Ward's method was able to begin splitting precontact and postcontact AU's (Figures 3.44 and 3.45). Depending on where one trims the resulting dendrogram, two to six clusters can be identified. These break down fairly consistently. A two cluster solution produces one larger mixed group containing both postcontact and all precontact AU's and one smaller cluster with only postcontact AU's.

When trimmings were done to produce larger numbers of clusters, additional groups were largely variations in postcontact AU's. This suggests a base of relatively similar AU's, to which most precontact AU's belong. From this base, greater variability appears in the postcontact period. Precontact AU's that break away and form cluster 4 in Figure 3.45 are the outlier AU from Cathlapotle discussed above.

Factor analysis was performed using NISP values and accumulation rates for various grouping of the data. Using NISP, PCA with rotation was able to differentiate sites (Figure 3.46). There are several interesting things to note about this analysis. First, the first two components (of six) were both loaded towards a slightly different group of fur trade species. The Cathlapotle "arm" was defined by the first component with elk, mountain beaver, and beaver having larger loadings. The second component, which stretched the Meier AU's out along the X axis, had heavy loadings on deer, muskrat, and raccoon. Subsequent components also tended to be associated with one or the other site (Table 3.24).

Using NISP as the basis of the PCA also began to sort out temporal components, although to a lesser degree. In general, precontact analytical units were restricted to a relatively small portion of the graph, while postcontact AU's spread from this point. This clustering was highlighted when accumulation rates were used as the basis of the PCA. Again, using all taxa produced results that were still fairly complex with six components. Excluding the rarest of species (NISP < 2), reduced the complexity to four components. Across these components the precontact/postcontact pattern was consistent (Figure 3.47).

Correspondence analysis produced similar results when using NISP as the basis of the test (Figure 3.48). When accumulation rates were used many of the precontact AU's spread out along the first component (Figure 3.49). There was still a common center of similar precontact and postcontact AU's. As this pattern emerged the question followed as to whether it can be related with an increase in population. If population was a significant factor in the pattern, there should be a clear difference between Cathlapotle (supported by multiple houses with a larger population) and Meier (with its single house) in both the postcontact and the precontact. This should be visible using PCA, with each site associated with a principle component or portion of a component especially in the precontact. When a scatterplot is marked using site and temporal component combined into single variables, it becomes apparent that the precontact core remains intact but not differentiated by site, with Cathlapotle and Meier precontact AU's becoming indistinguishable (Figure 3.50). Postcontact UA's from the sites are still split, but this can again be attributed to different species loading on the components in different ways.

This pattern is again seen when a multidimensional scaling analysis is undertaken. Using the edited dataset the model produced is fairly robust with a stress = .19317 and a R^2 = .96382 (Figure 3.51). In this case, the extension along the Y axis is caused by deer and elk, with other taxa causing the arcing pattern along the X axis. Adding additional taxa causes the two arms of the pattern to move closer together, but the overall pattern remains intact. If population had a major impact one would expect greater differences between the two sites especially in the precontact.

To further test patterning discriminant analyses were carried out. A 65% random sample of AU's was used for model building. In general, DA results followed PCA findings. Raw NISP values were quite successful at differentiating sites. The initial model correctly placed 96.1% of cases using all taxa. 73.1% of unselected cases were correctly grouped and 78.4% of cases were correctly grouped under cross-validation. The model was almost exactly as likely to place test AU's from Cathlapotle in Meier as the reverse, with 27% of unselected cases from each site misplaced. Using the edited data set of likely species exploited for the fur trade, the model was slightly more successful at grouping test cases. The initial model correctly placed 90.2% of cases. 76.5% of cross-validated cases were correctly classified. Test cases were correctly placed 80.8% of the time. Standardized canonical discriminant function coefficients associated deer and muskrat with Meier and elk and beaver with Cathlapotle, although all variables entered into the test were used in the final model.

Similar results were achieved using accumulation rates. Using all taxa, the model correctly placed 70.6% of cross-validated cases and 73.1% of test cases. Using the edited dataset, the model correctly grouped 84.3% of cross-validated cases and 73.1% of unselected cases.

Accumulation rates were also successful at separating precontact and postcontact. Using all taxa, the model correctly grouped 84.3% of selected cases (AU's). Only 64.7% of cross-validated cases were correctly grouped. However, 84.6% of AU's not in the initial model were correctly placed. The model was more likely to misplace postcontact AU's into precontact (27.3% of cases) than place precontact into postcontact (6.7%). Using the edited variable list the initial model was slightly less successful, correctly grouping AU's 76.5% of the time. Under cross-validation 64.7% of cases were correctly grouped. 80.8% of test AU's were correctly placed, with all incorrectly grouped cases misplaced from postcontact into precontact.

When the site and temporal component are combined into a single variable, DA was less successful at sorting cases. Using accumulation rates for all taxa a model was produced that correctly placed selected cases 76.5% of the time, test AU's 50% of the time, and 31.4% of AU's under cross-validation. With NISP and/or fewer species the model was even less successful at placing cases. It should be noted at this point that for all DA results presented thus far all AU's have been included. Removal of outliers had little impact, in some cases slightly improving results, slightly hurting them in other cases. In this case, exclusion of Cathlapotle's two outliers improved the model slightly, with 65.4% of test AU's correctly grouped.

Again the places where the models made mistakes can be suggestive of the larger pattern. Using accumulation rates and looking only at component for a moment, the model only misplaced postcontact AU's into precontact groups (Table 3.25). Precontact AU's were fairly stable in terms of component placement.

To test this general pattern, a bootstrap was run on the dataset generating 1000 discriminant analyses. Table 3.26 gives the mean percentages of placements for all 1000 runs. The derived models were still more likely to place postcontact AU's into precontact than the reverse. In no model were Meier precontact AU's grouped with Meier postcontact. A similar, although considerably less extensive, series of 20 tests where the 65% sample size was varied +/- up to 15% had similar results.

Summary of Faunal Analyses

This chapter presented results of analyses of the mammalian faunal assemblages from Cathlapotle and Meier. Several patterns were shown through this analysis. First, when using exploratory data analysis based on diversity and evenness measures, northern and central units at Meier tended to group together. Southern and exterior units also tended to group together in the same tests. Cathlapotle, on the other hand, does not show any well defined spatial patterning. At both sites, raw NISP and accumulation rates pointed to differences in representation of faunal elements between precontact and postcontact. In general, there is an increase in faunal representation in the postcontact. However, often the ratio of the representation of one taxon to another did not change, as seen when examining boxplots of an elk to deer index.

CHAPTER 6
DISCUSSION AND CONCLUSIONS

This report used exploratory data analysis and traditional significance testing to evaluate hypotheses dealing with production at the Cathlapotle and Meier sites in the Wapato Valley of Oregon and Washington. I proposed two hypotheses to be tested. These hypotheses were tested using two lines of evidence. First hearth structure, looked at in terms of variation in size, was analyzed. Second, the faunal assemblages associated with these features were analyzed. These hypotheses were:

I. Spatial: Cathlapotle with a larger labor pool and consumer demand will show more intensive investment in hearth features than Meier. This will be reflected in larger numbers of hearths with a greater diversity in size and form, relative to Meier, to meet demand. Similarly, there will also be a higher density of faunal elements associated with Cathlapotle. Further, these households were spatially organized by status (Smith 2008). This organization should be seen by greater diversity in fauna (driven by the presence of rare species) in high status areas of the house.

II. Temporal: Both sites were occupied at the beginning of the fur trade era in the Pacific Northwest (approximately A.D. 1792). Native populations were active participants in this new economy (Vaughn and Holm 1990). In order to meet the increased demands of the changing economic situation, there will be an increase in production seen in changes in the number of hearths and in the associated faunal assemblages in the postcontact period. Again, with its larger labor pool, the relative differences of faunal elements present between precontact and postcontact should be greater at Cathlapotle than Meier.

Using multiple methods several patterns became evident in the course of analysis of the metric and faunal data from Meier and Cathlapotle. These patterns fall under two general headings: change through time and variation across space. Different statistical methods tended to highlight different characteristics of the assemblages. No pattern was absolute, with at least a few excavation units violating some portion of the structure in almost every case.

In terms of spatial patterning, Meier was far more structured than Cathlapotle. Based on faunal data from Meier there was a clear segregation of house segments. This was seen in exploratory data analysis with northern and central units tending to group together consistently with greater variation in their assemblages. Southern and exterior units also tended to group together. These units' assemblages were more even and less rich than northern and central units.

Conversely, in terms of size, the northern hearths at Meier were significantly smaller than hearths located in other sections of the house. The southern hearth group had approximately twice the volume of the northern group. However, the central group had a similar volume to the southern.

This suggests a division within the house with different household segments occupying and using specific space. The northern hearths had a considerably smaller volume which can be equated with reduced production potential. This suggests that there was a much smaller population using them and/or that these hearths were only used infrequently. If the latter is the case, perhaps the people living at this northern end of the house used central and southern hearths on a day-to-day basis.

It is also worth noting that all of the northern hearths at Meier are situated in postcontact levels (Table 3.3). There is evidence to suggest that there was a large number of storage pits in the northern section of the house which were only filled in relatively late in the house's existence (Ames et al. 2008). These hearths could only have been built after these pits were filled in. Combined with size considerations, this suggests that there may have been a cultural shift in the final years of the house, with occupants of the northern section of the house limiting their contact with other members of the house. If these people were higher in status than household members living in other sections of the house (Smith 2008), the day to day use of central and southern hearths may have been done to reaffirm the communal aspect of the household. These were the people who may have had access to a wider range of relatively exotic species. This is suggested by the portion of the faunal assemblage associated with the northern section of the house being more diverse. The size indicates relatively short use-lives for these hearths, which would support the idea that they were late additions to the house. A similar pattern was seen at Cathlapotle in hearth size.

At Cathlapotle, hearths tended to become smaller in the postcontact, although less so than at Meier. There was also a shift in hearth placement. Although there were small exterior hearths in both precontact and postcontact, there was a significant increase in the relative number of hearths located in interior contexts at Cathlapotle in the postcontact. Even if hearths found in crossover contexts were actually used exclusively in the precontact, the number of postcontact hearths would almost double the total of precontact and crossover hearths. Again, this suggests a broadening of the base of potential production.

Alternately, an argument could be made that near the end of occupation at these sites, Meier and Cathlapotle became aggregation sites for refugees whose own households had been decimated by disease. In this scenario, there is less cohesion among people living in the house. There was no time for the effects of household transmission to integrate people into the existing household. As such, various people in the house would have been less likely to partake of communal production and distribution of food.

When looking at faunal assemblages, there is a clear shift in production from the precontact to the postcontact at both sites. This is illustrated in Figures 3.50 and 3.51 in which precontact analytical units at both sites are grouped into relatively small areas of the graphs with postcontact AU's spreading out from these points. There appears to be a core of production represented by tight clusters of precontact AU's. From this core of production, greater variability is present in the postcontact. This variability manifests in two ways. First, there is simply an increase in the accumulation rate of faunal specimens in the postcontact. Second, there is a drop in evenness at both sites. This is in part driven by massive increases in the representation of deer and elk. Analytically, this overall pattern in variability is visible when examining graphs of the results of various exploratory data analyses, with postcontact AU's stretching out away from the tight cluster of precontact AU's such a Figures 3.50 and 3.51.

Heterogeneity indices did not change from the precontact to the postcontact at these sites. This at first seems counterintuitive, but is probably a reflection of a degree of cultural continuity present in the midst of changing economic conditions. The people of Meier and Cathlapotle had a base of species which they exploited. This basic range in terms of richness did not change greatly with the introduced element of the fur trade. Rather, the people largely intensified production of species they were already taking. This is perhaps best seen in the elk index values. While the number of deer and elk were increasing, the ratio of elk to deer did not change. The people at Cathlapotle and Meier were still taking deer and elk in about the same proportions. Several ad hoc indices also showed this pattern.

The shift from precontact to postcontact is also seen in the change in structure of hearths over time. Both sites show a decrease in hearth size into the postcontact. It is possible that the demands of postcontact production led to increases in the number of short use hearths. It is also possible that production was being spread out among members of the household. Both of these scenarios are possible (and are not mutually exclusive) and may be reflected in the previously discussed construction of hearths in the northern section of Meier and an increase in interior hearths at Cathlapotle.

Methodologically, an interesting pattern emerged in the course of looking at these features. Often there were few obvious differences when looking at the characteristics and assemblages of the dataset in a step-by-step pair-wise fashion. Non-parametric tests showed few differences in means or shapes of distributions. However, when exploratory data techniques were used patterns began emerging. For instance, the shift in production between precontact and postcontact was most evident when looking at graphs produced by various clustering and data reduction analyses. Further, while discriminant analyses often had only mediocre success rates at placing units, the errors were telling in that the tests most often attempted to place postcontact AU's back into precontact. These were AU's that reflected the core of production discussed above.

The methodology was structured to provide mutually reinforcing analyses of the data under consideration. The advantage of exploratory data analysis is its ability to uncover patterning that might be lost in large datasets with many variables, cases, and/or possible subdivisions. The disadvantage is lack of a firm measure of significance of results for most tests. Although the division of supervised and unsupervised learning is not strictly speaking a methodology, but rather a way of separating various clustering analyses based on their strengths and goals, I have found it advantageous to consistently follow the former with the latter. Unsupervised learning, mainly PCA and hierarchical cluster analysis, was quite successful indicating underlying patterning. Supervised learning was useful in supporting or refuting patterning suggested by unsupervised learning. PCA and DA were useful in identifying which variables were influential in determining the characteristics of the clustering patterns. For instance, repeatedly taxa associated with the fur trade could be identified with the first few components of principle component analyses.

Conclusions

The results of this study were complex and often contradictory, but several conclusions can be drawn. When looking at production differences between sites in absolute terms there was often very little to distinguish one from the other. I had expected there to be significant differences in hearth sizes between sites. In pair-wise comparisons between sites, Kolmogorov-Smirnov, Mann-Whitney U, and t-tests rarely suggested this. Cathlapotle did have larger numbers of hearths present, which is probably related to presence of small, ephemeral external hearths at Cathlapotle. Further, hearths and dumps tended to be slightly larger at Cathlapotle than those at Meier, but again, often not significantly so. Cathlapotle also had ovens reflecting plant food processing. It is entirely possible, however, that ovens were simply missed in the sampling of Meier as noted in Chapter 4.

Based on expected variation in size, I had expected scattergrams based on principle component analysis to sort features by site. Specifically, if there is greater variation at Cathlapotle, this should be seen in a relatively diffuse scattering of graphed features as opposed to a tight cluster of Meier features. While various clustering routines did sort features by size, there was no visible relation between groupings created by these tests and sites. However, these same tests were able to sort features into house sections at Meier. This suggests that while my expectations were largely not met in this sense, the principle behind the expectation was basically sound. It also suggests that the hearth structure seen at these two sites reflect a range of nominal to optimal size for the production tasks undertaken. If hearths were any larger, they may well have wasted fuel without increasing efficiency. Conversely, any smaller and the hearths may not have been able to produce enough heat to meet production (be that cooking, hide processing, lithic modification, or general household heat and light) requirements.

Production differences were, however, seen in faunal assemblages. I had expected there to be greater variation in general in the postcontact. Some tests, such as multidimensional scaling, did point to variance between the sites in the postcontact. Such differences were probably the result of differences in types of species being taken as opposed to one site outstripping the other in production. Both sites seemed to show preferences for slightly different sets of species. This was seen in different taxa being associated with different components in principle component analyses and discriminant analyses.

On the other hand, I had hoped to see greater separation between sites in these same tests in the precontact period. As discussed briefly in the expectations associated with the temporal hyporeport (Chapter 3), with the increased demand of the fur trade removed from consideration in the precontact, the sites should have separated based on population differences. This was largely not the case. The multidimensional scaling test mentioned above did partially split sites in the precontact based largely on the higher frequency of deer and beaver NISP at Meier. However, these fine distinctions were swamped by change in the postcontact.

APPENDIX A

NISP for Cathlapotle and Meier by Temporal Component

		Cathlapotle			
		Postcontact		Precontact	
Taxon	Common Name	NISP	%NISP	NISP	%NISP
Aplodontia rufa	Mountain Beaver	26	.81	66	1.87
Canidae	Dog	8	.25	15	.42
Castor canadensis	Beaver	135	4.20	124	3.51
Cervidae	Cervidae	38	1.18	35	.99
Cervus elaphus	Elk	1380	42.88	1493	42.28
Equus caballus	Horse	3	.09	0	.00
Erethizon dorsatum	Porcupine	0	.00	0	.00
Felis concolor	Cougar	3	.09	4	.11
*Lepus americanus/ Sylvilagus sp.**	Rabbit	28	.87	3	.08
Lutra canadensis	RiverOtter	19	.59	28	.79
Lynx sp.	Bobcat	14	.44	6	.17
Martes pennanti	Fisher	1	.03	1	.03
Mustela sp.	Mink	11	.34	11	.31
Odocoileus sp.	Deer	1427	44.34	1499	42.45
Ondatra zibethicus	Muskrat	21	.65	57	1.61
Ovis aries	Domestic Sheep	1	.03	0	.00
Ovis canadensis	Bighorn Sheep	0	.00	1	.03
Pinnipedia	Seal	31	.96	24	.68
Procyon lotor	Raccoon	39	1.21	115	3.26
Sciuridae/ Tamiasciurus douglasii	Squirrel	0	.00	0	.00
Testudinidae	Turtle	0	.00	1	.03
Ursus americanus	Bear	33	1.03	43	1.22
Vulpes vulpes	Fox	0	.00	5	.14
Total		3218	100.00	3531	100.00

		Meier			
		Postcontact		Precontact	
Taxon	Common Name	NISP	%NISP	NISP	%NISP
Aplodontia rufa	Mountain Beaver	2	.13	0	.00
Canidae	Dog	23	1.46	12	2.05
Castor canadensis	Beaver	74	4.70	25	4.28
Cervidae	Cervidae	0	.00	0	.00
Cervus elaphus	Elk	227	14.40	86	14.73
Equus caballus	Horse	0	.00	0	.00
Erethizon dorsatum	Porcupine	1	.06	0	.00
Felis concolor	Cougar	2	.13	2	.34
*Lepus americanus/ Sylvilagus sp.**	Rabbit	2	.13	6	1.03
Lutra canadensis	RiverOtter	11	.70	4	.68
Lynx sp.	Bobcat	9	.57	0	.00
Martes pennanti	Fisher	10	.63	1	.17
Mustela sp.	Mink	26	1.65	17	2.91
Odocoileus sp.	Deer	1032	65.48	368	63.01
Ondatra zibethicus	Muskrat	56	3.55	35	5.99
Ovis aries	Domestic Sheep	0	.00	0	.00
Ovis canadensis	Bighorn Sheep	0	.00	0	.00
Pinnipedia	Seal	8	.51	1	.17
Procyon lotor	Raccoon	65	4.12	20	3.42
Sciuridae/ Tamiasciurus douglasii	Squirrel	1	.06	0	.00
Testudinidae	Turtle	4	.25	2	.34
Ursus americanus	Bear	23	1.46	5	.86
Vulpes vulpes	Fox	0	.00	0	.00
Total		1576	100.00	584	100.00

		Sites Combined			
		Postcontact		Precontact	
Taxon	Common Name	NISP	%NISP	NISP	%NISP
Aplodontia rufa	Mountain Beaver	28	.58	66	1.60
Canidae	Dog	31	.65	27	.66
Castor canadensis	Beaver	209	4.36	149	3.62
Cervidae	Cervidae	38	.79	35	.85
Cervus elaphus	Elk	1607	33.52	1579	38.37
Equus caballus	Horse	3	.06	0	.00
Erethizon dorsatum	Porcupine	1	.02	0	.00
Felis concolor	Cougar	5	.10	6	.15
*Lepus americanus/ Sylvilagus sp.**	Rabbit	30	.63	9	.22
Lutra canadensis	RiverOtter	30	.63	32	.78
Lynx sp.	Bobcat	23	.48	6	.15
Martes pennanti	Fisher	11	.23	2	.05
Mustela sp.	Mink	37	.77	28	.68
Odocoileus sp.	Deer	2459	51.29	1867	45.37
Ondatra zibethicus	Muskrat	77	1.61	92	2.24
Ovis aries	Domestic Sheep	1	.02	0	.00
Ovis canadensis	Bighorn Sheep	0	.00	1	.02
Pinnipedia	Seal	39	.81	25	.61
Procyon lotor	Raccoon	104	2.17	135	3.28
Sciuridae/ Tamiasciurus douglasii	Squirrel	1	.02	0	.00
Testudinidae	Turtle	4	.08	3	.07
Ursus americanus	Bear	56	1.17	48	1.17
Vulpes vulpes	Fox	0	.00	5	.12
Total		4794	100.00	4115	100.00

APPENDIX B

Summary Statistics for NISP for Faunal Taxa from Meier by Association

Association	Statistic	Mountain Beaver	Dog	Beaver	Elk	Porcupine
Central	N	5.00	5.00	5.00	5.00	5.00
	Mean	.00	2.80	4.80	19.60	.00
	Std. Deviation	.00	4.66	3.35	10.41	.00
	Median	.00	1.00	4.00	24.00	.00
	Association Total	.00	14.00	24.00	98.00	.00
Exterior	N	6.00	6.00	6.00	6.00	6.00
	Mean	.00	.50	2.17	9.50	.17
	Std. Deviation	.00	.55	2.71	7.64	.41
	Median	.00	.50	1.00	7.50	.00
	Association Total	.00	3.00	13.00	57.00	1.00
Midden	N	1.00	1.00	1.00	1.00	1.00
	Mean	.00	7.00	11.00	7.00	.00
	Std. Deviation	.	.	.	.	.
	Median	.00	7.00	11.00	7.00	.00
	Association Total	.00	7.00	11.00	7.00	.00
North	N	7.00	7.00	7.00	7.00	7.00
	Mean	.14	1.43	5.43	18.29	.00
	Std. Deviation	.38	1.13	4.50	15.00	.00
	Median	.00	2.00	4.00	18.00	.00
	Association Total	1.00	10.00	38.00	128.00	.00
South	N	6.00	6.00	6.00	6.00	6.00
	Mean	.17	.17	2.17	3.83	.00
	Std. Deviation	.41	.41	1.72	3.43	.00
	Median	.00	.00	2.00	3.50	.00
	Association Total	1.00	1.00	13.00	23.00	.00
Total	N	25.00	25.00	25.00	25.00	25.00
	Mean	.08	1.40	3.96	12.52	.04
	Std. Deviation	.28	2.52	3.68	11.46	.20
	Median	.00	1.00	3.00	9.00	.00
	Association Total	2.00	35.00	99.00	313.00	1.00

N = number of analytical units

Association	Statistic	Cougar	Rabbit	River Otter	Bobcat	Fisher
Central	N	5.00	5.00	5.00	5.00	5.00
	Mean	.20	.40	1.20	.60	1.20
	Std. Deviation	.45	.89	.84	.55	2.17
	Median	.00	.00	1.00	1.00	.00
	Association Total	1.00	2.00	6.00	3.00	6.00
Exterior	N	6.00	6.00	6.00	6.00	6.00
	Mean	.33	.83	.00	.00	.00
	Std. Deviation	.82	2.04	.00	.00	.00
	Median	.00	.00	.00	.00	.00
	Association Total	2.00	5.00	.00	.00	.00
Midden	N	1.00	1.00	1.00	1.00	1.00
	Mean	.00	.00	2.00	.00	.00
	Std. Deviation	.	.	.	.	.
	Median	.00	.00	2.00	.00	.00
	Association Total	.00	.00	2.00	.00	.00
North	N	7.00	7.00	7.00	7.00	7.00
	Mean	.14	.14	.86	.86	.71
	Std. Deviation	.38	.38	.90	1.22	1.89
	Median	.00	.00	1.00	.00	.00
	Association Total	1.00	1.00	6.00	6.00	5.00
South	N	6.00	6.00	6.00	6.00	6.00
	Mean	.00	.00	.17	.00	.00
	Std. Deviation	.00	.00	.41	.00	.00
	Median	.00	.00	.00	.00	.00
	Association Total	.00	.00	1.00	.00	.00
Total	N	25.00	25.00	25.00	25.00	25.00
	Mean	.16	.32	.60	.36	.44
	Std. Deviation	.47	1.07	.82	.76	1.39
	Median	.00	.00	.00	.00	.00
	Association Total	4.00	8.00	15.00	9.00	11.00

Association	Statistic	Mink	Deer	Muskrat	Seal	Raccoon
Central	N	5.00	5.00	5.00	5.00	5.00
	Mean	2.00	101.40	5.20	.80	6.60
	Std. Deviation	2.35	67.66	4.15	1.30	5.13
	Median	1.00	87.00	5.00	.00	7.00
	Association Total	10.00	507.00	26.00	4.00	33.00
Exterior	N	6.00	6.00	6.00	6.00	6.00
	Mean	1.00	36.17	4.33	.17	2.17
	Std. Deviation	.89	30.18	3.83	.41	2.04
	Median	1.00	25.50	3.00	.00	2.00
	Association Total	6.00	217.00	26.00	1.00	13.00
Midden	N	1.00	1.00	1.00	1.00	1.00
	Mean	7.00	68.00	2.00	.00	7.00
	Std. Deviation	.	.	.	.	.
	Median	7.00	68.00	2.00	.00	7.00
	Association Total	7.00	68.00	2.00	.00	7.00
North	N	7.00	7.00	7.00	7.00	7.00
	Mean	1.57	70.14	3.57	.43	3.86
	Std. Deviation	2.15	48.14	2.44	.79	5.27
	Median	.00	47.00	3.00	.00	1.00
	Association Total	11.00	491.00	25.00	3.00	27.00
South	N	6.00	6.00	6.00	6.00	6.00
	Mean	1.50	19.50	2.00	.17	.83
	Std. Deviation	1.38	19.46	2.68	.41	1.60
	Median	1.50	16.00	1.00	.00	.00
	Association Total	9.00	117.00	12.00	1.00	5.00
Total	N	25.00	25.00	25.00	25.00	25.00
	Mean	1.72	56.00	3.64	.36	3.40
	Std. Deviation	1.99	50.36	3.21	.76	4.18
	Median	1.00	46.00	3.00	.00	2.00
	Association Total	43.00	1400.00	91.00	9.00	85.00

Association	Statistic	Squirrel	Turtle	Bear	NISP	Richness
Central	N	5.00	5.00	5.00	5.00	5.00
	Mean	.00	.40	.80	148.00	9.80
	Std. Deviation	.00	.55	1.30	94.25	2.86
	Median	.00	.00	.00	130.00	10.00
	Association Total	.00	2.00	4.00	740.00	
Exterior	N	6.00	6.00	6.00	6.00	6.00
	Mean	.00	.33	.83	58.50	6.50
	Std. Deviation	.00	.82	1.17	47.82	3.02
	Median	.00	.00	.50	41.50	7.00
	Association Total	.00	2.00	5.00	351.00	
Midden	N	1.00	1.00	1.00	1.00	1.00
	Mean	.00	.00	1.00	112.00	9.00
	Std. Deviation	.	.	.	.	.
	Median	.00	.00	1.00	112.00	9.00
	Association Total	.00	.00	1.00	112.00	
North	N	7.00	7.00	7.00	7.00	7.00
	Mean	.14	.29	2.57	110.57	8.29
	Std. Deviation	.38	.76	2.76	82.13	3.82
	Median	.00	.00	1.00	81.00	8.00
	Association Total	1.00	2.00	18.00	774.00	
South	N	6.00	6.00	6.00	6.00	6.00
	Mean	.00	.00	.00	30.50	5.00
	Std. Deviation	.00	.00	.00	29.65	2.37
	Median	.00	.00	.00	26.00	6.00
	Association Total	.00	.00	.00	183.00	
Total	N	25.00	25.00	25.00	25.00	25.00
	Mean	.04	.24	1.12	86.40	7.40
	Std. Deviation	.20	.60	1.86	76.10	3.35
	Median	.00	.00	.00	62.00	7.00
	Association Total	1.00	6.00	28.00	2160.00	

APPENDIX C

Summary Statistics for NISP for Faunal Taxa from Cathlapotle by Association (Interior)

Association	Statistic	Mountain Beaver	Dog	Beaver	Cervidae	Elk
House 1B	N	2.00	2.00	2.00	2.00	2.00
	Mean	.00	.00	.00	.00	6.00
	Std. Deviation	.00	.00	.00	.00	8.49
	Median	.00	.00	.00	.00	6.00
	Association Total	.00	.00	.00	.00	12.00
House 1C	N	3.00	3.00	3.00	3.00	3.00
	Mean	.00	.33	2.67	.67	6.67
	Std. Deviation	.00	.58	3.06	1.16	4.93
	Median	.00	.00	2.00	.00	9.00
	Association Total	.00	1.00	8.00	2.00	20.00
House 1D	N	16.00	16.00	16.00	16.00	16.00
	Mean	.81	.13	4.56	1.50	60.44
	Std. Deviation	1.83	.34	4.03	2.25	68.27
	Median	.00	.00	4.50	.50	35.50
	Association Total	13.00	2.00	73.00	24.00	967.00
House 2	N	1.00	1.00	1.00	1.00	1.00
	Mean	2.00	1.00	6.00	1.00	92.00
	Std. Deviation	.	.	.	.	.
	Median	2.00	1.00	6.00	1.00	92.00
	Association Total	2.00	1.00	6.00	1.00	92.00
House 4	N	9.00	9.00	9.00	9.00	9.00
	Mean	1.11	.11	2.56	.67	22.56
	Std. Deviation	2.67	.33	2.79	.50	24.16
	Median	.00	.00	1.00	1.00	12.00
	Association Total	10.00	1.00	23.00	6.00	203.00
House 6	N	2.00	2.00	2.00	2.00	2.00
	Mean	.00	.00	2.00	.50	16.00
	Std. Deviation	.00	.00	2.83	.71	19.80
	Median	.00	.00	2.00	.50	16.00
	Association Total	.00	.00	4.00	1.00	32.00

Association	Statistic	Horse	Cougar	Rabbit	River Otter	Bobcat
House 1B	N	2.00	2.00	2.00	2.00	2.00
	Mean	.00	.00	.50	.00	.00
	Std. Deviation	.00	.00	.71	.00	.00
	Median	.00	.00	.50	.00	.00
	Association Total	.00	.00	1.00	.00	.00
House 1C	N	3.00	3.00	3.00	3.00	3.00
	Mean	.00	.00	1.00	.33	.00
	Std. Deviation	.00	.00	1.73	.58	.00
	Median	.00	.00	.00	.00	.00
	Association Total	.00	.00	3.00	1.00	.00
House 1D	N	16.00	16.00	16.00	16.00	16.00
	Mean	.19	.13	.94	.56	.50
	Std. Deviation	.54	.50	1.44	1.32	.63
	Median	.00	.00	.00	.00	.00
	Association Total	3.00	2.00	15.00	9.00	8.00
House 2	N	1.00	1.00	1.00	1.00	1.00
	Mean	.00	.00	.00	1.00	1.00
	Std. Deviation	.	.	.	.	.
	Median	.00	.00	.00	1.00	1.00
	Association Total	.00	.00	.00	1.00	1.00
House 4	N	9.00	9.00	9.00	9.00	9.00
	Mean	.00	.00	.78	.22	.22
	Std. Deviation	.00	.00	1.64	.67	.67
	Median	.00	.00	.00	.00	.00
	Association Total	.00	.00	7.00	2.00	2.00
House 6	N	2.00	2.00	2.00	2.00	2.00
	Mean	.00	.00	.00	.00	.50
	Std. Deviation	.00	.00	.00	.00	.71
	Median	.00	.00	.00	.00	.50
	Association Total	.00	.00	.00	.00	1.00

Association	Statistic	Fisher	Mink	Deer	Muskrat	Domestic Sheep
House 1B	N	2.00	2.00	2.00	2.00	2.00
	Mean	.00	.00	8.50	.00	.00
	Std. Deviation	.00	.00	10.61	.00	.00
	Median	.00	.00	8.50	.00	.00
	Association Total	.00	.00	17.00	.00	.00
House 1C	N	3.00	3.00	3.00	3.00	3.00
	Mean	.00	.00	11.00	.67	.00
	Std. Deviation	.00	.00	12.12	1.16	.00
	Median	.00	.00	9.00	.00	.00
	Association Total	.00	.00	33.00	2.00	.00
House 1D	N	16.00	16.00	16.00	16.00	16.00
	Mean	.06	.62	59.94	1.00	.00
	Std. Deviation	.25	1.54	64.15	1.63	.00
	Median	.00	.00	37.00	.00	.00
	Association Total	1.00	10.00	959.00	16.00	.00
House 2	N	1.00	1.00	1.00	1.00	1.00
	Mean	.00	.00	110.00	.00	1.00
	Std. Deviation	.	.	.	.	.
	Median	.00	.00	110.00	.00	1.00
	Association Total	.00	.00	110.00	.00	1.00
House 4	N	9.00	9.00	9.00	9.00	9.00
	Mean	.00	.11	17.89	.56	.00
	Std. Deviation	.00	.33	18.01	1.67	.00
	Median	.00	.00	19.00	.00	.00
	Association Total	.00	1.00	161.00	5.00	.00
House 6	N	2.00	2.00	2.00	2.00	2.00
	Mean	.00	.00	10.00	.00	.00
	Std. Deviation	.00	.00	12.73	.00	.00
	Median	.00	.00	10.00	.00	.00
	Association Total	.00	.00	20.00	.00	.00

Association	Statistic	Bighorn Sheep	Seal	Raccoon	Squirrel	Turtle
House 1B	N	2.00	2.00	2.00	2.00	2.00
	Mean	.00	.50	.50	.00	.00
	Std. Deviation	.00	.71	.71	.00	.00
	Median	.00	.50	.50	.00	.00
	Association Total	.00	1.00	1.00	.00	.00
House 1C	N	3.00	3.00	3.00	3.00	3.00
	Mean	.00	.00	.33	.00	.00
	Std. Deviation	.00	.00	.58	.00	.00
	Median	.00	.00	.00	.00	.00
	Association Total	.00	.00	1.00	.00	.00
House 1D	N	16.00	16.00	16.00	16.00	16.00
	Mean	.00	.69	1.69	.00	.00
	Std. Deviation	.00	.95	3.50	.00	.00
	Median	.00	.00	.00	.00	.00
	Association Total	.00	11.00	27.00	.00	.00
House 2	N	1.00	1.00	1.00	1.00	1.00
	Mean	.00	.00	4.00	.00	.00
	Std. Deviation	.	.	.	.	.
	Median	.00	.00	4.00	.00	.00
	Association Total	.00	.00	4.00	.00	.00
House 4	N	9.00	9.00	9.00	9.00	9.00
	Mean	.00	1.56	1.00	.00	.00
	Std. Deviation	.00	3.61	1.23	.00	.00
	Median	.00	.00	.00	.00	.00
	Association Total	.00	14.00	9.00	.00	.00
House 6	N	2.00	2.00	2.00	2.00	2.00
	Mean	.00	.50	1.00	.00	.00
	Std. Deviation	.00	.71	1.41	.00	.00
	Median	.00	.50	1.00	.00	.00
	Association Total	.00	1.00	2.00	.00	.00

Association	Statistic	Bear	Fox	NISP	Richness
House 1B	N	2.00	2.00	2.00	2.00
	Mean	.00	.00	16.00	3.00
	Std. Deviation	.00	.00	19.80	1.41
	Median	.00	.00	16.00	3.00
	Association Total	.00	.00	32.00	
House 1C	N	3.00	3.00	3.00	3.00
	Mean	.00	.00	23.67	4.33
	Std. Deviation	.00	.00	20.60	2.08
	Median	.00	.00	26.00	5.00
	Association Total	.00	.00	71.00	
House 1D	N	16.00	16.00	16.00	16.00
	Mean	1.38	.00	135.12	7.06
	Std. Deviation	2.96	.00	140.78	3.96
	Median	.00	.00	87.00	6.50
	Association Total	22.00	.00	2162.00	
House 2	N	1.00	1.00	1.00	1.00
	Mean	4.00	.00	223.00	11.00
	Std. Deviation	.	.	.	.
	Median	4.00	.00	223.00	11.00
	Association Total	4.00	.00	223.00	
House 4	N	9.00	9.00	9.00	9.00
	Mean	.22	.00	49.56	5.33
	Std. Deviation	.67	.00	49.73	3.12
	Median	.00	.00	28.00	4.00
	Association Total	2.00	.00	446.00	
House 6	N	2.00	2.00	2.00	2.00
	Mean	1.00	.00	31.50	5.00
	Std. Deviation	1.41	.00	40.31	4.24
	Median	1.00	.00	31.50	5.00
	Association Total	2.00	.00	63.00	

APPENDIX D

Summary Statistics for NISP for Faunal Taxa from Cathlapotle by Association (Exterior)

Association	Statistic	Mountain Beaver	Dog	Beaver	Cervidae	Elk
Midden A	N	3.00	3.00	3.00	3.00	3.00
	Mean	2.67	.00	2.67	.00	42.67
	Std. Deviation	3.79	.00	4.62	.00	73.04
	Median	1.00	.00	.00	.00	1.00
	Association Total	8.00	.00	8.00	.00	128.00
Midden B	N	1.00	1.00	1.00	1.00	1.00
	Mean	5.00	.00	11.00	8.00	56.00
	Std. Deviation	.	.	.	.	.
	Median	5.00	.00	11.00	8.00	56.00
	Association Total	5.00	.00	11.00	8.00	56.00
MB/Basal	N	1.00	1.00	1.00	1.00	1.00
	Mean	.00	.00	.00	.00	5.00
	Std. Deviation	.	.	.	.	.
	Median	.00	.00	.00	.00	5.00
	Association Total	.00	.00	.00	.00	5.00
Shell Midden (House 1)	N	11.00	11.00	11.00	11.00	11.00
	Mean	3.27	.64	8.73	1.45	77.55
	Std. Deviation	7.67	1.03	17.02	2.42	175.28
	Median	.00	.00	1.00	.00	10.00
	Association Total	36.00	7.00	96.00	16.00	853.00
Shell Midden (House 2)	N	1.00	1.00	1.00	1.00	1.00
	Mean	18.00	11.00	27.00	14.00	461.00
	Std. Deviation	.	.	.	.	.
	Median	18.00	11.00	27.00	14.00	461.00
	Association Total	18.00	11.00	27.00	14.00	461.00
Shell Midden (House 6)	N	2.00	2.00	2.00	2.00	2.00
	Mean	.00	.00	1.50	.50	22.00
	Std. Deviation	.00	.00	2.12	.71	29.70
	Median	.00	.00	1.50	.50	22.00
	Association Total	.00	.00	3.00	1.00	44.00

N = number of analytical units

Association	Statistic	Horse	Cougar	Rabbit	River Otter	Bobcat
Midden A	N	3.00	3.00	3.00	3.00	3.00
	Mean	.00	.00	.33	.33	.00
	Std. Deviation	.00	.00	.58	.58	.00
	Median	.00	.00	.00	.00	.00
	Association Total	.00	.00	1.00	1.00	.00
Midden B	N	1.00	1.00	1.00	1.00	1.00
	Mean	.00	.00	.00	.00	1.00
	Std. Deviation	.	.	.	.	.
	Median	.00	.00	.00	.00	1.00
	Association Total	.00	.00	.00	.00	1.00
MB/Basal	N	1.00	1.00	1.00	1.00	1.00
	Mean	.00	.00	1.00	1.00	.00
	Std. Deviation	.	.	.	.	.
	Median	.00	.00	1.00	1.00	.00
	Association Total	.00	.00	1.00	1.00	.00
Shell Midden (House 1)	N	11.00	11.00	11.00	11.00	11.00
	Mean	.00	.18	.27	1.55	.36
	Std. Deviation	.00	.41	.47	2.42	.81
	Median	.00	.00	.00	.00	.00
	Association Total	.00	2.00	3.00	17.00	4.00
Shell Midden (House 2)	N	1.00	1.00	1.00	1.00	1.00
	Mean	.00	3.00	.00	15.00	3.00
	Std. Deviation	.	.	.	.	.
	Median	.00	3.00	.00	15.00	3.00
	Association Total	.00	3.00	.00	15.00	3.00
Shell Midden (House 6)	N	2.00	2.00	2.00	2.00	2.00
	Mean	.00	.00	.00	.00	.00
	Std. Deviation	.00	.00	.00	.00	.00
	Median	.00	.00	.00	.00	.00
	Association Total	.00	.00	.00	.00	.00

Association	Statistic	Fisher	Mink	Deer	Muskrat	Domestic Sheep
Midden A	N	3.00	3.00	3.00	3.00	3.00
	Mean	.00	.33	73.33	2.33	.00
	Std. Deviation	.00	.58	125.29	4.04	.00
	Median	.00	.00	1.00	.00	.00
	Association Total	.00	1.00	220.00	7.00	.00
Midden B	N	1.00	1.00	1.00	1.00	1.00
	Mean	.00	.00	62.00	.00	.00
	Std. Deviation	.	.	.	.	.
	Median	.00	.00	62.00	.00	.00
	Association Total	.00	.00	62.00	.00	.00
MB/Basal	N	1.00	1.00	1.00	1.00	1.00
	Mean	.00	.00	26.00	.00	.00
	Std. Deviation	.	.	.	.	.
	Median	.00	.00	26.00	.00	.00
	Association Total	.00	.00	26.00	.00	.00
Shell Midden (House 1)	N	11.00	11.00	11.00	11.00	11.00
	Mean	.09	.55	78.82	2.36	.00
	Std. Deviation	.30	1.51	149.20	4.61	.00
	Median	.00	.00	15.00	1.00	.00
	Association Total	1.00	6.00	867.00	26.00	.00
Shell Midden (House 2)	N	1.00	1.00	1.00	1.00	1.00
	Mean	.00	4.00	418.00	15.00	.00
	Std. Deviation	.	.	.	.	.
	Median	.00	4.00	418.00	15.00	.00
	Association Total	.00	4.00	418.00	15.00	.00
Shell Midden (House 6)	N	2.00	2.00	2.00	2.00	2.00
	Mean	.00	.00	16.50	3.50	.00
	Std. Deviation	.00	.00	20.51	4.95	.00
	Median	.00	.00	16.50	3.50	.00
	Association Total	.00	.00	33.00	7.00	.00

Association	Statistic	Bighorn Sheep	Seal	Raccoon	Squirrel	Turtle
Midden A	N	3.00	3.00	3.00	3.00	3.00
	Mean	.00	.33	3.67	.00	.33
	Std. Deviation	.00	.58	6.35	.00	.58
	Median	.00	.00	.00	.00	.00
	Association Total	.00	1.00	11.00	.00	1.00
Midden B	N	1.00	1.00	1.00	1.00	1.00
	Mean	.00	3.00	.00	.00	.00
	Std. Deviation	.	.	.	.	.
	Median	.00	3.00	.00	.00	.00
	Association Total	.00	3.00	.00	.00	.00
MB/Basal	N	1.00	1.00	1.00	1.00	1.00
	Mean	.00	2.00	.00	.00	.00
	Std. Deviation	.	.	.	.	.
	Median	.00	2.00	.00	.00	.00
	Association Total	.00	2.00	.00	.00	.00
Shell Midden (House 1)	N	11.00	11.00	11.00	11.00	11.00
	Mean	.00	1.82	3.55	.00	.00
	Std. Deviation	.00	2.93	8.01	.00	.00
	Median	.00	1.00	.00	.00	.00
	Association Total	.00	20.00	39.00	.00	.00
Shell Midden (House 2)	N	1.00	1.00	1.00	1.00	1.00
	Mean	1.00	1.00	59.00	.00	.00
	Std. Deviation	.	.	.	.	.
	Median	1.00	1.00	59.00	.00	.00
	Association Total	1.00	1.00	59.00	.00	.00
Shell Midden (House 6)	N	2.00	2.00	2.00	2.00	2.00
	Mean	.00	.50	.50	.00	.00
	Std. Deviation	.00	.71	.71	.00	.00
	Median	.00	.50	.50	.00	.00
	Association Total	.00	1.00	1.00	.00	.00

Association	Statistic	Bear	Fox	NISP	Richness
Midden A	N	3.00	3.00	3.00	3.00
	Mean	1.00	.00	130.00	5.33
	Std. Deviation	1.73	.00	221.71	5.86
	Median	.00	.00	3.00	3.00
	Association Total	3.00	.00	390.00	
Midden B	N	1.00	1.00	1.00	1.00
	Mean	4.00	.00	150.00	8.00
	Std. Deviation	.	.	.	.
	Median	4.00	.00	150.00	8.00
	Association Total	4.00	.00	150.00	
MB/Basal	N	1.00	1.00	1.00	1.00
	Mean	2.00	.00	37.00	6.00
	Std. Deviation	.	.	.	.
	Median	2.00	.00	37.00	6.00
	Association Total	2.00	.00	37.00	
Shell Midden (House 1)	N	11.00	11.00	11.00	11.00
	Mean	1.36	.18	182.73	7.55
	Std. Deviation	2.16	.60	373.07	4.28
	Median	.00	.00	37.00	7.00
	Association Total	15.00	2.00	2010.00	
Shell Midden (House 2)	N	1.00	1.00	1.00	1.00
	Mean	21.00	3.00	1074.00	16.00
	Std. Deviation	.	.	.	.
	Median	21.00	3.00	1074.00	16.00
	Association Total	21.00	3.00	1074.00	
Shell Midden (House 6)	N	2.00	2.00	2.00	2.00
	Mean	.50	.00	45.50	5.00
	Std. Deviation	.71	.00	60.10	4.24
	Median	.50	.00	45.50	5.00
	Association Total	1.00	.00	91.00	

APPENDIX E

Summary Statistics for Cathlapotle and Meier Fauna by Analytical Unit

Site	Component	Measure	Unit Mean	Standard Deviation	Coefficient of Variation	Unit Median
Cathlapotle	Postcontact	NISP	97.52	121.93	1.25	37.00
		Log10 NISP	1.52	.77	.51	1.57
		Richness	6.18	3.75	.61	5.00
		Elk-Deer Index	.47	.19	.41	.48
	Precontact	NISP	185.84	360.21	1.94	37.00
		Log10 NISP	1.71	.73	.42	1.57
		Richness	7.16	4.38	.61	7.00
		Elk-Deer Index	.45	.20	.44	.47
	Total	NISP	129.79	238.68	1.84	37.00
		Log10 NISP	1.59	.75	.48	1.57
		Richness	6.54	3.97	.61	6.00
		Elk-Deer Index	.46	.19	.41	.47
Meier	Postcontact	NISP	121.23	83.37	.69	101.00
		Log10 NISP	1.98	.32	.16	2.00
		Richness	9.08	2.87	.32	8.00
		Elk-Deer Index	.18	.04	.23	.18
	Precontact	NISP	48.67	45.44	.93	27.50
		Log10 NISP	1.44	.57	.40	1.44
		Richness	5.58	2.94	.53	6.00
		Elk-Deer Index	.20	.15	.76	.18
	Total	NISP	86.40	76.10	.88	62.00
		Log10 NISP	1.72	.53	.31	1.79
		Richness	7.40	3.35	.45	7.00
		Elk-Deer Index	.19	.11	.58	.18
Total	Postcontact	NISP	104.22	111.99	1.07	60.50
		Log10 NISP	1.65	.71	.43	1.78
		Richness	7.00	3.73	.53	7.00
		Elk-Deer Index	.38	.21	.54	.42
	Precontact	NISP	132.74	288.48	2.17	37.00
		Log10 NISP	1.61	.67	.42	1.57
		Richness	6.55	3.91	.60	6.00
		Elk-Deer Index	.35	.22	.62	.36
	Total	NISP	115.70	201.18	1.74	48.00
		Log10 NISP	1.63	.69	.42	1.68
		Richness	6.82	3.78	.55	6.00
		Elk-Deer Index	.37	.21	.57	.40

APPENDIX F

Cross-Tabulation of Total Number of Analytical Units Containing Hearth and/or Related Features at Cathlapotle and Meier by Temporal Component

		Component		
Site		Postcontact	Precontact	Total
Cathlapotle	Count	33	19	52
	Expected Count	31.1	20.9	52
	% within Site	63.50%	36.50%	100.00%
	% within Component	71.70%	61.30%	67.50%
	% of Total	42.90%	24.70%	67.50%
	Residual	1.9	-1.9	
	Std. Residual	0.3	-0.4	
Meier	Count	13	12	25
	Expected Count	14.9	10.1	25
	% within Site	52.00%	48.00%	100.00%
	% within Component	28.30%	38.70%	32.50%
	% of Total	16.90%	15.60%	32.50%
	Residual	-1.9	1.9	
	Std. Residual	-0.5	0.6	
Total	Count	46	31	77
	Expected Count	46	31	77
	% within Site	59.70%	40.30%	100.00%
	% within Component	100.00%	100.00%	100.00%
	% of Total	59.70%	40.30%	100.00%

Chi-square = .922, *df* = 1, *p* = .337

Count = Number of analytical units for each component by site.

APPENDIX G

Summary Statistics for Evenness and Diversity Measures by Meier Site Association for Precontact and Postcontact Analytical Units

Component	Association	Statistic	Richness	D	H'	H' Log10
Postcontact	Central	N	4	4	4	4
		Mean	10.75	.49	1.18	.51
		Std. Deviation	2.22	.09	.24	.10
	Exterior	N	1	1	1	1
		Mean	8.00	.39	1.35	.59
		Std. Deviation	.	.	.	.
	North	N	5	5	5	5
		Mean	9.40	.48	1.19	.52
		Std. Deviation	3.65	.08	.23	.10
	South	N	3	3	3	3
		Mean	6.67	.44	1.22	.53
		Std. Deviation	.58	.02	.04	.02
	Total	N	13	13	13	13
		Mean	9.08	.46	1.20	.52
		Std. Deviation	2.87	.07	.18	.08
Precontact	Central	N	1	1	1	1
		Mean	6.00	.61	.87	.38
		Std. Deviation	.	.	.	.
		Median	6.00	.61	.87	.38
	Exterior	N	5	5	5	5
		Mean	6.20	.44	1.13	.49
		Std. Deviation	3.27	.05	.24	.10
	Midden	N	1	1	1	1
		Mean	9.00	.39	1.41	.61
		Std. Deviation	.	.	.	.
	North	N	2	2	2	2
		Mean	5.50	.57	.89	.39
		Std. Deviation	3.54	.25	.54	.23
	South	N	3	3	3	3
		Mean	3.33	.51	.82	.36
		Std. Deviation	2.31	.11	.34	.15
		Median	2.00	.50	.69	.30
	Total	N	12	12	12	12
		Mean	5.58	.49	1.01	.44
		Std. Deviation	2.94	.11	.32	.14

N = number of analytical units

Component	Association	Statistic	Shannon Scaled	1-D	E 1-D	1/D
Postcontact	Central	N	4	4	4	4
		Mean	.38	.51	.57	2.11
		Std. Deviation	.08	.09	.09	.44
	Exterior	N	1	1	1	1
		Mean	.43	.61	.70	2.60
		Std. Deviation	.	.	.	.
	North	N	5	5	5	5
		Mean	.38	.52	.59	2.15
		Std. Deviation	.07	.08	.07	.34
	South	N	3	3	3	3
		Mean	.39	.56	.66	2.27
		Std. Deviation	.01	.02	.02	.09
	Total	N	13	13	13	13
		Mean	.38	.54	.61	2.20
		Std. Deviation	.06	.07	.08	.33
Precontact	Central	N	1	1	1	1
		Mean	.28	.39	.47	1.65
		Std. Deviation	.	.	.	.
		Median	.28	.39	.47	1.65
	Exterior	N	5	5	5	5
		Mean	.36	.56	.71	2.28
		Std. Deviation	.08	.05	.09	.22
	Midden	N	1	1	1	1
		Mean	.45	.61	.68	2.53
		Std. Deviation	.	.	.	.
	North	N	2	2	2	2
		Mean	.28	.43	.54	1.95
		Std. Deviation	.17	.25	.22	.86
	South	N	3	3	3	3
		Mean	.26	.49	.82	2.01
		Std. Deviation	.11	.11	.16	.41
		Median	.22	.50	.75	2.00
	Total	N	12	12	12	12
		Mean	.32	.51	.69	2.13
		Std. Deviation	.10	.11	.16	.41

Component	Association	Statistic	E 1/D	J'	Simpson Estimate	Simpson Scaled	E_{VAR}
Postcontact	Central	N	4	4	4	4	4
		Mean	.20	.50	.48	.54	.28
		Std. Deviation	.04	.08	.09	.09	.03
	Exterior	N	1	1	1	1	1
		Mean	.32	.65	.37	.64	.39
		Std. Deviation	.	.	.	.	.
	North	N	5	5	5	5	5
		Mean	.24	.54	.47	.55	.35
		Std. Deviation	.05	.05	.08	.08	.06
	South	N	3	3	3	3	3
		Mean	.34	.65	.42	.58	.47
		Std. Deviation	.04	.03	.02	.02	.06
	Total	N	13	13	13	13	13
		Mean	.26	.56	.46	.56	.36
		Std. Deviation	.07	.08	.07	.07	.09
Precontact	Central	N	1	1	1	1	1
		Mean	.27	.49	.60	.41	.38
		Std. Deviation	.	.	.	.	.
		Median	.27	.49	.60	.41	.38
	Exterior	N	5	5	5	5	5
		Mean	.47	.69	.42	.58	.53
		Std. Deviation	.24	.12	.05	.05	.18
	Midden	N	1	1	1	1	1
		Mean	.28	.64	.39	.63	.41
		Std. Deviation	.	.	.	.	.
	North	N	2	2	2	2	2
		Mean	.38	.54	.55	.45	.37
		Std. Deviation	.09	.11	.24	.26	.04
	South	N	3	3	3	3	3
		Mean	.73	.83	.30	.51	.75
		Std. Deviation	.30	.17	.26	.11	.28
		Median	.80	.81	.39	.52	.81
	Total	N	12	12	12	12	12
		Mean	.49	.68	.43	.53	.54
		Std. Deviation	.26	.16	.17	.12	.22

Component	Association	Statistic	Richness	D	H'	H' Log10
Combined	Central	N	5	5	5	5
		Mean	9.80	.51	1.12	.48
		Std. Deviation	2.86	.09	.25	.11
	Exterior	N	6	6	6	6
		Mean	6.50	.43	1.17	.51
		Std. Deviation	3.02	.05	.23	.10
	Midden	N	1	1	1	1
		Mean	9.00	.39	1.41	.61
		Std. Deviation	.	.	.	.
	North	N	7	7	7	7
		Mean	8.29	.50	1.10	.48
		Std. Deviation	3.82	.13	.32	.14
	South	N	6	6	6	6
		Mean	5.00	.48	1.02	.44
		Std. Deviation	2.37	.08	.31	.13
	Total	N	25	25	25	25
		Mean	7.40	.48	1.11	.48
		Std. Deviation	3.35	.09	.27	.12

Component	Association	Statistic	Shannon Scaled	1-D	E 1-D	1/D
Combined	Central	N	5	5	5	5
		Mean	.36	.49	.55	2.02
		Std. Deviation	.08	.09	.09	.43
	Exterior	N	6	6	6	6
		Mean	.37	.57	.71	2.34
		Std. Deviation	.07	.05	.08	.23
	Midden	N	1	1	1	1
		Mean	.45	.61	.68	2.53
		Std. Deviation	.	.	.	.
	North	N	7	7	7	7
		Mean	.35	.50	.58	2.09
		Std. Deviation	.10	.13	.11	.46
	South	N	6	6	6	6
		Mean	.33	.52	.74	2.14
		Std. Deviation	.10	.08	.13	.30
	Total	N	25	25	25	25
		Mean	.35	.52	.65	2.16
		Std. Deviation	.09	.09	.13	.37

Component	Association	Statistic	E 1/D	J'	Simpson Estimate	Simpson Scaled	E_{VAR}
Combined	Central	N	5	5	5	5	5
		Mean	.21	.50	.51	.51	.30
		Std. Deviation	.05	.07	.09	.10	.05
	Exterior	N	6	6	6	6	6
		Mean	.44	.69	.41	.59	.51
		Std. Deviation	.22	.11	.05	.05	.17
	Midden	N	1	1	1	1	1
		Mean	.28	.64	.39	.63	.41
		Std. Deviation	.	.	.	.	.
	North	N	7	7	7	7	7
		Mean	.28	.54	.49	.52	.35
		Std. Deviation	.09	.06	.12	.13	.05
	South	N	6	6	6	6	6
		Mean	.54	.74	.36	.55	.61
		Std. Deviation	.29	.15	.18	.08	.24
	Total	N	25	25	25	25	25
		Mean	.37	.62	.44	.55	.44
		Std. Deviation	.21	.13	.13	.10	.18

APPENDIX H

Summary Statistics for Evenness and Diversity Measures by Cathlapotle Site Association for Precontact and Postcontact Analytical Units

		Richness			D			H'		
Component	Association	N	Mean	Std. Dev.	N	Mean	Std. Dev.	N	Mean	Std. Dev.
Postcontact	H1B	2	3.00	1.41	2	.47	.04	2	.81	.17
	H1C	3	4.33	2.08	3	.39	.10	3	1.11	.36
	H1D	11	8.27	3.90	11	.40	.06	11	1.15	.24
	H2	1	11.00	.	1	.42	.	1	1.12	.
	H4	5	5.40	2.51	5	.39	.08	5	1.12	.25
	H6	1	2.00	.	1	.56	.	1	.64	.
	MA	2	2.00	1.41	2	.67	.47	2	.55	.78
	MB	1	8.00	.	1	.32	.	1	1.40	.
	SM (H1)	6	6.67	3.98	6	.36	.03	6	1.21	.09
	SM (H6)	1	2.00	.	1	.56	.	1	.64	.
	Total	33	6.18	3.75	33	.42	.13	33	1.07	.31
Precontact	H1D	5	4.40	2.79	5	.48	.15	5	.91	.30
	H4	4	5.25	4.19	4	.53	.33	4	.94	.66
	H6	1	8.00	.	1	.36	.	1	1.32	.
	MA	1	12.00	.	1	.43	.	1	1.13	.
	MB/Basal	1	6.00	.	1	.52	.	1	1.03	.
	SM (H1)	5	8.60	4.83	5	.37	.10	5	1.27	.30
	SM (H2)	1	16.00	.	1	.34	.	1	1.43	.
	SM (H6)	1	8.00	.	1	.37	.	1	1.24	.
	Total	19	7.16	4.38	19	.44	.17	19	1.10	.38
Total	H1B	2	3.00	1.41	2	.47	.04	2	.81	.17
	H1C	3	4.33	2.08	3	.39	.10	3	1.11	.36
	H1D	16	7.06	3.96	16	.43	.10	16	1.07	.27
	H2	1	11.00	.	1	.42	.	1	1.12	.
	H4	9	5.33	3.12	9	.45	.22	9	1.04	.45
	H6	2	5.00	4.24	2	.46	.14	2	.98	.49
	MA	3	5.33	5.86	3	.59	.36	3	.74	.64
	MB	1	8.00	.	1	.32	.	1	1.40	.
	MB/Basal	1	6.00	.	1	.52	.	1	1.03	.
	SM (H1)	11	7.55	4.28	11	.37	.07	11	1.24	.20
	SM (H2)	1	16.00	.	1	.34	.	1	1.43	.
	SM (H6)	2	5.00	4.24	2	.46	.13	2	.94	.42
	Total	52	6.54	3.97	52	.43	.14	52	1.08	.34

N= number of analytical units.

		E 1-D			1/D			E 1/D		
Component	Association	N	Mean	Std. Dev.	N	Mean	Std. Dev.	N	Mean	Std. Dev.
Postcontact	H1B	2	.87	.19	2	2.12	.17	2	.78	.31
	H1C	3	.88	.13	3	2.69	.71	3	.71	.28
	H1D	11	.73	.12	11	2.56	.43	11	.41	.25
	H2	1	.64	.	1	2.41	.	1	.22	.
	H4	5	.78	.13	5	2.63	.54	5	.57	.25
	H6	1	.89	.	1	1.80	.	1	.90	.
	MA	2	1.00	.00	2	2.00	1.41	2	1.00	.00
	MB	1	.78	.	1	3.12	.	1	.39	.
	SM (H1)	6	.80	.10	6	2.81	.19	6	.54	.26
	SM (H6)	1	.89	.	1	1.80	.	1	.90	.
	Total	33	.80	.13	33	2.53	.54	33	.56	.29
Precontact	H1D	5	.73	.14	5	2.19	.48	5	.60	.21
	H4	4	.83	.18	4	2.42	1.15	4	.64	.35
	H6	1	.73	.	1	2.80	.	1	.35	.
	MA	1	.62	.	1	2.33	.	1	.19	.
	MB/Basal	1	.58	.	1	1.93	.	1	.32	.
	SM (H1)	5	.75	.11	5	2.85	.87	5	.42	.23
	SM (H2)	1	.70	.	1	2.93	.	1	.18	.
	SM (H6)	1	.72	.	1	2.70	.	1	.34	.
	Total	19	.74	.13	19	2.50	.74	19	.48	.26
Total	H1B	2	.87	.19	2	2.12	.17	2	.78	.31
	H1C	3	.88	.13	3	2.69	.71	3	.71	.28
	H1D	16	.73	.12	16	2.44	.47	16	.47	.25
	H2	1	.64	.	1	2.41	.	1	.22	.
	H4	9	.81	.15	9	2.54	.81	9	.60	.28
	H6	2	.81	.11	2	2.30	.70	2	.62	.39
	MA	3	.87	.22	3	2.11	1.02	3	.73	.47
	MB	1	.78	.	1	3.12	.	1	.39	.
	MB/Basal	1	.58	.	1	1.93	.	1	.32	.
	SM (H1)	11	.78	.11	11	2.83	.57	11	.49	.24
	SM (H2)	1	.70	.	1	2.93	.	1	.18	.
	SM (H6)	2	.80	.12	2	2.25	.63	2	.62	.40
	Total	52	.78	.13	52	2.52	.61	52	.53	.28

			J'			Simpson Estimate			Simpson Scaled	
Component	Association	N	Mean	Std. Dev.	N	Mean	Std. Dev.	N	Mean	Std. Dev.
Postcontact	H1B	2	.83	.23	2	.21	.30	2	.55	.04
	H1C	3	.85	.15	3	.21	.19	3	.64	.11
	H1D	11	.62	.18	11	.39	.06	11	.63	.07
	H2	1	.47	.	1	.41	.	1	.61	.
	H4	5	.72	.17	5	.34	.13	5	.63	.08
	H6	1	.92	.	1	.33	.	1	.46	.
	MA	2	1.00	.00	2	.00	.00	2	.35	.49
	MB	1	.67	.	1	.32	.	1	.71	.
	SM (H1)	6	.73	.18	6	.30	.08	6	.67	.03
	SM (H6)	1	.92	.	1	.33	.	1	.46	.
	Total	33	.73	.19	33	.31	.14	33	.61	.13
Precontact	H1D	5	.70	.13	5	.46	.15	5	.54	.15
	H4	4	.80	.21	4	.24	.20	4	.50	.35
	H6	1	.64	.	1	.35	.	1	.67	.
	MA	1	.45	.	1	.43	.	1	.60	.
	MB/Basal	1	.57	.	1	.51	.	1	.50	.
	SM (H1)	5	.66	.16	5	.36	.10	5	.65	.10
	SM (H2)	1	.52	.	1	.34	.	1	.69	.
	SM (H6)	1	.60	.	1	.36	.	1	.66	.
	Total	19	.67	.16	19	.37	.15	19	.58	.18
Total	H1B	2	.83	.23	2	.21	.30	2	.55	.04
	H1C	3	.85	.15	3	.21	.19	3	.64	.11
	H1D	16	.65	.17	16	.41	.10	16	.60	.10
	H2	1	.47	.	1	.41	.	1	.61	.
	H4	9	.76	.18	9	.30	.16	9	.57	.23
	H6	2	.78	.20	2	.34	.01	2	.57	.15
	MA	3	.82	.31	3	.14	.25	3	.43	.38
	MB	1	.67	.	1	.32	.	1	.71	.
	MB/Basal	1	.57	.	1	.51	.	1	.50	.
	SM (H1)	11	.70	.17	11	.33	.09	11	.66	.07
	SM (H2)	1	.52	.	1	.34	.	1	.69	.
	SM (H6)	2	.76	.23	2	.35	.02	2	.56	.14
	Total	52	.71	.18	52	.33	.14	52	.60	.15

			E_{VAR}	
Component	Association	N	Mean	Std. Dev.
Postcontact	H1B	2	.67	.47
	H1C	3	.70	.30
	H1D	11	.38	.25
	H2	1	.22	.
	H4	5	.46	.28
	H6	1	.92	.
	MA	2	1.00	.00
	MB	1	.33	.
	SM (H1)	6	.52	.28
	SM (H6)	1	.92	.
	Total	33	.53	.31
Precontact	H1D	5	.51	.16
	H4	4	.66	.35
	H6	1	.36	.
	MA	1	.19	.
	MB/Basal	1	.42	.
	SM (H1)	5	.39	.15
	SM (H2)	1	.20	.
	SM (H6)	1	.27	.
	Total	19	.45	.23
Total	H1B	2	.67	.47
	H1C	3	.70	.30
	H1D	16	.42	.23
	H2	1	.22	.
	H4	9	.55	.31
	H6	2	.64	.40
	MA	3	.73	.47
	MB	1	.33	.
	MB/Basal	1	.42	.
	SM (H1)	11	.46	.23
	SM (H2)	1	.20	.
	SM (H6)	2	.60	.46
	Total	52	.50	.28

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PART IV

THE INTERPRETATION OF INDOOR STORAGE FACILITIES FROM TWO PLANK HOUSE SITES IN THE GREATER LOWER COLUMBIA RIVER REGION

Stephanie T. Butler

ABSTRACT

The indoor storage facilities from two Chinookan plank house sites, the Meier Site (35CO5) and the Cathlapotle Site (45CL1), excavated in the Greater Lower Columbia River region were investigated to better understand the significance of household storage in the Pacific Northwest. These houses date to the late precontact/early contact period, from ca. 1400 AD to 1830 AD. They contain some of the most complex indoor storage facilities known on the Northwest Coast. The storage facilities played an important role in the household's socio-economical organization. The food supply as well as the tools of production and consumption activities was stored in these storage facilities.

The organization of household labor and status differentiation was investigated through the analysis of these features and their associated contents. This research had two primary objectives. The first was to identify and define the characteristics of the features. Storage pit criteria were established on storage pit size, contents, distribution, and profile. The results suggested that the storage facilities were used to some extent by individuals in all areas of the houses.

The second objective of this research project was to determine if the spatial distribution of the storage pits as well as their contents could be used to measure social differentiation within and between the households. Ethnohistoric and archaeological evidence suggests Chinookans of the Lower Columbia region were socially ranked. Within the houses, household members belonged to incipient social classes and inhabited different areas of the household and participated in various activities based on their social rank. The spatial distribution of the storage pit artifacts was analyzed using correspondence analysis (CA). The artifacts were grouped into activity classes, and the CA identified which activities were uniformly distributed in the households. The results suggest that all household members, regardless of rank, participated in the same basic production activities. However, certain activities, such as woodworking, fishing, and hunting, were differentiated according to social rank within the houses.

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CHAPTER 1
INTRODUCTION

This study addresses issues of household organization and status differentiation by examining the spatial distribution of interior storage facilities and their artifact contents from two archaeological sites. Archaeological investigations along the Lower Columbia River of Oregon and Washington have developed a large dataset on native Chinookan plank houses and their related features (e.g. Ames et al 1992, Ames et al. 1999, Banach 2002, Davis 1998, Hamilton 1994, Kaehler 2002, Smith 2004, Sobel 2004, Wolf 1996) (Figure 4.1). The Meier site (35CO5) contains the remnants of a large, single plank house and its associated features and middens. The Cathlapotle site (45CL1) has remains of six large plank house structures with their associated features and middens.

The Organization of the Study

Chapter 2 reviews both historic and prehistoric households on the Northwest Coast and outlines central issues in the study of prehistoric households on the coast, including issues of household economy and inequality. Both social and spatial models for Northwest Coast households are discussed. The spatial organization of the Cathlapotle and Meier archaeological sites is examined, including their household features. In particular, this chapter discusses the spatial organization of the storage pit facilities at both sites, which are the focus of this study.

Chapter 3 explores the theoretical models incorporated with the practice of storage. It also examines the practice of storage technology on the Northwest Coast by reviewing ethnographic evidence. The chapter examines various approaches that are used to detect storage technology in the archaeological record on the Northwest Coast. Lastly, post-depositional issues associated with the storage pits will be addressed.

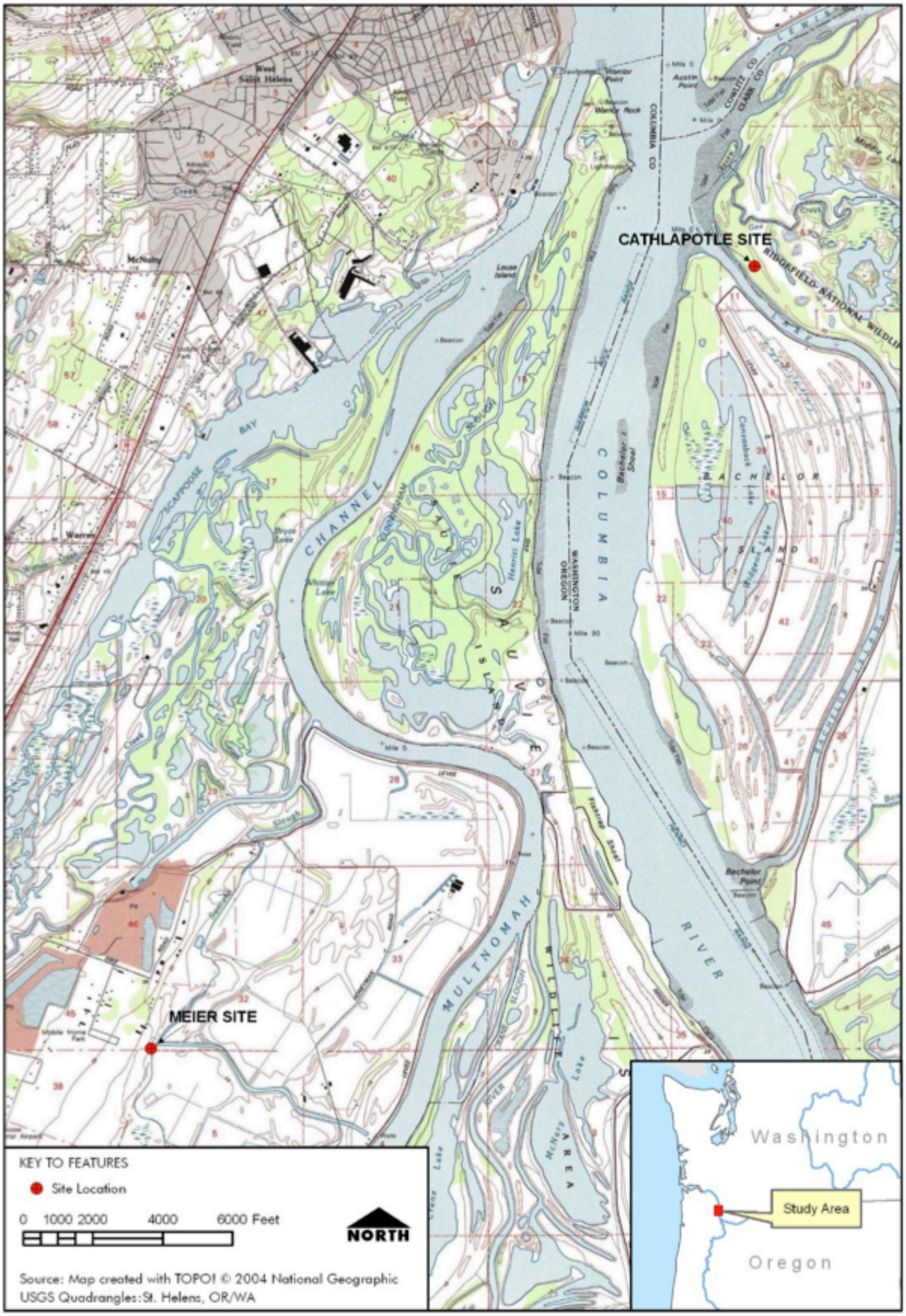
Chapter 4 provides a functional analysis of the storage pits at both the Cathlapotle and Meier sites. The chapter presents intra and intersite comparisons of the storage pits for the two archaeological sites. It describes the storage facilities characteristics, including depth, diameter, and volume measurements. The distribution of the storage pits within the houses is also examined. The functional analysis provides insight into how the pits themselves were used and distributed throughout the house.

Chapter 5 analyzes the spatial distribution of the artifacts in the Cathlapotle and Meier storage pits. Household activities can be inferred from the artifacts in the pits. By analyzing the distribution of artifacts, it can be determined what activities were conducted in the plank house, including whether certain activities were performed in conjunction with each other. This will help determine if there was any sort of specialization within the households. Specifically, chapter 5 will discuss whether certain members of household rank were performing particular tasks in the household. Correspondence Analysis, a multivariate statistical technique, is used to determine the spatial patterning of the storage pit artifacts. This statistical method is a technique to understanding the spatial patterning of storage pit contents.

Chapter 6 further analyzes the distribution of the storage pit artifacts. The correspondence analysis demonstrates the co-occurrences of activities. However, the CA does not reveal the locations of the activities within the household. In chapter 6, percentages are used to determine where in the houses residents were performing certain activities and how intensively these activities were performed.

Chapter 7 discusses the results within the framework of the study and presents conclusions. Overall, this study found that the indoor storage facilities were utilized throughout the Meier and Cathlapotle plank houses. However, it is evident that residents of certain areas of the households used the storage facilities more intensely than other areas of the houses. The largest storage pits appear to be in the lower status ends of the households. The production activities in the lower status ends of the households most likely necessitated the larger storage pits found at the Cathlapotle and Meier sites.

The statistical analyses demonstrated that there was some specialization of activities in the Meier and Cathlapotle households. All household members, regardless of rank, participated in general maintenance activities for the houses. However, subsistence production activities such as fish-



Source: Map created with TOPO! © 2004 National Geographic
USGS Quadrangles: St. Helens, OR/WA

Figure 4.1. Meier and Cathlapotle Archaeological Site Locations.

ing and hunting as well as woodworking activities occurred only in certain areas of the households. Hence, I infer certain household members were performing particular tasks for the household.

Formal Statement of Research Questions and Hypothesis

There are two primary objectives to this study:

1. First, the project will identify and define the characteristics of indoor storage facilities at the Cathlapotle and Meier archaeological sites in the Lower Columbia River Region.

The storage pits at the Meier and Cathlapotle site are extremely unusual features. Worldwide, indoor storage facilities are infrequent in the archaeological record, particularly of hunter-gatherers. The excavations at the Meier and Cathlapotle sites revealed the most extensive indoor storage facilities known on the Northwest Coast of North America. These storage pits are a prominent structural feature throughout the entire plank house, and they are exceptionally large in size.

2. Second, the project investigates the relationship, if any, between storage pit sizes, spatial distribution, content and labor organization and social differentiation within the plank houses.

It is expected that the storage pit artifact assemblages should reflect the distribution of activities among the separate family groups residing in the plank houses, including their wealth and status. The spatial patterning of the storage pit contents can be used to test whether particular members of the household in their respective living areas performed certain activities. Storage facilities with items of wealth may suggest the living quarters of high status household members. Additionally, the size, quantity, and spatial distribution of the storage facilities should reflect labor organization and social differentiation between household members. It is projected that household areas with larger numbers and sizes of storage pits were using the storage areas more intensely. The intense use of the storage pits may suggest that these particular areas of the house were involved with more household labor.

CHAPTER 2
STORAGE TECHNOLOGY: THEORETICAL AND METHODOLOGICAL APPROACHES

Introduction

For this research, the storage facilities were analyzed from the Meier and Cathlapotle archaeological sites. These sites contain some of the most complex indoor storage facilities known on the Northwest Coast. The storage facilities played an important role in the household's socio-economical organization. The household's food supply, as well as the tools of production and consumption activities, was stored in these facilities. Hence, to understand them, it was essential to review the on-going debates regarding theory and the practice of storage in the archaeological record. The sections below discuss how the storage facilities at the Cathlapotle and Meier site can contribute to these underlying issues regarding the practice of storage.

Although it is widely accepted that storage was an important factor in the evolution of socio-economic complexity among hunters and gatherers, the nature of its role is controversial. This chapter explores the theoretical issues involved with the appearance of storage-based economies as well as discusses storage techniques on the Northwest Coast. It also examines various approaches that are used to detect storage technology in the archaeological record on the Northwest Coast.

In general, storage ensures the availability of a wide range of products, including subsistence and material commodities (Christakis 1999). Storage may be conceptualized in three different ways: ecological, practical, and social (Ingold 1983: 554). This study is only concerned with practical and social storage. Practical storage involves the direct accumulation of food or material surpluses for use during the off-season. Ingold describes practical storage as "the practical activity of setting aside harvested produce in response to a temporal scheduling of resource extraction, transport, preparation, and consumption" (Ingold 1983: 553). In contrast, social storage refers to the convergence of materials and food stores into social obligations, wealth, or property (Ingold 1983).

The Meier and Cathlapotle storage facilities provide an excellent example for both practical and social storage. To date, research involving the practice of storage has largely concentrated on food storage, the setting aside of raw or processed foods (Ingold 1983, Binford 1990, Ames 1994, Christakis 1999). This research project is unique given that it focuses on the storage of household materials, including the tools of production and consumption activities. The Meier and Cathlapotle storage pits involved practical storage. The facilities contained both food remains as well as material commodities. This suggests that the pits were being used in the practical sense which was to store food and commodities for later use. Because the storage facilities contained items of wealth as well as different proportions of material commodities, I will suggest that the storage facilities were also being used for social purposes. The stored materials may have been used or vested in social storage.

The section below will discuss the theoretical debates that encompass practical and social storage.

Theoretical Issues

Recent anthropological debates concerning storage practices in hunter-gatherer societies have primarily revolved around two theoretical viewpoints. The first theory suggests that storage developed as a response to a variable environment and did not necessarily necessitate social change and inequality. The second viewpoint suggests that storage signaled evolutionary changes that lead to social complexity and inequality in hunter-gatherer societies. These theoretical positions are not necessarily alternatives to one another; rather, they focus on different components of storage. One model focuses on the social aspects of storage whereas the other concentrates on the physical or practical nature of storage.

Storage and the Environment. The first theoretical model suggests that storage, as with subsistence in general, is related to environmental variation. This approach does not stress a social role for the practice of storage. It views storage as a practical activity of setting aside resources in response to variable environmental conditions (Ingold 1983, Binford 1990). The role of storage is a security mechanism in settings with shorter growing seasons (Binford 1990).

This view asserts that under some demographic conditions and geographic constraints on mobility, storage may be an appropriate response to a variable environment. Storage under these circumstances simply reflects the character of the selective environment under which the people were living (Binford 1990: 141). Storage combined with mobility and exchange is a cultural mechanism for buffering seasonal and long-term variability in food supply (Christakis 1999). Therefore, the ability to create stores is one of the critical preconditions permitting a population to live permanently in an area (Ingold 1983).

The practice of storage is highly correlated with environmental variables and logistical mobility. Storage is expected to increase in importance as effective temperature decreases. As temperature decreases, environmental productivity is lower and annual seasonality produces variable resource distributions (Binford 1980). Temporal incongruities in resources require some sort of cultural response. Thus, groups develop labor organization and storage techniques so that resource availability can be extended (Binford 1980, Ames 1985, Bettinger 1991). In turn, storage means that some resources, generally those in great abundance for short periods at certain times of the year, must be obtained in bulk (Binford 1980, Bettinger 1991).

Storage requires heavy investments in mobility for procurement, labor for processing, and the construction of facilities to protect the stores. These costs of expending additional effort during the growing season pay off by ensuring against consumption shortfalls during the non-growing season (Binford 1990). Storage is designed to provide the long and short-term preservation of resource commodities beyond their natural period of availability. This strategy is important because cultural groups can have access to stored foods when the environment is not as productive (Binford 1990).

Binford (1990) claims that when there is high investment into producing stores and storage facilities, housing structures are minimal. Archaeologically, the most elaborate and greatest concentration of storage structures are associated with the most “portable” and “lowest investment forms of housing” (Binford 1990:145). At locations with substantial housing, storage facilities were few (Binford 1990). Therefore, he asserts that storage does not have to be associated with social complexity. Binford’s argument concerning house size is not applicable for the Wapato Valley. Both the Meier and Cathlapotle plank houses are considerably large in size and therefore they are high investments. These elaborate households contain high concentrations of large storage facilities.

Storage and Social Complexity. Like the first model, the second theoretical model suggests that storage developed as a response to environments with abundant but variable resources. However, this model further explains that the appearance of storage in the archaeological record signals a major set of evolutionary changes leading to sedentism, social complexity, and nonegalitarian societies (Ames 1981, Testart 1982, Ingold 1983). The argument claims a causal role for storage, and it focuses on the social and economical aspects of storage. More recent work has expanded this view by examining the role that storage played in the evolution of the political economy (Wesson 1999).

This model stresses the role of a material surplus in the emergence of hierarchical social formations. Testart presents this materialist view of storage:

> Where some natural food resources are bountiful but seasonal, they can be gathered en masse while available and stored on a large scale...The central idea...is that the massive stockpiling of staples constitutes the material base for a possible development of socio-economic inequalities to the extent that the bulk of production is thenceforward transformed by techniques appropriated and accumulated differentially by individuals or by groups. (1982: 523)

Thus according to this view, where the environment is highly productive but seasonal, large-scale storage, and in turn, social hierarchy will result.

The focus of this argument is that there is a strong relationship between storage and social complexity and inequality. In the development of social complexity in hunter-gatherer groups, the emergence of hierarchical social formations has appeared when there has been a material advantage. The control of surplus food and other economic resources is an essential mechanism in the development of social ranking in many societies (Arnold 1996). Elites' social power arises out of their role as surplus managers. The elites control the communal stores of surplus goods, the redistribution of these goods, and the available labor (Wesson 1999). Often, these elites have the right to call for contributions or necessitate changes to these stores (Wesson 1999). Differential access to the stores develops between the elites and other members of a group. From this materialist perspective, it is thought that once the elites have control over the stores or the relations of production, they are able to manage other social issues (Ingold 1983, Earle 1997, Muller 1997, Wesson 1999). Earle explains, "control over the economy is a direct and material power over the lives of people" (1997: 67).

This view argues that storage can play an important role in the negotiation of social ranking and political power. Thus, elites gain support and social power through the manipulation of the political economy (Wesson 1999). Additionally, when individuals take control of stores, they usually have some way of signaling this ownership. The ability to manipulate resources and social relations for the advancement of an individual's honor and prestige is referred to as symbolic capital (Wesson 1999). It is suggested that storage represents a source of potential wealth and symbolic capital. Stores become property which signals wealth (Ingold 1983). Individuals may compete for the control of these stores and symbolic capital. Thus, the practice of storage is not only important to the political economy, but the stores themselves represent a great deal of social meaning in certain societies (Wessen 1999).

Storage Practice on the Northwest Coast

Storage was an important development in the Northwest Coast and Wapato Valley that likely contributed to the rise of social complexity. Many of the attributes that are associated with Northwest Coast cultural complexity, including social inequality, task specialization, and centralization of authority, are associated with a storage economy (Ames and Maschner 1999).

The harvesting and preservation of large amounts of foods was the foundation of the historic Northwest Coast economy. Ethnographic evidence has suggested that in most places on the coast anadromous salmon was the most important stored resource (e.g. Ray 1938, Oberg 1983, Ames 1994). Salmon provided an abundant and high-quality food supply that could be processed and stored efficiently.

Like Testart, Schalk (1977) argues that storage is strongly associated with social complexity on the Northwest Coast. Social complexity develops out of the need to process and manage stored resources. It has been hypothesized that logistical mobility, storage, and social complexity all increase on the Northwest Coast in a south to north gradient (Ames 1985). Schalk suggests that the implementation of a storage strategy represents an "evolutionary threshold" (1977: 231). The carrying capacity of the environment is greater for storing adaptations compared to non-storing ones. Without storage, limits are placed on populations by the availability of resources. With stored foods, populations become more independent of the natural cycles in productivity. Populations increase and mobility decreases when storage is practiced (Schalk 1977, Panowski 1985).

Another change associated with the use of storage is technological innovations. Storage in itself is an example of a technological innovation, and in conjunction, additional technologies developed to support it. These technologies will be discussed in the following sections.

Storage allows for the extraction of greater quantities of fish in larger streams and in shorter periods of time. Weirs, traps, and nets are examples of innovations that were developed as part of storage on the Northwest Coast (Moss 1990; Stewart 1977). Other technological requirements associated with storage are facilities utilized in processing resources, including drying racks, smokehouses, baskets, boxes, and storage pits (Oberg 1973; Schalk 1977).

Finally, the practice of storage would influence the reorganization of social systems. Storage requires changes in labor organization, and consequently changes in social organization. The stores represent considerable labor for a household (Smith 2002). The processing of fish for storage is a demanding technique, and it may produce significant constraints upon the organization of labor. The process does not simply require that the fish are cleaned and hung to dry. It requires a lot of preseason preparation of the facilities used in the processing such as the smokehouses and drying racks as well as the storage facilities used to store the finished product (Oberg 1973; Schalk 1977). It is also suggested that where there is stress upon efficiency of storage, specialization in task performance would be necessary. Also, there may be increased centralization of authority in the group leader who manages the tasks (Schalk 1977).

Schalk (1977) notes that the social organization on the Northwest Coast was more complex in the north compared to the south. He explains that there was "increasing control of larger labor forces, increased importance of social differentiation, and greater discreteness of social units" (Schalk 1977: 237). Also, there was more emphasis on task specialization and the authority of a group leader as one moves northward on coast. Schalk argues that these variations in social organization are directly related to "differences in the demands placed upon cultural systems by variations in the fish resource" (Schalk 1977: 237; Schalk 1981).

Overall, it is argued that many of the features that are associated with Northwest Coast cultural complexity, including social differentiation, task specialization, and centralization of authority, are organizational responses to increased storage efficiency. These characteristics are emphasized as one moves northward along the Northwest Coast, where resource availability becomes patchy and not as predictable (Schalk 1981, Ames 1985).

In summary, storage, sedentism, and the social environment are clearly linked. Though linked, it is unknown how they are connected. This study does not attempt to answer this question; rather the results of the study may be useful in evaluating these various hypotheses.

Archaeological Evidence of Storage Practice on the Northwest Coast

Several lines of evidence are used to infer storage practice on the Northwest Coast. Although there are many indicators of storage on the Northwest Coast, the appearance of indoor storage structures are the most elaborate and obvious lines of evidence. A brief description of archaeological evidence of storage in the Northwest is discussed below.

Ames (1994:217) argues that rectangular surface dwellings and villages indicate storage beginning around 3500 B.P. Ethnographic evidence has shown that these houses were the major food processing and storage facilities on the coast. The use of wooden boxes indicates that the technology needed to make storage boxes was available by 3500 B.P (Ames 1994: 212). Evidence of freight canoes may demonstrate the practice of storage (Boas 1909, Drucker 1951, Ames 2002). Large amounts of salmon and smelt remains have been recovered from sites as far as 100 km from where they were caught. Canoes probably transported large volumes of fish (Ames 1994, Ames 2002).

Another way that storage is recognized in the archaeological record is by identifying salmon processing techniques using differential skeletal part frequencies. The basic model is that faunal assemblages dominated by post-cranial elements and low frequencies of cranial elements indicate salmon storage. Assemblages consisting mostly of cranial elements are thought to indicate locations where salmon were caught and processed for storage. This model is primarily derived from ethnographic evidence. An understanding of other cultural and taphonomic processes was also necessary in the development of the model (Butler and Chatters 1994; Ames 1994; Hoffman et al. 2000).

The development of a storage-based economy on the Northwest Coast may have required innovations in technology. It is argued that evidence for harvesting large numbers of fish is indicative of the practice of storage. Archaeological evidence for expanded use of mass-harvesting techniques, including nets and fishing weirs, suggests larger harvests, and indirectly to increased demand for fish as well as the capacity to process more fish for storage (Ames 1994). Wood stake fish weirs are one of several types of archaeological sites suggesting salmon exploitation, intensification, and mass harvesting. Once harvested and processed, large amounts of salmon were presumably stored to take advantage of economy of scale. These sites indicate prehistoric fishing camps where salmon were processed for future storage and consumption (Moss et al. 1990).

House interior storage pit features represent the most direct indicator of storage; however, these features are rare in the archaeological record on the Northwest Coast. The storage facilities can provide information regarding household organization. It is unknown whether these storage facilities were used for the surplus of individual families or if the pits were primarily used as communal storage of bulk material. The indoor storage pits have been found to contain both valuable items as well as food remains. An analysis of the contents of the pit features can determine if specific activities were performed by certain members of social rank. The following discussion will explore evidence for indoor storage facilities in the Lower Columbia Region in the Northwest of North America.

Evidence of Indoor Storage in the Lower Columbia River Region

Clah-Cla-Lah (45SA11). Clah-Cla-Lah is a seven plankhouse village site in the Columbia Gorge dating to the 18th and 19th Centuries (Skinner 1980, Sobel 2004). Little information has been published regarding the pit features at this site. It is known that rows of storage pits flanked the single hearths in the houses. There were approximately 12 pits per house. The pit features had a mean diameter of 80 cm and a mean depth of 40 cm. These storage facilities were maintained through three house maintenance periods (Skinner 1980).

Meier (35CO5) and Cathlapotle House 1 and 4 (45CL1) Storage Pits. The excavations at the Meier and Cathlapotle plank houses in the Wapato Valley near Portland, Oregon exposed the most extensive indoor storage facilities excavated on the Northwest Coast, and possibly, in North America. In the Meier plank house excavation area, 105 separate domestic storage pits were identified as features (Figure 4.2). The storage pits flanked the central hearths, producing two long trenches beneath the floor. Because of the large sizes of the storage pits and their placement between the bench and hearth/periphery, it is likely that they existed beneath a plank floor (Ames et al. 1992, Smith 2004). It would be impossible for the household inhabitants to jump over these large pits to get to their hearth spaces. This grouping of closely-spaced storage pits is referred to as the cellar.

At the Cathlapotle site, all of the tested houses contained storage pits beneath the sleeping platforms or benches. In Cathlapotle Houses 1 and 4, there is a total of 89 excavated storage pits. Twenty-one pits were excavated in House 4, and 68 in House 1. Their size, structure, and content are similar to the storage pits at the Meier site. These pit characteristics are discussed in detail in Chapter 4. Test excavations of Cathlapotle Houses 2 and 6 revealed that they also contained storage facilities.

There are several types of storage pit features, including unlined, rock-lined, shell-lined, and plank-lined storage facilities. These types and their distributions will be discussed in Chapter 4. The morphological variation of the pits suggests they probably had different functions. Because the pits were carefully lined with rocks, shell, or planks, it is likely that the inhabitants cared about what was contained in these storage areas. Therefore, these pits were not simply used as refuse containers.

It has been established, however, that the storage pits were used as refuse or debris containers as well as places to store wealth items, foodstuffs, and the tools of production (Smith 2005). These storage pits contained perishable food items, including salmon, elk, sturgeon, and many other food resources. The pits also contained non-perishable artifacts, including chipped lithics, ground stone, fire-cracked rock, and bone and antler tools (Smith 2005). Intact, usable artifacts as well as broken artifacts were found in the cellars (Ames et al. 1999, Smith 2004). Hence, both the products and the tools of production activities were stored in the cellars as well as waste.

In the Meier and Cathlapotle houses, the cellars were used continuously. The cellars were used as secondary refuse facilities before artifacts were moved to the tertiary midden deposits outside of the house. In general, the cellars have the

Figure 4.2. Storage pits at the Meier Site, excavated during the 1988 field season (photo by K. Ames).

highest relative frequency of artifacts compared to the other architectural facilities in the Meier plank house (Smith 2004).

The storage facilities signify a considerable amount of labor for the plank house inhabitants. The initial excavation of these pits would have required a large amount of labor as would their continual use and maintenance. Maintenance would have included rebuilding damaged pits, cleaning out the facilities, and the construction of the floor planks which would have covered the storage trenches (Ames et al. 1999, Smith 2004).

Site Formation Processes

Site formation processes were examined to understand the spatial distributions of the storage pits at Meier and Cathlapotle (Smith 2004). Schiffer (1987) theorizes that it is necessary to understand the diverse processes of people and nature that determine the location and condition of artifacts and other archaeological phenomena that comprise the archaeological record. There are two types of formation processes, cultural and non-cultural processes (Schiffer 1987). Cultural processes refer to the way in which human behavior affects artifacts after their use in a given activity. Non-cultural processes are defined as activities or taphonomic agents of the environment that affect archaeological features and artifacts (Schiffer 1987).

Smith (2004, 2005) analyzed site formation processes at the Meier and Cathlapotle. It was found that the deposition of artifacts was a result of cultural processes rather than natural processes. Artifacts (3-8 cm in diameter) found in situ were unlikely to have been moved more than 10 cm in any direction since final deposition (Smith 2005). Therefore, this movement is a result of patterned human behavior. This study is primarily concerned with consequences of site formation processes on

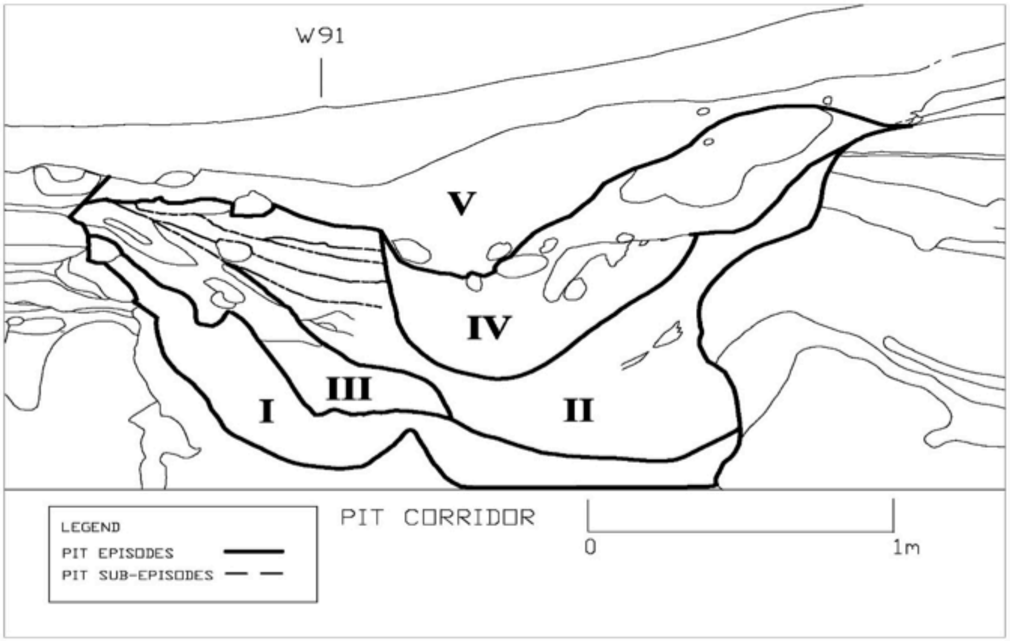


Figure 4.3. Cathlapotle (45CL1) pit feature profile, Trench N159-160.

the cellars. The inhabitants of the plank house had a significant effect on the formation processes of the storage pits.

Cellar Maintenance: Use Stages of Pits and Pit Fills

The storage pits at the Meier and Cathlapotle sites were in continuous use during the occupancy of the plank houses. The pits primarily experienced two phases: the *use phase* and the *cleanout phase*. These phases are evident in the form of stratigraphic cut and fill relationships visible in their stratigraphic profiles (Figure 4.3). The storage facilities at both sites exhibit extensive reworking, primarily due to maintenance activities (Smith 2005). These maintenance activities ranged from minor cleaning activities during the pits' use phase to major reconstruction of the pits during the cleanout phase. These two phases are discussed in detail below.

During the use-phase, storage pits were regularly cleaned, maintained, and reused by the plank house inhabitants. At both sites, the storage pits were used to store food items as well as tools. This was evident during excavation where pits contained an organically-rich matrix with large quantities of artifacts and artifact debris as well as faunal and flora remains. This dark, greasy matrix indicates that the storage pits were filled in during their use with a variety of decaying organics, including basketry, food items, planks lining pits, and bone/antler artifacts. Additionally, the pits' fill consisted of soils (possibly from the house floors or shaken from vegetation, hides, and clothing), ashes, charcoal, and decaying floorboard undersurfaces (Smith 2005). The household members constantly reexcavated the pits as they filled up with debris (Kenneth M. Ames, personal communication). During the use phase, the pits were renewed on a regular basis.

The pits were continually used until they underwent a major cleanout phase. During the cleanout phase, the accumulation of detritus was completely dug out of the pits, allowing for new, clean storage facilities. In the use-life of the Meier house, this cleanout phase occurred at least three times. This activity is evident in the stratigraphic profiles (e.g. Figure 4.3). During these cleaning episodes, the storage pit fill was deposited into the exterior midden, wall/structural support foundations, or possibly, into other pits within the plank house (Smith 2005). Damaged pits were also reconstructed or completely abandoned. In some instances, one pit would be cut into another pit, amalgamating into a single larger one (Cameron M. Smith, personal communication).

Figure 4.3 illustrates use-phases or episodes of a Cathlapotle storage pit. The profile demonstrates four distinct pit episodes during the Cathlapotle House I occupancy. Episode I consists of the original pit construction beneath the bench area. During episode I, the pit was filled with organic matrix, including food, debris, and tools. Eventually, the pit would have collapsed from use and required a major maintenance or cleanout episode. This is evident in episode II where the pit was completely re-dug. During episode II, the pit was regularly maintained and cleaned. This is illustrated by several smaller stratigraphic layers or sub-episodes within episode II. The profile also highlights two additional major reconstructions of the pit, episodes III and IV. The stratigraphy illustrates minor maintenance activities within these larger episodes.

Although the stratigraphy in Figure 4.3 depicts the original pit construction followed by episodes of maintenance and reconstruction, it is impossible to distinguish different fill rates based on the stratigraphy. Individual pits were filled at different rates.

The movement of artifacts from the storage facilities to the midden does not disrupt the analyses of northern, central, and southern zones of the plank houses. The pit contents moved directly from their storage facilities to areas outside of the plank house. The artifact did not move laterally within the plank house (Smith 2005). The artifact assemblage from the pits at Meier and Cathlapotle is from the last pit fill episodes and not for the entire 400 year occupancy of the house (Kenneth M Ames, personal communication). In order to further understand the use-stages of the pits, future studies will be extensively analyzing the pit stratigraphy from the Meier and Cathlapotle.

CHAPTER 3
ANALYSIS OF THE MEIER AND CATHLAPOTLE STORAGE PIT CHARACTERISTICS

This chapter presents size and distribution data for the storage pit features at the Cathlapotle and Meier sites. The storage facilities are compared both within and between the two archaeological sites. The Meier plank house sample has 105 separate pits. At Cathlapotle, the House 1 sample has 68 excavated separate storage pits and the House 4 sample has 21 storage pits. The discussion below describes the attributes associated with these storage facilities.

Methods

Before the statistical properties of the storage pits were analyzed, the relevant background literature, field reports, feature forms, site maps, and stratigraphic profiles were reviewed to establish the methods of excavating and recording the pits. It was determined that several attributes defined a storage facility in the field (Kenneth M. Ames, personal communication). These included but were not limited to: 1) size; 2) contents; 3) location; and 4) profile and stratigraphy. These four attributes were used as storage pit criteria for this study and will be discussed in detail below.

1. Size

The sizes of the storage pit features at both the Cathlapotle and Meier sites were variable. For this study, features were included in the analysis when they met the following size criteria:

- >10 cm in depth
- >15 cm in diameter
- They had discrete boundaries

The depth of the pits was measured from their upper elevations to the lowest elevation. Depth measurements were taken from the point where the pit became visible in the fill. Storage pit diameters were defined by using Mauger's (1978) data on posthole size at the Ozette site to this

Table 4.1. Artifact Counts for Meier and Cathlapotle House Features.

Sites	Analytical Units	N Artifacts	% of Total
Meier			
	Bench	970	9.43
	Cellar	5021	48.81
	Exterior	1355	13.17
	Hearth/Periphery	1175	11.42
	Midden	1081	10.51
	Walls	684	6.65
	Total	10286	100.00
Cathlapotle			
	Bench/Cellar	3426	40.92
	Hearth/Periphery	1566	18.70
	Midden	731	8.73
	Sheet Midden	1756	20.97
	Wall	894	10.68
	Total	8373	100.00

study. At Ozette, features less than 15 cm were classified as posts (Mauger 1978).

Pit boundaries, depths, and diameters were available on the feature forms and photographs. The feature forms were filled out in the field. Excavators received precise instruction for pit feature excavation, measurement, and documentation. Pit features were excavated in natural and arbitrary levels. Pit fill was excavated and screened separately from surrounding features and deposits. For this study, pit data was extrapolated from the feature forms and entered into Excel databases.

2. Contents

The pits were also identifiable by their fill or matrix. Pit matrices were dark, organic artifact-rich sediments. Archaeologically, the storage pits were artifact-rich compared to other household features (Table 4.1). Useable artifacts and valued items, including bone, antler, ground stone, and chipped-stone tools, were found in the pits. They also contained high numbers of debris items. Large and small debris both were also placed in the pits. Additionally, the pits contained food items, including bird, mammal, fish, and shell remains.

In addition to high artifact numbers, pits had distinctive matrices compared to other house features. The Meier and Cathlapotle pit fill was usually soft, dark, and greasy. This kind of matrix was probably from decaying organics, ashes, and charcoal (Smith 2005). The decaying organics most likely included organic artifacts, e.g., basketry, planks lining pits, bone/antler artifacts, soil, possibly shaken from vegetation, hides and clothing and decaying floorboard undersurfaces as well as ashes and charcoal (Smith 2005).

3. Location

The storage pit features were located in distinct areas of the plank house. In the Meier house, the pits were contained in a trench between the bench and the hearths in the house's center. Due to their size, the pits would have been covered with floorboards (Ames et al. 1992). In the Cathlapotle houses, the pits were located directly beneath the sleeping platforms. They may have been uncovered, though more material could be stored if they were covered (Smith 2006).

4. Profile and Stratigraphy

The storage pits had to be stratigraphically distinguishable from other plank house features. Storage pits frequently exhibited unclear internal stratigraphy because of the reworking and cleaning of the pits by the native inhabitants. These repeated activities are visible in the profiles as cutting and refilling. Although the stratigraphy was complex, the walls and bottoms of the pits were always discernible. In contrast, post holes and post molds were usually simple in profile, lacking the complex fill patterns. Figure 4.3 illustrates typical cellar deposits in the south profile of Cathlapotle.

The four storage pit criteria were applied to every potential storage feature, yielding 105 clearly identifiable storage pits at the Meier plank house, 89 pits in Cathlapotle Houses 1 and 4. Once the storage pits were defined in the plank houses, their shape could be described and their volumes calculated.

Storage Pit Morphology and Volumes

The morphology of the storage pits was defined to determine the appropriate formula for their volume. There are two pit bottom shapes at Meier and Cathlapotle: flat bottom and round. The flat-bottomed pits were cylindrical with straight sidewalls. The round pits had concave or bowl-shaped bottoms. In the feature forms, it was possible to identify what types of pits were encountered. The cylindrical-shaped pits were the more common. Only a few of the pits in the Meier house were concave and there were no concave pits in the two Cathlapotle houses.

Because most storage pits were cylindrical-shaped, the volumes of storage pits were calculated by using the formula of a cylinder: $\pi r^2 h$. Once the volumes were calculated, they were converted from cubic centimeters to liters, allowing readers to more easily conceptualize their size.

In addition to calculating pit volumes, postholes volumes were also calculated to distinguish these features from the storage pits. It was expected that postholes were smaller in size compared to the pits with the exception of large post-

Table 4.2. Summary Size Statistics for the Meier and Cathlapotle Storage Pits.

Site/House/Facility	Mean Volume (L)	Mean Diameter (cm)	Mean Depth (cm)
Meier Site, n=105	180	76	34
Cathlapotle Site, n=89	113	59	28
Meier-north, n=28	130	77	22
Meier-central, n=25	133	71	31
Meier-south, n=52	229	78	38
Cathlapotle House 1, n=68	117	55	29
Cathlapotle House 4, n=21	99	70	22
Cathlapotle House 1b, n=20	51	44	23
Cathlapotle House 1c, n=12	167	70	29
Cathlapotle House 1d, n=36	137	54	33
Cathlapotle House 4-north, n=10	122	73	26
Cathlapotle House 4-central, n=7	97	69	22
Cathlapotle House 4-south, n=4	46	65	13

holes in the house corners. By calculating the post volumes, it was possible to identify whether there was a significant size difference between posts and pits. If pits and post were similar in size, there would be the possibility that these features could be misidentified.

Simple descriptive statistics were used to compare the pit sizes, including means, standard deviations, medians and modes. The storage pit volumes were compared among the analytical zones within the house structures.

Box plots were used to visually compare storage pit sizes within the analytical units of the plank houses as well as between Cathlapotle and Meier. The box plots were useful because they identified outliers in the data. The outliers were reviewed and explanations for their presence developed. Scatterplots and regression analyses were used to determine whether there was a correlation between pit feature volume, diameter, and depth. This relationship was tested to determine which measurement was affecting the volume of the storage pits. Deep and narrow pits would be affected by depth and wide and shallow pits by diameter and regression analyses were performed to determine if there were significant correlations among storage pit volumes and artifact counts.

In addition to determining the sizes of storage pit features, their spatial distributions were also analyzed. Storage pit densities were calculated from the pit frequencies and total excavation volume for each analytical area in the plank house. Pit densities will be used to measure whether the storage pits were evenly distributed throughout the households.

Results

In the following discussion, the characteristics of the Meier and Cathlapotle storage pits are described. The storage pits are differentiated from household posthole features. Additionally, rim diameters, depths, volumes, distributions, types, and contents of the storage pits are defined.

Posts vs. Storage Pits

The size difference between a posthole and pit feature was considerable (see Figures 4.4 and 4.5). At the Meier and Cathlapotle site, the mean pit was 179.50 liters and 112.85 liters, respectively (Table 4.2). Conversely, the mean posthole size was 7.18 liters and 6.82 liters, respectively.

As expected, pit and post features were distributed differently in the houses. The Meier storage pits were located between the bench area and the central hearth zone of the house. The Cathlapotle pits were located beneath the bench areas of the houses. In both houses, the pits were positioned in a straight line from the entrance of the house to the back. Conversely, the Meier and

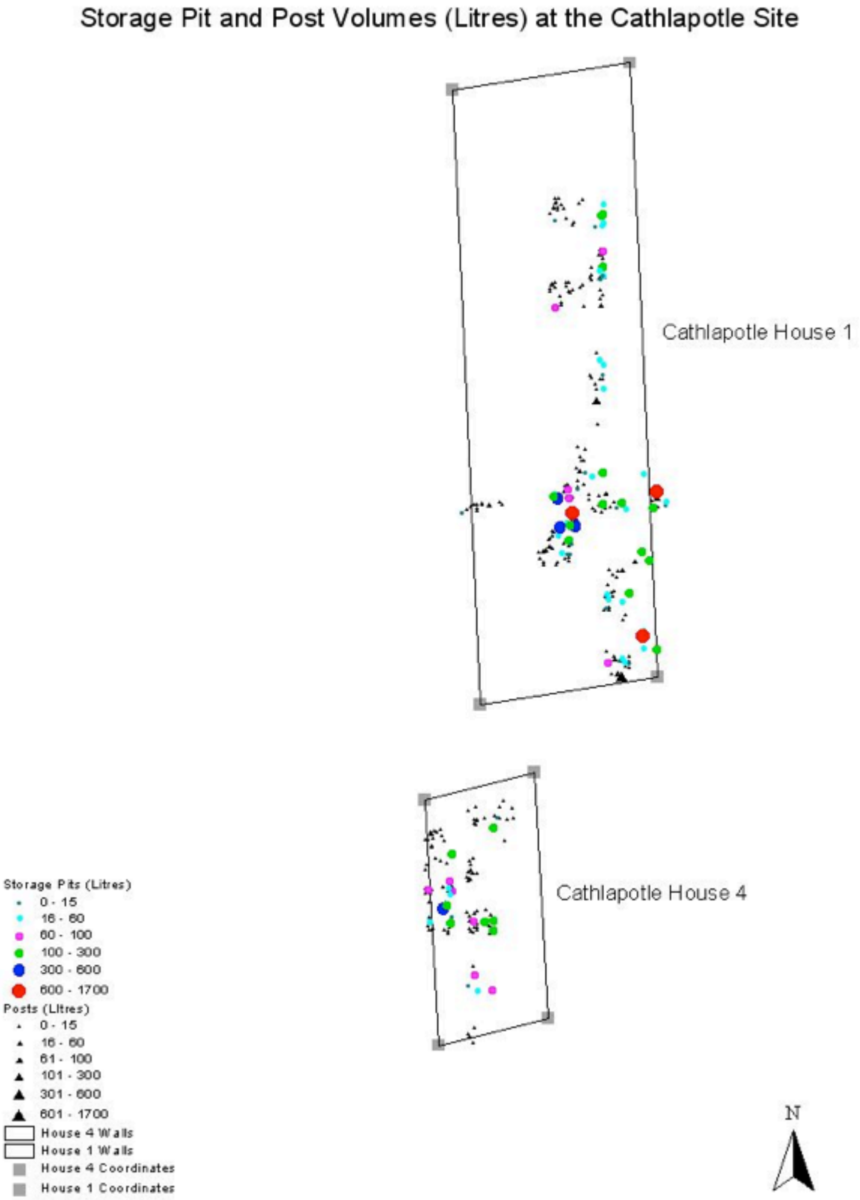


Figure 4.4. Storage pit and post volumes (liters) at the Cathlapotle site.

Cathlapotle postholes were irregularly distributed throughout the houses with large postholes in the corners. Figures 4.4 and 4.5 illustrate the spatial distribution of the storage pits and posts in both Meier and Cathlapotle plank houses.

The Meier and Cathlapotle pits and post had distinctive contents. Posthole contents included fire-cracked rock, stones, and hard packed earth. The corner postholes sometimes contained large stones in their bottoms (Ames et al. 1992). In addition to their distinctive artifact contents, pits and posts also had different matrices. The matrices of storage pits were usually soft, dark, and greasy and the matrices of the postholes were often a silty orange due to the cedar posts (PSU field notes 1991).

Storage Pit Rim Diameters

Storage pit diameters at the Meier and Cathlapotle sites vary considerably. At the Meier site, the storage pit features range between 20 and 150 cm in rim diameter with a mean of 76 cm, a mode of 100 cm, and a median of 70 cm (Table 4.3). Among the Meier analytical units, the stor-

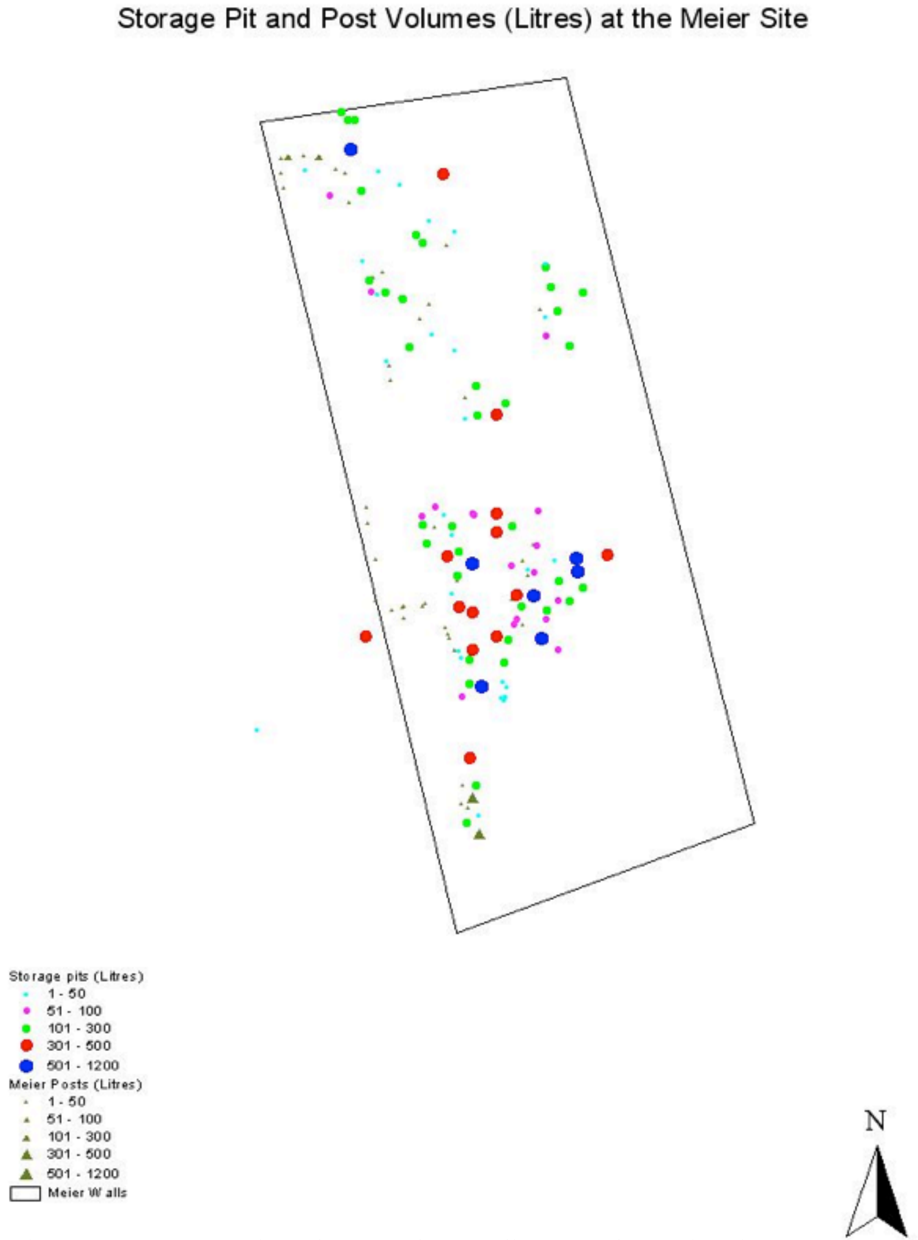


Figure 4.5. Storage pit and post volumes (liters) at the Meier site.

Table 4.3. Summary Size Statistics for the Meier and Cathlapotle Storage Pits.

Meier Diameters	
N	105
Mean	75.8
Standard Error	2.7
Median	70
Mode	100
Standard Deviation	27.8
Sample Variance	775.3
Kurtosis	0.1
Skewness	0.4
Range	130
Minimum	20
Maximum	150
Sum	7962

Cathlapotle Diameters	
N	89
Mean	58.7
Standard Error	3.4
Median	55
Mode	75
Standard Deviation	31.8
Sample Variance	1013.7
Kurtosis	15.4
Skewness	3
Range	235.5
Minimum	14.5
Maximum	250
Sum	5228.5

Cathlapotle House 4 Diameters	
N	21
Mean	70.1
Standard Error	4.5
Median	73.5
Mode	75
Standard Deviation	20.8
Sample Variance	433.4
Kurtosis	-0.2
Skewness	-0.2
Range	79.5
Minimum	29.5
Maximum	109
Sum	1473

Cathlapotle House 1 Diameters	
N	68
Mean	55.2
Standard Error	4.1
Median	49
Mode	55
Standard Deviation	33.9
Sample Variance	1148.8
Kurtosis	17.5
Skewness	3.5
Range	235.5
Minimum	14.5
Maximum	250
Sum	3755.5

Mean Pit Diameters for Meier		Mean Storage Pits Diameters for Cathlapotle	
North	76.61	North	48.18
Central	71.00	Central	69.54
South	77.73	South	54.38

age pit diameters are similar in size. The diameters are largest in the southern end of the house, averaging 78 cm. Pits in the northern and central portions of the house average 77 and 71 cm in diameter, respectively.

The rim diameters of the Cathlapotle storage pits are smaller (Table 4.3). Although ranging between 15 and 250 cm, the Cathlapotle mean rim diameters are only 58 cm with a mode of 75 cm and a median of 55 cm. In Cathlapotle House 1, pit diameters range between 15 and 250 cm with a mean of 55 cm. Within the house, the diameters are largest in compartment 1c, with a mean of 70 cm. Compartment 1b and 1d had mean rim diameters are 48 and 54 cm.

Storage Pit Depths

The Meier and Cathlapotle storage pit depths also vary considerably (Table 4.4). At Meier, the mean pit depth is 34 cm with a mode of

20 cm and a median of 30 cm. Within the Meier House, the depths are largest in the southern end of the household, averaging 38 cm. The mean depth in the northern end of the household is 28 cm, and the mean depth in the central area of the house is 31 cm.

As with the rim diameters, the Cathlapotle storage pit depths are slightly smaller than the pits at the Meier site. The mean storage pit depth at Cathlapotle is 28 and the median is 22 cm and the mode is 12 cm. At Cathlapotle House 1, the mean depth is 29 cm, whereas the storage pits average 22 cm in depth at Cathlapotle House 4. Within Cathlapotle House 1, compartment 1d storage features are the deepest pits, averaging 33 cm. The mean depth is 23 cm for 1b storage pits and 29 cm for the 1c storage features.

Although, some of the storage pit features at both sites are quite deep relative to their diameters. Many of the pits have depths significantly less than half of their diameters, resulting in broader, open basin structures. Figures 4.6 and 4.7 demonstrate the relationship between the depth and diameter of each storage pit at both the Cathlapotle and Meier sites.

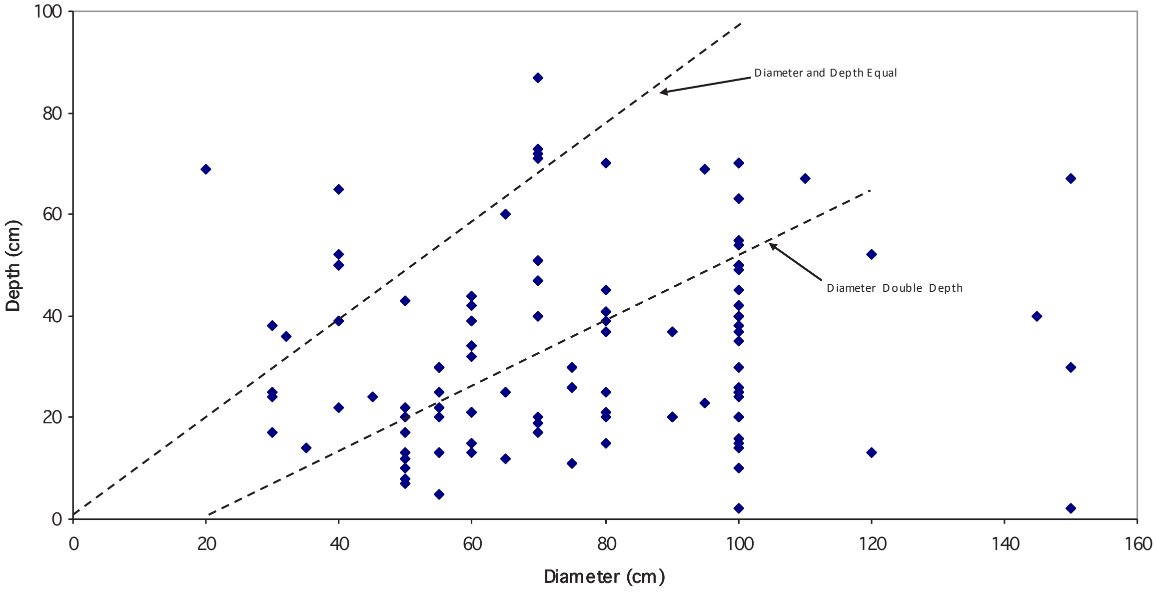


Figure 4.6. Pit Depth by Diameter for the Meier Storage Facilities.

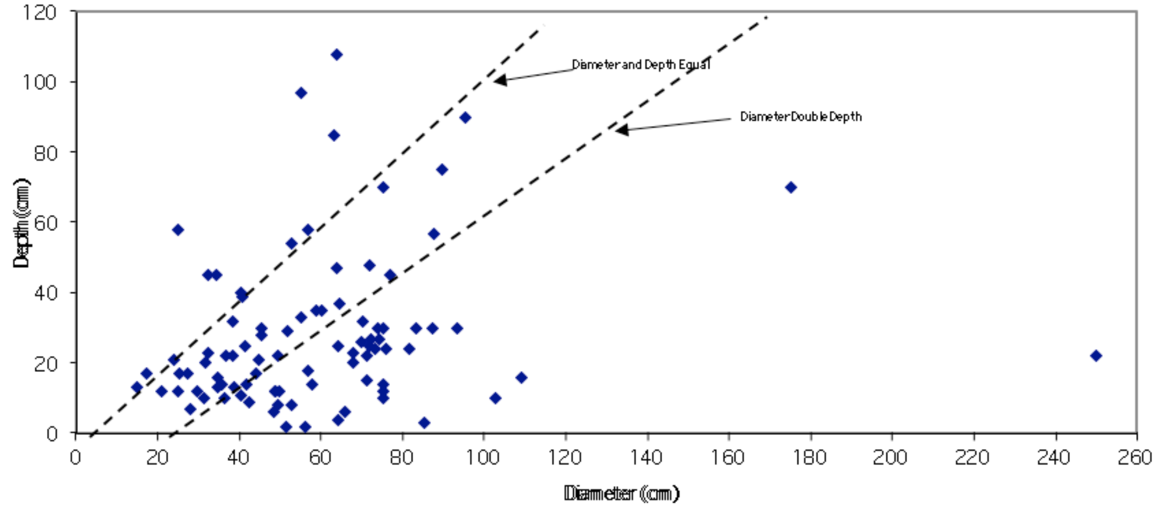


Figure 4.7. Pit Depth by Diameter for the Cathlapotle Storage Facilities.

Table 4.4. Statistical Summaries of the Meier and Cathlapotle Pit Depths.

Meier Depth	
N	105
Mean	33.6
Standard Error	1.9
Median	30
Mode	20
Standard Deviation	19.2
Sample Variance	368.1
Kurtosis	-0.4
Skewness	0.6
Range	85
Minimum	2
Maximum	87
Sum	3532

Cathlapotle Depth	
N	89
Mean	27.6
Standard Error	2.3
Median	22
Mode	12
Standard Deviation	21.6
Sample Variance	465.7
Kurtosis	3.1
Skewness	1.7
Range	106
Minimum	2
Maximum	108
Sum	2455

Cathlapotle House 4 Depth	
N	21
Mean	22
Standard Error	3.4
Median	20
Mode	30
Standard Deviation	15.5
Sample Variance	240
Kurtosis	6.2
Skewness	1.9
Range	73
Minimum	2
Maximum	75
Sum	462

Cathlapotle House 1 Depth	
N	68
Mean	29.3
Standard Error	2.8
Median	22.5
Mode	12
Standard Deviation	22.9
Sample Variance	527.3
Kurtosis	2.4
Skewness	1.6
Range	106
Minimum	2
Maximum	108
Sum	1993

Mean Depths for Pits at Meier		Mean Depths for Pits at Cathlapotle	
North	28.20	North	22.60
Central	30.80	Central	29.00
South	37.94	South	33.14

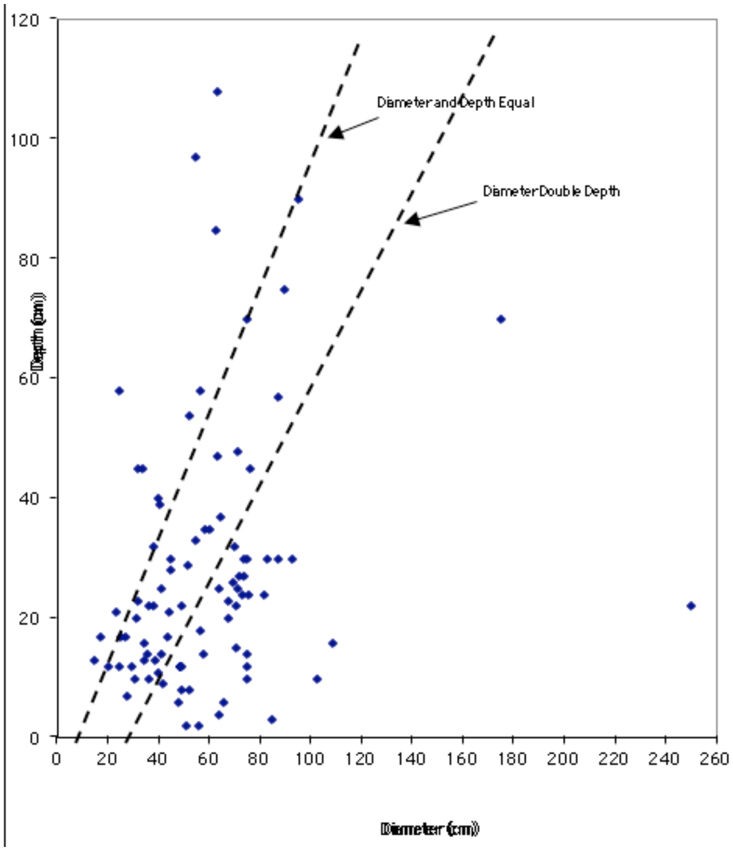


Figure 4.8. Sample box plot diagram.

Storage Pit Volumes: Means and T-tests within and between Plank Houses

The estimated volumes of the storage pits in the households also varied considerably. The Meier storage pits range between 10 liters to 1184 liters with a mean of 180 liters, a mode of 236 liters, and a median of 118 liters (Table 4.5). The northern and central storage pits are comparable in size. In the northern end of the Meier house, the storage pit mean is 130 liters. The mean storage pit volume in the central portion of the house is 133 liters.

The Meier southern storage pits are relatively larger in size compared to the northern and central areas of the Meier house (Table 4.5). The largest storage pit in the Meier house is located in the southern end. The median and mode are also larger in the southern end of the household compared to the north and central sections.

T-tests were generated to determine whether the differences in pit volume for each section of the Meier house were statistically significant as measured by their means. The t-tests of storage pit volumes for the north and central zone pits (n=53) indicated that they have nearly identical means (130.0 and 132.7, respectively). At the 0.05 significance level, the northern and central pit sizes are statistically indistinguishable (t=0.082, p=0.935). When testing the differences in storage pit size between the north and southern sections of the house, it was found that the differences were statistically significant. The t-tests of the pit volumes for the northern and southern pits (n=81) indicated that the mean volumes (130.0 and 231.5, respectively) are significantly different (t=2.45, p=0.016). The difference is found in higher storage pit volumes in the southern end of the plank house. The storage facilities in the southern portion of the house are roughly twice the volume than those found in the north.

The Cathlapotle storage pit volumes also vary considerably (Table 4.6). In Cathlapotle House 1, the mean pit volume is 117 liters, and

Table 4.5. Statistical Summaries for the Meier Pit Volumes.

Meier Pit Volumes	
N	105
Mean	179.5
Standard Error	18.8
Median	117.8
Mode	235.6
Standard Deviation	192.9
Sample Variance	37204.7
Kurtosis	7.3
Skewness	2.3
Range	1176.1
Minimum	7.9
Maximum	1183.9
Sum	18847.4

Northern Pit Volumes	
N	28
Mean	130.1
Standard Error	25.6
Median	112.6
Mode	157.1
Standard Deviation	135.3
Sample Variance	18314.5
Kurtosis	8.4
Skewness	2.5
Range	652.7
Minimum	7.9
Maximum	660.5
Sum	3642.5

Central Pit Volumes	
N	25
Mean	132.8
Standard Error	20.4
Median	90.5
Mode	196.4
Standard Deviation	102.2
Sample Variance	10439.3
Kurtosis	-0.8
Skewness	0.7
Range	317.9
Minimum	12.0
Maximum	329.9
Sum	3319.3

Southern Pit Volumes	
N	52
Mean	228.6
Standard Error	32.9
Median	125.7
Mode	549.8
Standard Deviation	237.5
Sample Variance	56394.1
Kurtosis	4.25
Skewness	1.8
Range	1172.1
Minimum	11.9
Maximum	1183.9
Sum	11885.6

Mean Depths for Pits at Meier		Mean Depths for Pits at Cathlapotle 1	
North	130.09	North	50.66
Central	132.77	Central	166.85
South	228.57	South	137.33

Table 4.6. tatistical Summaries of the Cathlapotle House 1 Pit Volumes.

Cathlapotle House 1 Pit Volumes	
N	68
Mean	117.0
Standard Error	30.5
Median	38.6
Mode	21.7
Standard Deviation	251.1
Sample Variance	63259.5
Kurtosis	25.2
Skewness	4.7
Range	1680.7
Minimum	2.2
Maximum	1682.3
Sum	7959.3

House 1d Pits	
N	36
Mean	137.3
Standard Error	49.2
Median	38.6
Mode	21.7
Standard Deviation	295.4
Sample Variance	87262.5
Kurtosis	22.5
Skewness	4.5
Range	1682.9
Minimum	3.8
Maximum	1682.8
Sum	4943.8

House 1c Pits	
N	12
Mean	166.9
Standard Error	86.5
Median	71.9
Mode	#N/A
Standard Deviation	299.5
Sample Variance	89701.58
Kurtosis	9.6
Skewness	3.0
Range	1069.2
Minimum	10.2
Maximum	1079.4
Sum	2002.2

House 1b Pits	
N	20
Mean	50.7
Standard Error	13.1
Median	34.4
Mode	N/A
Standard Deviation	58.4
Sample Variance	3409.2
Kurtosis	2.9
Skewness	1.9
Range	204.6
Minimum	2.2
Maximum	206.7
Sum	1013.3

the median and mode are 39 liters and 22 liters, respectively. The largest Cathlapotle storage pit is 1683 liters. The storage pits in Cathlapotle House 1 have a greater size range than do the Meier storage pits. When comparing the largest pits in the Meier and Cathlapotle houses, Cathlapotle House 1 contains a storage pit that is 500 liters larger than the Meier pit. However, the mean storage pit volume is significantly smaller at Cathlapotle compared to the Meier site (t=1.742, p=0.042).

Within Cathlapotle House 1, compartment 1b storage pits have a mean of 51 liters with the largest storage pit consisting of 207 liters. The mean in the northern area (1b) is three times smaller than the means in the southern (1d) and central (1c) areas of House 1. The mean storage pit volume in the compartment 1c of the house is 167 liters. The largest storage pit in House 1c is 1079 liters. In southern end of the Cathlapotle House I (House 1d), the mean pit volume is 137 liters and the largest storage pit is 1683 liters. Although the largest pit is in compartment 1d, the mean volume is significantly smaller compared to the compartment 1c of the house (Table 4.6).

In Cathlapotle House 1, the t-tests of storage pit volumes for the north and central zone pits

Table 4.7. Statistical Summaries for Cathlapotle House 4 Pit Volumes.

Cathlapotle House 4	
N	21
Mean	99.3
Standard Error	22.3
Median	82.5
Mode	N/A
Standard Deviation	101.9
Sample Variance	10401.2
Kurtosis	8.8
Skewness	2.6
Range	467.5
Minimum	4.1
Maximum	471.6
Sum	2084.6

House 4 Northern Pit Volumes	
N	10
Mean	122.1
Standard Error	42.1
Median	87.2
Mode	N/A
Standard Deviation	133.2
Sample Variance	17741.8
Kurtosis	6.2
Skewness	2.3
Range	463.4
Minimum	8.2
Maximum	471.6
Sum	1221.5

House 4 Central Pit Volumes	
N	7
Mean	97.3
Standard Error	26.0
Median	107.4
Mode	N/A
Standard Deviation	68.9
Sample Variance	4747.9
Kurtosis	-0.4
Skewness	-0.0
Range	199.6
Minimum	4.1
Maximum	203.4
Sum	680.9

House 4 Southern Pit Volumes	
N	4
Mean	45.6
Standard Error	16.0
Median	42.5
Mode	N/A
Standard Deviation	32.0
Sample Variance	1023.0
Kurtosis	-3.7
Skewness	0.3
Range	67.5
Minimum	15.0
Maximum	82.5
Sum	182.3

(n=32) indicated that their means are not similar (50.7 and 166.9, respectively). However, at the 0.05 level of significance, compartment 1b and compartment 1c pit sizes are not statistically significant (t=1.329, p=0.210). The difference in the pit means is not significant because several large storage pits in the central zone of the house are driving up the mean. When testing the differences in storage pit size between the north and southern sections of the house, it was found that the differences were not statistically significant. The t-tests of the pit volumes for compartment 1b and compartment 1d (n=56) indicated that the mean volumes (50.7 and 137.3, respectively) are not significantly different (t=1.701, p=0.097). However, the t-test value is near the 0.05 level of significance indicating that compartment 1d (south) pit volumes are larger than compartment 1b (north) pits in Cathlapotle House 1.

Storage pit volumes were also compared between Cathlapotle House 1 and House 4. In Cathlapotle House 4, the storage pit volumes were notably smaller than the storage pits in Cathlapotle House 1. The mean pit volume in House 4 is 99 liters and the median is 83 liters.

Within Cathlapotle House 4, the mean pit volume is largest in the northern section of

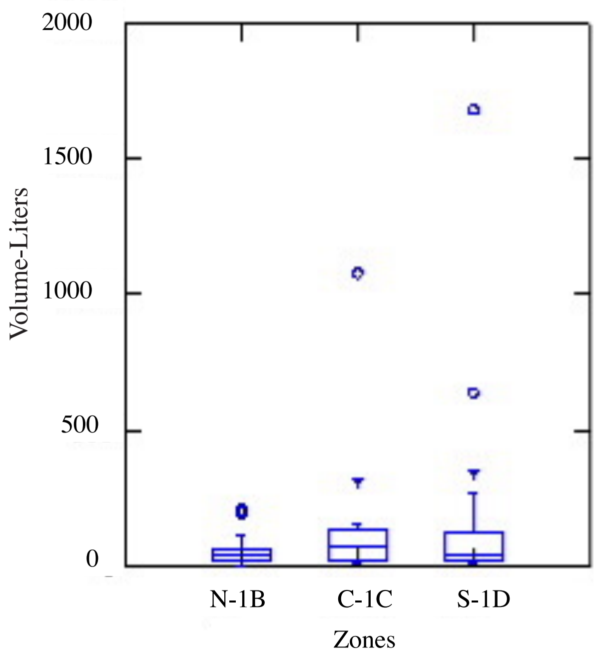


Figure 4.9. Cathlapotle House 1 North, Central, and Southern Pit Volumes.

the house, with an average of 122 liters. This is the only plank house with the largest storage pits in the northern section of the house. The mean is significantly larger in the north compared to the southern area of the house (n=14, t=1.699, p=0.050). The mean pit volume is 97 liters in the central area of the house and 46 liters in the south (Table 4.7).

Box Plots

To further compare storage pit volumes within the analytical areas of the houses, box plots were developed. The box plots provide a graphical technique to identify outliers in the analytical areas of the plank houses. The box plot graph is used to show the shape of the distribution, its central value, and the spread. The picture produced consists of the most extreme values in the dataset (maximum and minimum values), the lower and upper quartiles, and the median (Figure 4.8).

The box plots produce three lines within the box. The upper and lower lines represent the quartiles. The lower or first quartile (Q1) is the value under which 25% of the dataset lie. The upper third quartile (Q3) is the value over which 25% of the data are found. The horizontal line in the center of the box represents the median or second quartile (Q2). When the dataset is sorted, the median is the middle value in the data.

In Cathlapotle House 1, all three analytical zones have outliers (Figure 4.9). This indicates that several of the pits are much larger in size compared to the median. In the southern area (1d), the far outliers are 638 liters and 1683 liters. The far outlier in the central zone (1c) is 1079 liters, and the northern (1b) zone contains outliers of 193 and 207 liters. Hence, the storage pits in the northern area are considerably smaller than in the central and southern sections. In Cathlapotle House 4, there is one large outlier in the northern section of the house (1b). This storage pit is 472 liters (Figure 4.10).

Figure 4.11 compares the storage pit volumes from Cathlapotle House 1 and House 4. The figure illustrates that the median pit volume is larger in House 4 compared to House 1. The median pit volume in House 4 is 83 liters and the median storage pit volume in House 1 is 39 liters. However, there are several extremely large storage pits in House 1. These large storage pits are indicated by the box plot outliers and the mean of 46 liters.

In Figure 4.12, box plots show the storage pit volumes for the three analytical zones in the Meier plank house. There are two outliers in the southern storage pit volumes. These pits are 1184 liters and 835 liters. There are also two outliers in the northern storage pit volumes. These outliers are 393 liters and 661 liters, respectively. The central area of the house does not contain any pit outliers.

Figure 4.13 compares the storage pit volumes from the Meier plank house and the two Cathlapotle households. Overall, the storage pit volumes vary in size at both sites. The figure illustrates that Meier contains larger storage pits than Cathlapotle. Although, Cathlapotle has the largest storage pit found at both sites. The outliers represent these extremely large storage pits.

It is important to note that the outliers were initially removed from the box plots. Removing the outliers did not change the median pit values and new outliers were created. It was found there were always extremely large pits compared

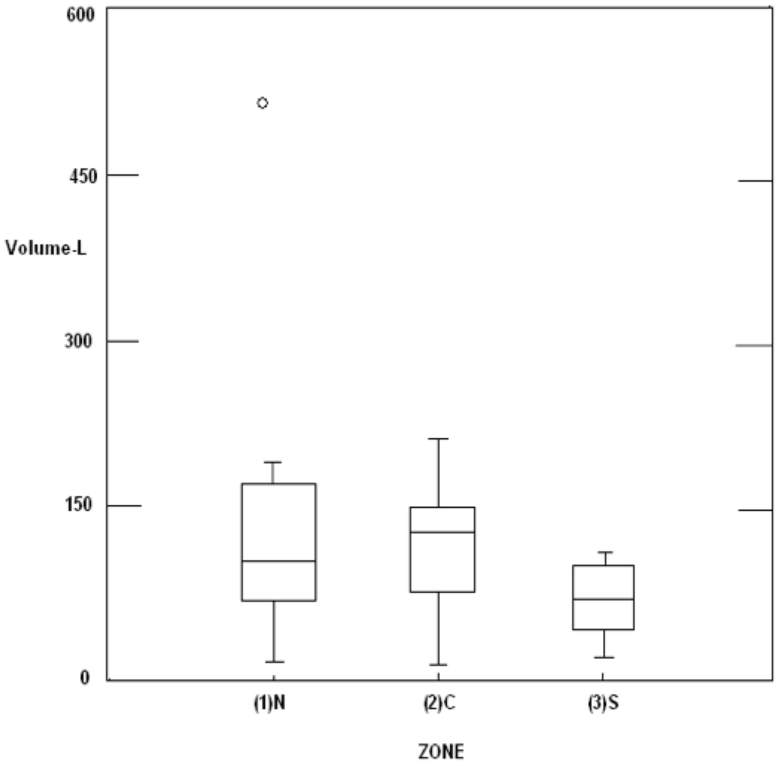


Figure 4.10. Cathlapotle House 4 North, Central, and South Pit Volumes.

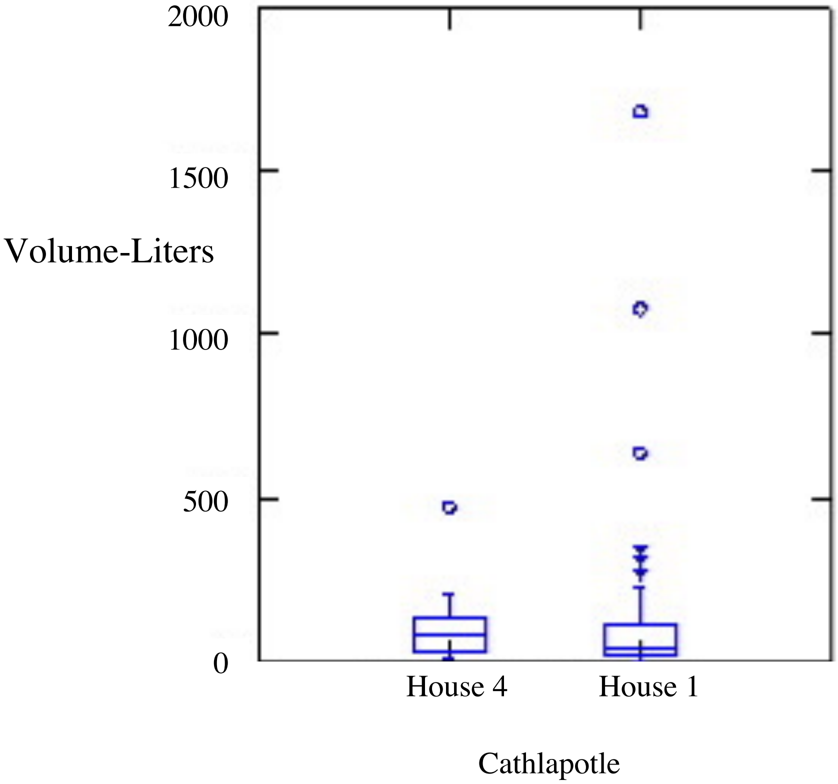


Figure 4.11. Box Plots of Cathlapotle House 1 and House 4 Storage Pit Size.

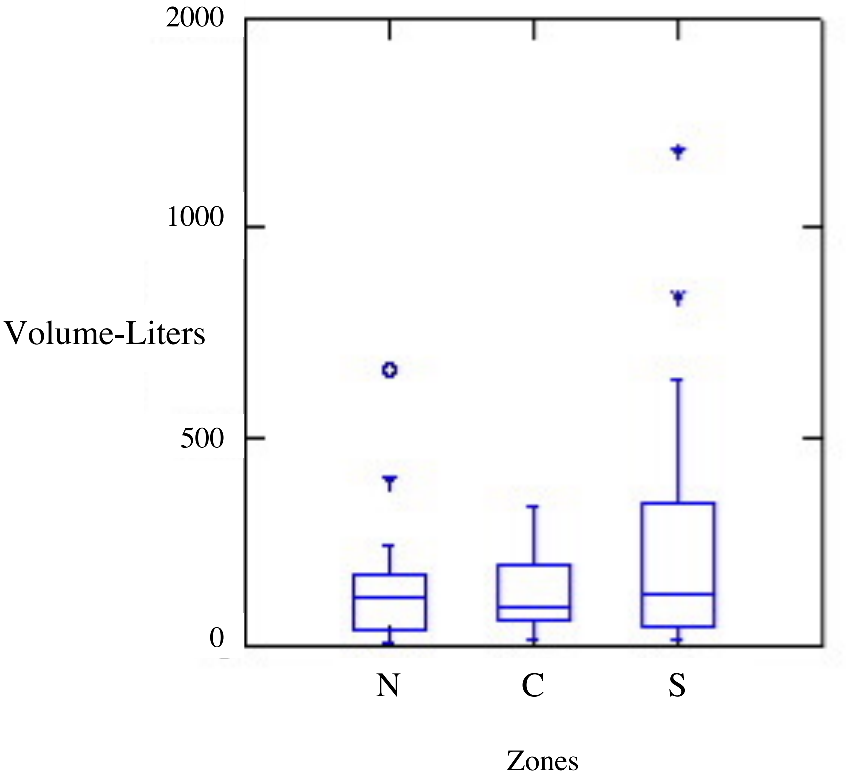


Figure 4.12. Box Plots of Meier North, Central, and Southern Zone Pit Volumes.

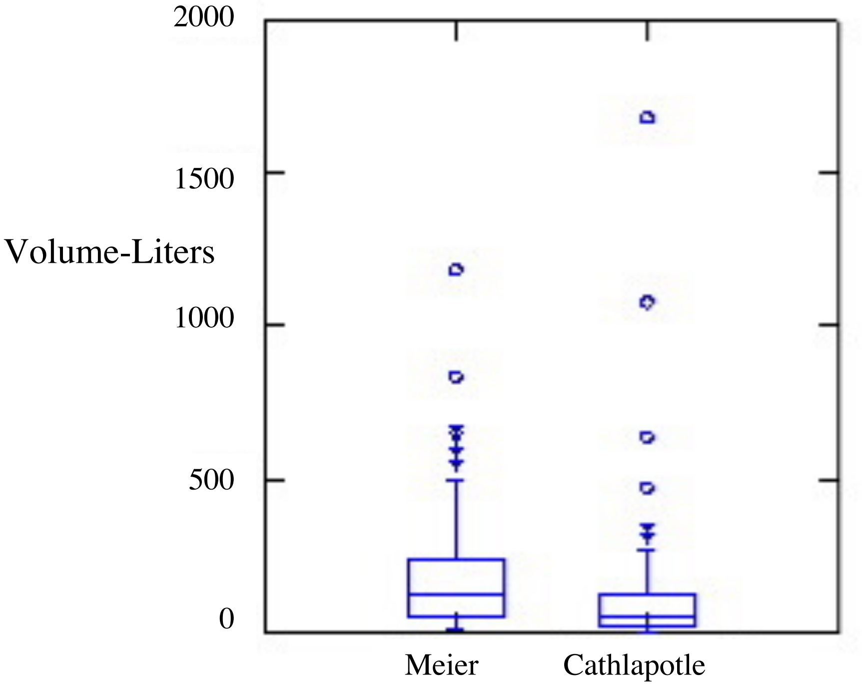
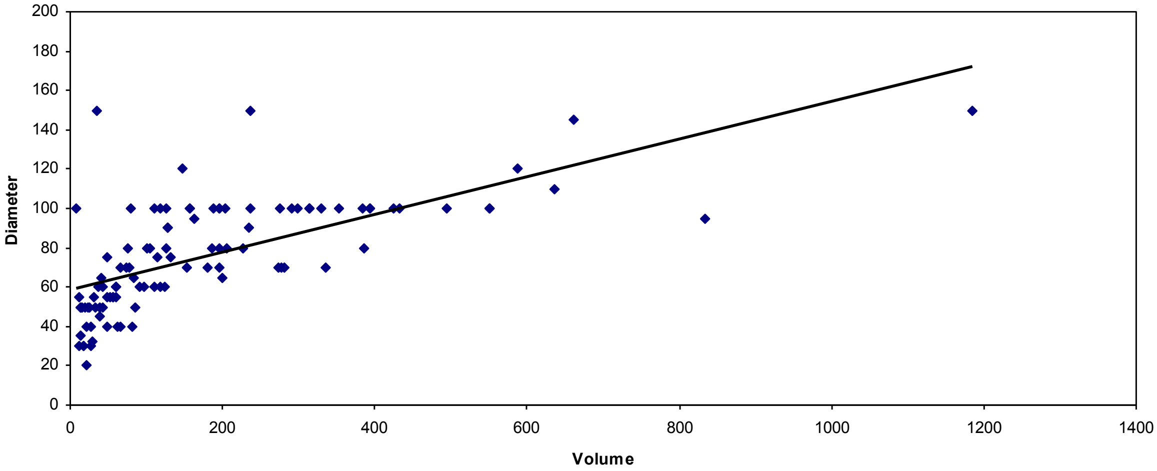


Figure 4.13. Box Plots of Cathlapotle and Meier Storage Pit Volume.



SUMMARY OUTPUT					
Regression Statistics					
Multiple R	0.66499203				
R Square	0.4422144				
Adjusted R Square	0.436799005				
Standard Error	20.89561012				
Observations	105				
	df	SS	MS	F	Significance F
Regression	1	35654.38249	35654.38249	81.6587648	1.02246E-14
Residual	103	44972.5318	436.6265223		
Total	104	80626.91429			

Figure 4.14. Relationship between Meier Pit Rim Diameters and Volumes.

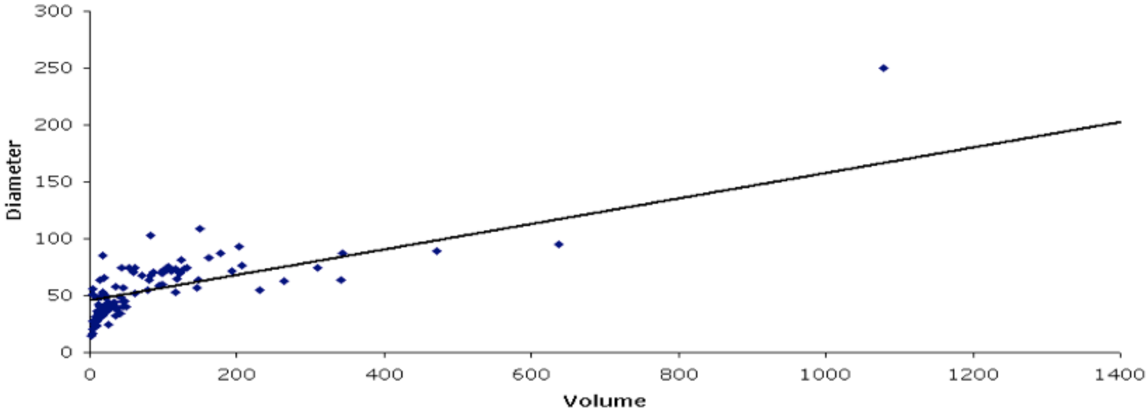
to the median pit value, and therefore, the outliers remained in the dataset.

Rim Diameters versus Volume

Figure 4.14 illustrates the relationship between rim diameter and volume for the storage pits in the Meier plank house. There is a moderately strong positive correlation between diameter and storage pit volume (p=.0001, r=0.665). At the Cathlapotle site, there is also a strong correlation between rim diameter and volume (p=.0001, r=0.789) (Figure 4.15). Thus, the Meier and Cathlapotle storage pits with larger rim diameters have larger volumes. This suggests that the shape of the storage facilities tends to be wide, basin-shaped rather than long and narrow.

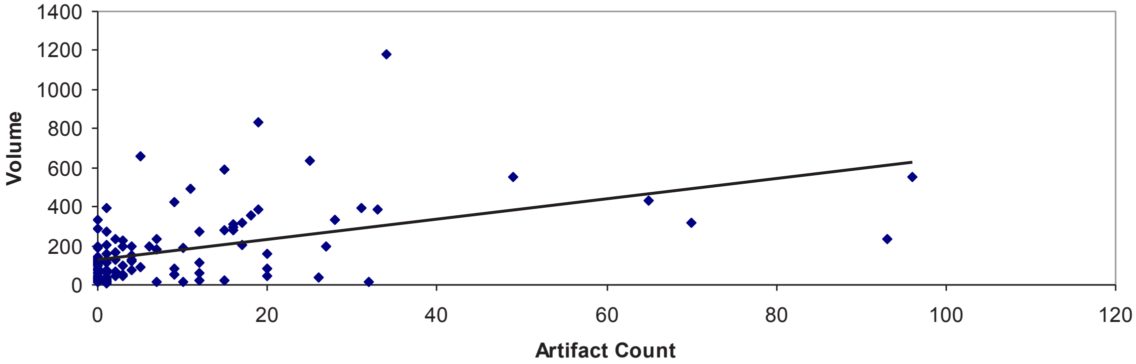
Number of Artifacts versus Volume

As an exploration of pit content variability, the number of artifacts in the storage pits was examined. Pit artifacts were defined as all non-debitage, shaped tools, including glass, metal, lithic, and bone materials. The composition of the artifact assemblages in the storage pits and pit function will be discussed in detail in Chapters 5 and 6. At this point in the study, the relationship between the number of artifacts in a pit and the storage pit volume was explored. This will show whether artifact count increased with the size of the storage pit. A regression analysis is used to test this relationship. In the Meier site, there is a correlation between pit volume and artifact count, although it is not very strong (p=.0001, r=0.468). There are many storage pits in the Meier house that have small volumes but large quantities of artifacts (Figure 4.16). At the Cathlapotle site, there is a strong correlation between artifact counts and storage pit volume (p=.0001, r=0.838). It appears that as the storage pits at Cathlapotle increase in volume, they tend to have more artifacts (Figure 4.17). At both Meier and Cathlapotle, all site deposits were screened with the same proportion of 1/4” and 1/8th” mesh screens.



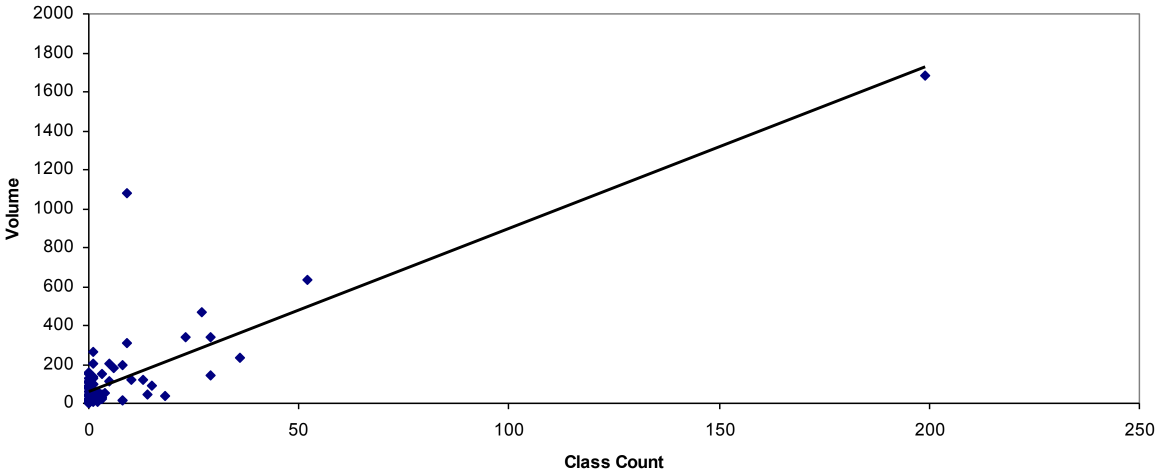
SUMMARY OUTPUT					
Regression Statistics					
Multiple R	0.788817289				
R Square	0.622232716				
Adjusted R Square	0.617890563				
Standard Error	139.0289028				
Observations	89				
	df	SS	MS	F	Significance F
Regression	1	2769860.776	2769860.776	143.3005146	4.36818E-20
Residual	87	1681626.115	19329.0358		
Total	88	4451486.891			

Figure 4.15. Relationship between Cathlapotle Pit Rim Diameters and Volumes.



SUMMARY OUTPUT					
Regression Statistics					
Multiple R	0.468246005				
R Square	0.219254321				
Adjusted R Square	0.211674266				
Standard Error	171.2583712				
Observations	105				
	df	SS	MS	F	Significance F
Regression	1	848358.4985	848358.4985	28.92516176	4.72681E-07
Residual	103	3020931.26	29329.4297		
Total	104	3869289.758			

Figure 4.16. The Relationship between Artifact Counts and Pit Volume at Meier.



SUMMARY OUTPUT

Regression Statistics					
Multiple R	0.837804141				
R Square	0.701915779				
Adjusted R Square	0.698489524				
Standard Error	123.4987087				
Observations	89				
	df	SS	MS	F	Significance F
Regression	1	3124568.89	3124568.89	204.8638222	1.37876E-24
Residual	87	1326918.001	15251.93104		
Total	88	4451486.891			

Figure 4.17. The Relationship between Artifact Counts and Pit Volume at Cathlapotle.

Additionally, it is apparent that artifact content did not vary according to pit size. The larger pits at both of the sites contained the same densities of artifacts as the smaller storage facilities.

Storage Pit Density Per Analytical Area

Storage pit densities were calculated by dividing the total number of pits for each analytical area by the excavation volume (m) (Table 4.8). The conversion of raw pit counts to densities controlled for discrepancies in excavation volume between analytical units. One-sample chi-squared tests were used to examine whether the frequency of pits per analytic unit was what would be expected if frequency were uniform or uneven.

The storage pits are fairly evenly distributed throughout the Meier plank house. The chi-square shows there is not a significant among the observed and expected frequencies of storage pits for each household zone at the Meier site (Table 4.9). In the Meier plank house, the higher count of storage pits is in the southern end of the house with 53 storage pits. However, the central portion of the house has the highest density of pits. There are 1.21 pits per m in the central portion of the house, whereas there are 0.91 pits per m in the south and 0.85 pits per m in the north (x^2=2.07, p-value=0.35).

In House 1 at Cathlapotle, the pit densities are highest in the northern (1b) (0.97 m) and southern areas of the plank house (1d) (0.95 m) and lowest in House 1's central portion (1c) (0.64 pits per m). As in the Meier plank house, pit density is highest in the central portion of House 4 at Cathlapotle with 0.70 pits per m . There are 0.47 pits per m in the south and 0.34 pits per m in the north. Cathlapotle House 4 contains fewer storage pits than House I or the Meier plank house. However, the chi-square indicates that there is not a significant difference between the observed and expected storage pit counts for the household zones at Cathlapotle House 1 (x^2=1.64, p-value=0.44) or Cathlapotle House 4 (x^2=2.53, p-value=0.28).

Table 4.8. Storage Pit Frequencies and Densities.

Site/House/Facility	Excavation Vol. (m^3)	Pit Densities
Meier-north, n=28	33.07	0.85
Meier-central, n=25	20.69	1.21
Meier-south, n=52	56.93	0.91
Cathlapotle House 1b, n=20	20.70	0.97
Cathlapotle House 1c, n=12	18.61	0.64
Cathlapotle House 1d, n=36	37.75	0.95
Cathlapotle House 4-north, n=10	29.20	0.34
Cathlapotle House 4-central, n=7	9.96	0.70
Cathlapotle House 4-south, n=4	8.52	0.47

Table 4.9. Chi-Squares for Meier and Cathlapotle Pit Frequency Per Analytic Unit.

Site/House/Facility	Observed	Expected	Chi-Square	P-value	Degrees of Freedom
Meier-north, n=28	28	31.45	0.378		
Meier-central, n=25	25	19.35	1.650		
Meier-south, n=52	52	53.55	0.045		
Sums	105	104.35	2.073	0.355	2
Cathlapotle House 1b, n=20	20	17.68	0.304		
Cathlapotle House 1c, n=12	12	16.32	1.143		
Cathlapotle House 1d, n=36	36	33.44	0.196		
Sums	68	67.44	1.644	0.44	2
Cathlapotle House 4-north, n=10	10	12.81	0.616		
Cathlapotle House 4-central, n=7	7	4.20	1.866		
Cathlapotle House 4-south, n=4	4	3.57	0.052		
Sums	21	20.58	2.535	0.282	2

In sum, the storage pits were fairly evenly distributed throughout the Meier and Cathlapotle plank houses. The Meier central zone contains slightly more pits than the other analytical areas of the house. In Cathlapotle House 1, the storage pits have similar densities in the northern (1b) and southern (1d) areas, while the central (1c) area contains the fewest pits. However, these differences in the distribution of the storage pits with both houses are not statistically significant.

Pit Types

The pits excavated at Meier can be placed into four pit types. These pit types were defined based on their lining. Storage pit lining has not been identified in other Northwest Coast sites. The most common type was the unlined pit. These pits were usually rounded at the bottom which may indicate a base for the placement of a basket. The second type is pits lined with fire-cracked rock. The fire-cracked rock appears to have been deliberately pressed into the walls of the pits. The third pit type is storage pits with a thin layer of crushed-shell and burnt grass lining the interior. The fourth type is lined with planks. Although it is known that some of the pits were rock, shell, or plank-lined, these pit types were not analyzed for this study.

The Meier excavation did not expose a sufficient number of pit types to establish distribution patterns within the household. Four plank-lined pits and one rock-lined pit were found in the southern portion of the house. The northern end (1b) of the household contained two rock-lined and two shell-lined pits. The central (1c) section of the house had one rock-lined pit. In observing the pit artifact contents, it did not appear that certain pit types contained particular contents. The Cathlapotle houses did not contain a variety of pit types. Only unlined pits were encountered.

Summary

At the Meier site, pit volume is greatest in the southern end of the household. The northern storage pits are significantly smaller although there are several storage pits in this area that are as large as the southern storage pits.

The storage pits at Cathlapotle are generally smaller than at Meier. However, a few storage pits at the Cathlapotle site are actually larger than any Meier pits. The storage pits are largest in the central zone (1c) of Cathlapotle House 1, although the differences among the House 1 sections are not statistically significant. In Cathlapotle House 4, the storage pits are significantly smaller than the House 1 storage facilities. Unlike the other plank houses, the storage pits in House 4 are significantly larger in the northern portion of the house.

The storage pits are relatively evenly distributed through the Meier house. The central portion of the structure has slightly more storage pits than the southern portion. In Cathlapotle House 1, the storage pits are evenly distributed in the northern (1b) and southern (1d) portions of House 1. The central area (1c) of the house has fewer pits than the other analytical units. In Cathlapotle House 4, there are more storage pits in the central area of the household than the southern and northern ends of the house which parallels Meier.

Because of the size and distribution of the storage pits at both sites, it appears that household residents in all areas of the house used the pits to some degree. However, the northern area of the Meier site and the central area of the Cathlapotle site contained fewer and smaller pits. This may indicate that the inhabitants in these areas of the houses were not using the pits as commonly as the other zones of the houses.

CHAPTER 4
SPATIAL DISTRIBUTIONS OF ARTIFACTS IN THE CATHLAPOTLE AND MEIER STORAGE PITS

Introduction

To identify spatial patterning among the storage pit artifacts, correspondence analysis, a multivariate technique, was used. Correspondence analysis was employed to identify associations among household activities as well as status. The following sections will define correspondence analysis and discuss why it was the preferred statistical method for this study.

The Significance of Artifact Distributions in the Storage Pits

To identify meaningful spatial patterns using correspondence analysis, the artifacts recorded in the pits were grouped into activity classes. The artifacts recovered from the storage pits within the houses can be classified based on their inferred functions, allowing it possible to establish activities that took place within the houses (Grier 2001). Additionally, the artifacts in the storage pits can be used to determine how activities were spatially organized in the houses.

According to Grier (2001:185), function and social organization/status are the key cultural factors that determine how artifacts were deposited in houses. These two factors, function and status, had important roles in arranging how the various classes of artifacts were deposited in the storage pits. Household activities or tasks required a variety of tools. Artifacts used in the same activity are functionally related and functional relationships can be major factors in producing co-distributions of artifact types. When household activities are performed differentially through the house, differential spatial associations of artifacts can be produced (Grier 2001).

However, not all artifacts from the storage pits relate to activities carried out within the houses themselves. For example, terrestrial hunting or fishing obviously did not take place within the house, but the tools used in these activities were deposited in the house. Therefore, these artifacts may occur together not because they were used together in a particular location or in a common activity but because they may have belonged to an individual or family who stored their artifacts together. In this case, artifacts that co-occur were not necessarily functionally related through use in a common activity. They were brought together spatially by household social organization (Grier 2001).

A second cultural factor that may influence how artifacts co-occur in the houses is status (Grier 2001). According to Northwest Coast ethnographic accounts, household activities were often linked to the status of the individuals performing them. Also, certain individuals may have had access to resources that others did not have (Smith 2004). The artifacts associated with a particular individual or group in the house can be used as a measure of differences in access to resources of wealth and status (Grier 2001).

The distribution of artifacts is also affected by site formation processes. Smith's (2006) analysis of site formation processes at Meier and Cathlapotle concluded that the movement of artifacts within the Meier and Cathlapotle structures resulted primarily from cultural rather than natural processes. The household members had a significant effect on the formation processes of the storage pits. In general, it was found that the artifacts in the storage pits were recovered at or close to their point of discard or storage. Movement of artifacts occurred during cleaning episodes when pit contents were removed from the storage facilities to the outside middens. It is unlikely that pit contents moved laterally along the long axes of the houses (Smith 2002). Although the pits contained both refuse and useable items, this study concentrated on the non-debris artifacts. There is no pit refuse in this analysis.

Methods

Correspondence Analysis of Meier and Cathlapotle Artifact Types and Classes

The storage pits yielded artifacts classifiable into forty-nine artifact types. Considering all of these types would make it difficult to establish relationships of co-occurrence among them. Correspondence analysis (CA), a multivariate dimension reduction technique, was used to reduce the number of artifact types into a smaller number of new variables or dimensions (Shennan 1997).

This technique is effective when working with counts or frequencies in a complex dataset (Shennan 1997). For this study, correspondence analysis identifies which types of artifacts are occurring or not occurring together in the storage pits excavated at the Meier and Cathlapotle sites.

The correspondence analysis method is useful because its results can be examined visually. Correspondence analysis displays both the rows and columns of a contingency table as points in a two-dimensional space or plot. This allows one to examine relations not only among row or column variables but also between row and column variables (Shennan 1997). The object of correspondence analysis is to explain the inertia in this contingency table. Inertia means variance within the context of correspondence analysis. Generally, inertia is the squared distance of a variable from the centroid of the distribution. Specifically, it is defined as the total Pearson Chi-square for the two-way variable divided by the total sum of the contingency table (I=Chi-square/Total N) (Greenacre 1984). Often, inertia is used interchangeably with eigenvalues. Each eigenvalue is the amount of inertia (variance) a given factor explains in the correspondence table. This will be further discussed in the results discussion.

In this study, the goal of correspondence analysis is to explore associations among the artifact types found in the storage pits. Correspondence analysis is used to identify which artifact types co-occur or do not co-occur in the storage pits (Shennan 1997). To measure the similarity of the variables (artifact types) and cases (the storage pits) in the dataset, the correspondence analysis uses a distance measure similar to chi-squared tests. The technique defines a measure of distance between any two points or variables. Because correspondence analysis employs a distance formula, it uses count data and these frequencies do not have to be normally distributed (Shennan 1997).

One of the problems with using raw count data in many statistical analyses is differences in sample sizes. Often, cases (i.e., storage pits) vary in size or volume and consequently the quantity of artifacts and artifact types present. The calculations used by correspondence analysis take advantage of frequency data in a way that is not strongly influenced by sample size differences. Larger samples and more common categories do not have a proportionally greater effect on the outcome of the analysis (Shennan 1997). In the correspondence analysis for this study, frequencies of artifact types for each storage pit form the input data for the CA plots. This will be further explained below.

The CA Variables: Artifact Types

At Cathlapotle 566 artifacts could be assigned to specific pit features; at Meier 1064 artifacts could be classified to a specific storage pit (Appendix A) (Smith 2004). These types have functional, morphological, or raw material characteristics (Smith 2004).

For this study, it was necessary to reduce the number of types to a manageable number. Of the 125 artifact types, several were eliminated at once. All bone, antler, lithic, and historical artifacts that could not be assigned to a specific activity were eliminated from the study. For example, artifacts that were too fragmented to be identified were omitted. Lithic debitage was omitted, although lithic debitage is concentrated in the storage pits. After this initial reduction of artifact types, forty-nine types were initially used in analyzing the storage pit contents.

The correspondence analysis of the forty-nine artifact types produced a very complex variable plot. Because of the still large number of artifact types, there were no clear associations or relationships among the types. Therefore, the number of artifact types had to be further reduced to determine relationships among them. It can be difficult to distinguish associations among the types when there are too many points on the two-dimensional variable plot. In order to reduce the number of variables in the correspondence analysis, the artifact types were grouped into nine broad but distinct activity classes (Table 4.10). Most of these activity classes relate to subsistence, materials production, or status.

The *fishing* gear category includes artifacts used in aquatic hunting (i.e. antler harpoon valves) as well as net and line fishing (i.e. netweights, bone bi-points). *Chipped stone production* includes tools used in making lithic tools (i.e. lithic hammers). This class also contains unfinished lithic tools such as cores and bifaces,

Table 4.10. Artifact Classes for Meier and Cathlapotle Storage Pits.

Chipped Stone Production
Lithic Hammer
Lithic Anvil
Lithic Bipolar Core
CCS Manuport
Lithic RUM Biface
Lithic Core

Fishing (Line and Aquatic)
Antler Harpoon Valve
Bone Bi-Point
Bone Point
Metal Hook
Lithic Net Weight

Status/Personal Adornment
Bone Bead
Metal Bead
Shell Bead
Bone/Shell Bead
Lithic Bead
Decorated Lithic
Decorated Bone
Bone Pendant
Lithic Pendant
Beaver Incisor
Sea Lion Canine
Lithic Pigment
Shell Sand Dollar
Gun Item

Organics Manufacturing

Bone/Antler Perforator
Lithic Scraper

Terrestrial Hunting
Lithic Point
Metal Point

Woodworking
Antler Wedge
Lithic Adze
Lithic Maul/Pestle
Wood Peg
Wood Worked-Item
Bone Chisel/Wedge
Lithic Saw
Lithic Shaver
Lithic Abrader

Food/Plant Processing
Lithic Mortar/Bowl

Ceremonial
Ceramic Smoking Pipe
Clay Figurine
Ceramic Baked Items
Lithic Club

Bone/Antler Tool Production
Antler Worked Item
Bone Worked Item
Lithic Graver
Lithic Wedge

* Artifacts in italics are found only at Cathlapotle

although there had to be substantial evidence that an artifact was in the process of becoming a finished tool to be included. Lithic projectile points represented the *terrestrial hunting gear* category. Artifact types used in hide preparation characterized the *organics manufacturing* class. Lithic bowls and mortars were assigned to the *food and plant processing* category. The *woodworking* class includes tools used in boat and house related construction (i.e. mauls).

Artifacts that would have played roles in symbolizing status or ritual behavior were placed in the *status/personal adornment* or *ceremonial* classes. Interpretations of the significance of these items are based on ethnographic accounts. In the status/personal adornment class, beads and pendants represent the majority of the artifact types in this category. Bone, shell, and metal beads are included in the analysis.

The ceremonial class is comprised of several artifact types, including ceramic smoking pipes and clay figurines. Lithic clubs are also included in the ceremonial class because they were often associated with symbolic rituals among the Chinook. Frequently, the clubs were elaborately decorated (Kenneth M. Ames, personal communication).

Once the artifact types were assigned to their corresponding classes, the relationships between these artifact classes were investigated with correspondence analysis.

Interpreting Correspondence Analysis

When considering the organization of activities within the household, the particular location of variables or artifact classes on the plot is relevant to understanding their importance in household organization.

Figure 4.18 depicts a sample correspondence analysis plot and illustrates how it should be deciphered. The two-dimensional scatterplot graph retains all information about the similarities and differences between the activity classes identified in the storage pits. The correspondence analysis graph is presented in two dimensions or axes so that the majority of the variation in the activity classes can be examined at once.

In the scatterplot, variables or activity classes that co-occur close to the origin point of the plot (zero along both of the axes) do not vary from the average or expected profile of the items found in the storage pits. When variables plot closer to the origin, this indicates a uniform distribution of these artifact classes in the house. Variables that plot away from the origin or do not co-occur in the storage pits differ from the average profile. These variables or activities were more unevenly distributed or restricted in the household. Also, the variables that plot away from the origin may be less typical constituents of the artifact assemblages.

The correspondence analysis produces axes that are plotted orthogonally. Each axis has an eigenvalue that expresses its contribution to the total variability in the dataset. Eigenvalues reflect the relative importance of the axes. The first axis always explains the most inertia or variance and has the largest eigenvalue. The eigenvalues decrease in value in each subsequent axis. Each variable has a score or loading on each axis. This score may be positive or negative. The higher the score, the more it contributes to the variability measured by a particular axis.

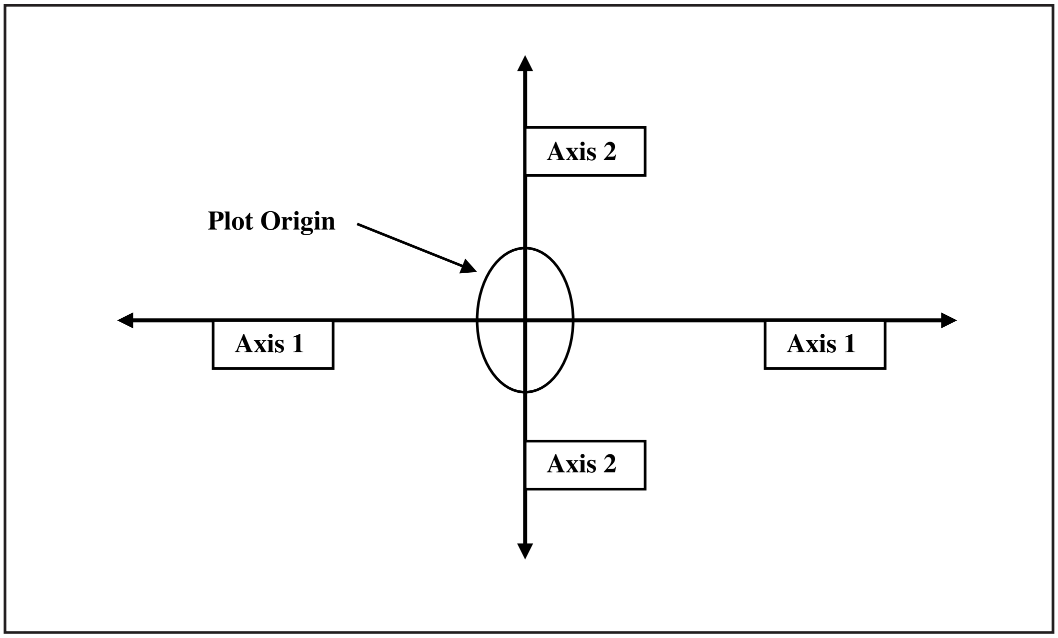


Figure 4.18 Sample Correspondence Analysis Plot.

Results of the Correspondence Analysis in the Meier House

The correspondence analysis for the Meier house shows patterned results that indicate spatial relationships among the artifact classes. Figure 4.19 is a two-dimensional plot of the relative locations of the nine artifact class variables. In the plot, axes 1 and 2 have inertia values of 19.8% and 17.3%, accounting for 38% of the variability or inertia in the entire dataset (see Appendix A). These two axes depict spatial relationships among some of the artifact classes, although these relationships are not strong.

The first plot produced two axes defined by (1) terrestrial hunting gear and ceremonial items and (2) fishing and plant/food processing. The two axes primarily represent artifact classes related to resource acquisition. The ceremonial class is the only category that is not associated with subsistence-production. Because these four variables plot away from the origin, these activities were unevenly distributed throughout the household. This may reflect different activity patterns or assemblages in the household.

The manufacturing classes, including organics manufacturing, chipped stone production and bone/antler production, fall near the origin of the first plot. The status items are also closer to the origin of the plot. The variables that occur close to the origin of the plot do not vary from the average or expected profile. This suggests that these manufacturing and status classes are widespread in the household, and hence, most members of the household may have practiced these activities. It is important to note that the status class does not follow the expectations of this study because these items are dispersed throughout the household rather than in particular high status areas of the household. This topic will be discussed later in this chapter.

Axes 1 and 2. In CA, the individual axes on the plots need to be considered. Axis 1 accounts for the most variability in the CA analysis for the Meier house, although by a small margin. Figure 4.19 shows that the fishing/aquatic hunting category is an influential class on both axes suggesting that it is unevenly distributed in the house. Fishing strongly contrasts with ceremonial items and terrestrial hunting on axis 1. High positive scores on axis 1 characterize the ceremonial and terrestrial hunting classes. In contrast, fishing has a high negative score on axis 1; suggesting fishing gear is negatively correlated with terrestrial hunting and ceremonial.

On axis 1, land hunting and fishing/aquatic hunting are also strongly opposed to one another. This suggests a division of labor or task specialization between these two activities. Also, ceremonial activities are differentiated from the rest of the household activities on axis 1. Axis 2 separates the nine classes into three groups: fishing/food processing, ceremonial/woodworking/status/terrestrial hunting, and general manufacturing activities. The manufacturing classes are situated near the origin of the plot for both axes, demonstrating little variability in these classes.

Table 4.11a summarizes the eigenvalues for axis 1 and 2 that are depicted on the correspondence analysis plot. To summarize, each variable or artifact class has one axis score. The axis' eigenvalue represents the variance for each activity class. On the CA graph, each activity class plotted represents one eigenvalue. In Tables 4.11a and 4.11b, the eigenvalues labeled "total" represent the total inertia for each axis.

Axes 3 and 4. While the relationships among the variables are well represented by axes 1 and 2, axes 3 and 4 depict slightly different associations. Axes 3 and 4 account for an additional 30 percent of the variability in the dataset, and therefore play a significant role in the analysis. Figure 4.20 shows a plot of axes 3 and 4. Unlike the first two axes, the third axis differentiates woodworking activities with a high negative score. As with the first two axes, fishing is isolated from most variables. On the fourth axis, terrestrial hunting is contrasted by ritual activities, status behavior, and bone tool production. Table 4.11b lists the scores for each artifact class in axis 3 and 4.

Summary of the CA Results for the Meier House. In the correspondence analysis for the storage pits at the Meier house, the first four axes explain the relationships among the nine variables (Table 4.12). The most significant result of the correspondence analysis is that subsistence related activities were separated from the material

Table 4.11a. Axis 1 and 2 Eigenvalues for the Meier Plank House, 9 Variable Analysis.

Artifact Class	Axis 1 Scores	Axis 2 Scores
Chipped Stone Production	-0.041	-0.809
Terrestrial Hunting	1.410	0.698
Woodworking	-0.782	1.565
Fishing	-2.773	3.227
Status Items	-0.623	0.553
Organics Manufacturing	-0.364	-0.500
Food/Plant Processing	-1.440	3.194
Bone Tool Production	-0.321	-0.431
Ceremonial Items	3.621	1.567
Total Eigenvalues	0.155	0.135

Table 4.11b. Axis 3 and 4 Eigenvalues for the Meier Plank House, 9 Variable Analysis.

Artifact Class	Axis 1 Scores	Axis 2 Scores
Chipped Stone Production	-0.381	0.810
Terrestrial Hunting	0.478	1.032
Woodworking	-2.118	-0.378
Fishing	3.739	2.082
Status Items	0.434	-1.212
Organics Manufacturing	0.419	-0.318
Food/Plant Processing	-1.792	0.373
Bone Tool Production	0.612	-1.285
Ceremonial Items	0.294	-1.707
Total Eigenvalues	0.129	0.112

Table 4.12: Important Variables on the Four Axes for the Meier CA.

Axis	Important Variables
1	Fishing, Resource Processing, Ceremonial, Hunting
2	Woodworking, Fishing, Processing, Ceremonial
3	Woodworking, Fishing
4	Ceremonial, Status, Bone Tool Production

production, with the exception of woodworking on the third axes. This suggests that the manufacturing classes are more widespread in the house compared to subsistence activities.

As for specific artifact classes, fishing and aquatic hunting stands out on all four axes. This is spatially the most distinctive artifact class for the Meier house. Resource processing, terrestrial hunting and ceremonial activities are also isolated from the rest of the artifact classes on most of the axes. These four artifact classes represent the most important classes when considering the distribution of artifact classes in the storage pits, suggesting the possibility of specialized activities in the household.

It is also important to note that woodworking is a strong variable on Axes 2 and 3. Woodworking is the only manufacturing class that does not co-occur with the other classes. This suggests that it was a distinctive manufacturing activity in the household.

Results of the Correspondence Analysis for Cathlapotle House 1

Because of low artifact counts in the House 4 storage pits, Cathlapotle House 1 was the only house at the site used for correspondence analysis. Additionally, the ceremonial class was removed from the analysis because it was not represented in the sampled storage pits in House 1.

Figures 4.21 and 4.22 present results of the correspondence analysis for the storage pit data at Cathlapotle House 1. The first two axes on the two-dimensional plot account for 50 percent of the total variation in the entire dataset (see Appendix A). This indicates that half of the information contained in the eight variables can be captured in a two-dimensional plot. Axes 3 and 4 account for 26 percent of the variability in the input data.

Axis 1 and 2. The CA results illustrate that there are three isolated variables on axes 1 and 2 (Figure 4.21). On axis 1, the fishing variable produces an extremely high positive score, whereas food/plant processing scores high on axis 2. Also, status has a high negative score suggesting it is negatively correlated with food and plant processing. Because of these isolated variables, the rest of the variables are packed closer to the origin of the plot. Table 13a summarizes the eigenvalue scores for axis 1 and 2.

Axis 3 and 4. These axes capture variability relating to the remaining artifact classes (Figure 4.22). On axes 3, bone tool production has the highest negative eigenvalue. Food/plant processing and status have high positive eigenvalues suggesting that they have somewhat mutually exclusive distributions. Axis 4 separates food production, bone tool production, status, and woodworking from the other activity classes. Table 13b illustrates the eigenvalues for the Cathlapotle axis 3 and 4.

Summary of the CA Results for the Cathlapotle House 1. In the correspondence analysis for the storage pits at the Cathlapotle House 1, the first four axes explain the relationships among the nine variables (Table 4.14). The first two axes account for 50 percent of the total variation in the dataset, which is much stronger of a result that at Meier.

In House 1, fishing/aquatic hunting, status, and food/plant processing stands out on the first two axes. These are spatially the most distinctive artifact classes for Cathlapotle House 1. These three artifact classes represent the most important classes when considering the distribution of artifacts in the storage pits, suggesting the possibility of specialized activities in the household. It is also important to note that woodworking and bone tool production are strong variables on Axes 3 and 4.

Summary

Overall, the correspondence analysis suggests relationships among the artifact classes present in the storage pits at both the Meier and Cathlapotle sites (Tables 4.12 and 4.14). These relationships indicate a division of labor for certain activities. Since the correspondence analysis produced relationships between the artifact classes, it was necessary to determine where their relationships were occurring in the household. The spatial patterning of these artifact classes is discussed in the following section.

Table 4.13a. Axis 1 and 2 Eigenvalues for Cathlapotle House 1, 8 Variable Analysis.

Artifact Class	Axis 1 Scores	Axis 2 Scores
Chipped Stone Production	-0.109	0.180
Bone Tool Production	0.220	1.059
Terrestrial Hunting	-0.231	0.155
Woodworking	0.268	-0.226
Fishing	8.225	-0.957
Status Items	-0.542	-3.804
Organics Manufacturing	-0.210	-0.385
Food/Plant Processing	0.480	4.758
Total Eigenvalues	0.280	0.164

Table 4.13b. Axis 3 and 4 Eigenvalues for Cathlapotle House 1, 8 Variable Analysis.

Artifact Class	Axis 1 Scores	Axis 2 Scores
Chipped Stone Production	-0.412	-0.446
Bone Tool Production	-2.529	3.579
Terrestrial Hunting	0.772	-0.281
Woodworking	-0.420	1.799
Fishing	0.370	-0.774
Status Items	1.739	1.621
Organics Manufacturing	0.089	-0.443
Food/Plant Processing	5.564	2.554
Totals Eigenvalues	0.156	0.123

Table 4.14. Important Variables on the Four Axes for Cathlapotle CA.

Axis	Important Variables
1	Food/Plant Processing, Status
2	Fishing
3	Woodworking, Bone Tool Production, Status, Processing
4	Status, Bone Tool Production, Processing

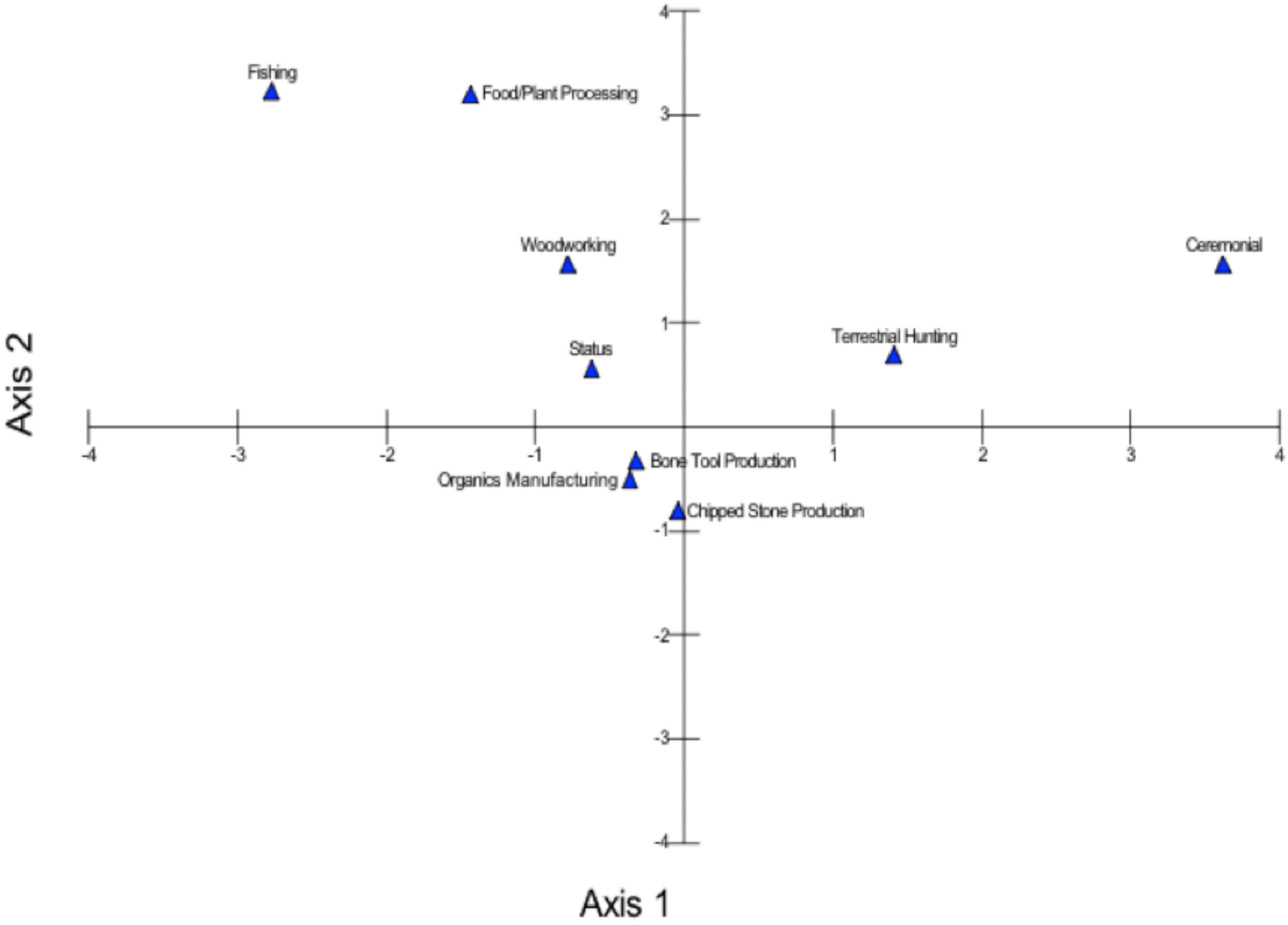


Figure 4.19. Axis 1 and 2 Correspondence Analysis for Meier Pits.

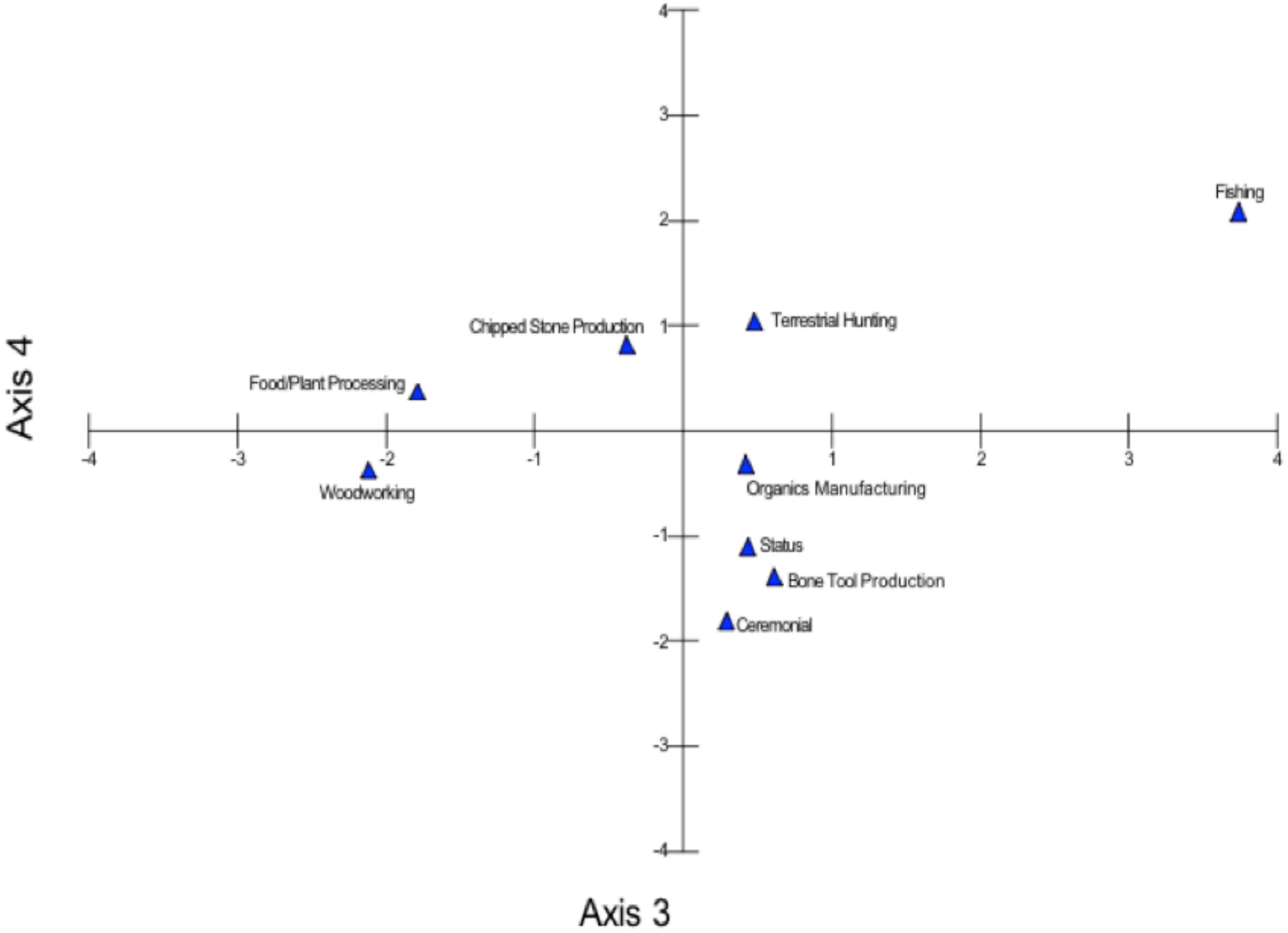


Figure 4.20. Axis 3 and 4 Correspondence Analysis Scores for Meier Pits.

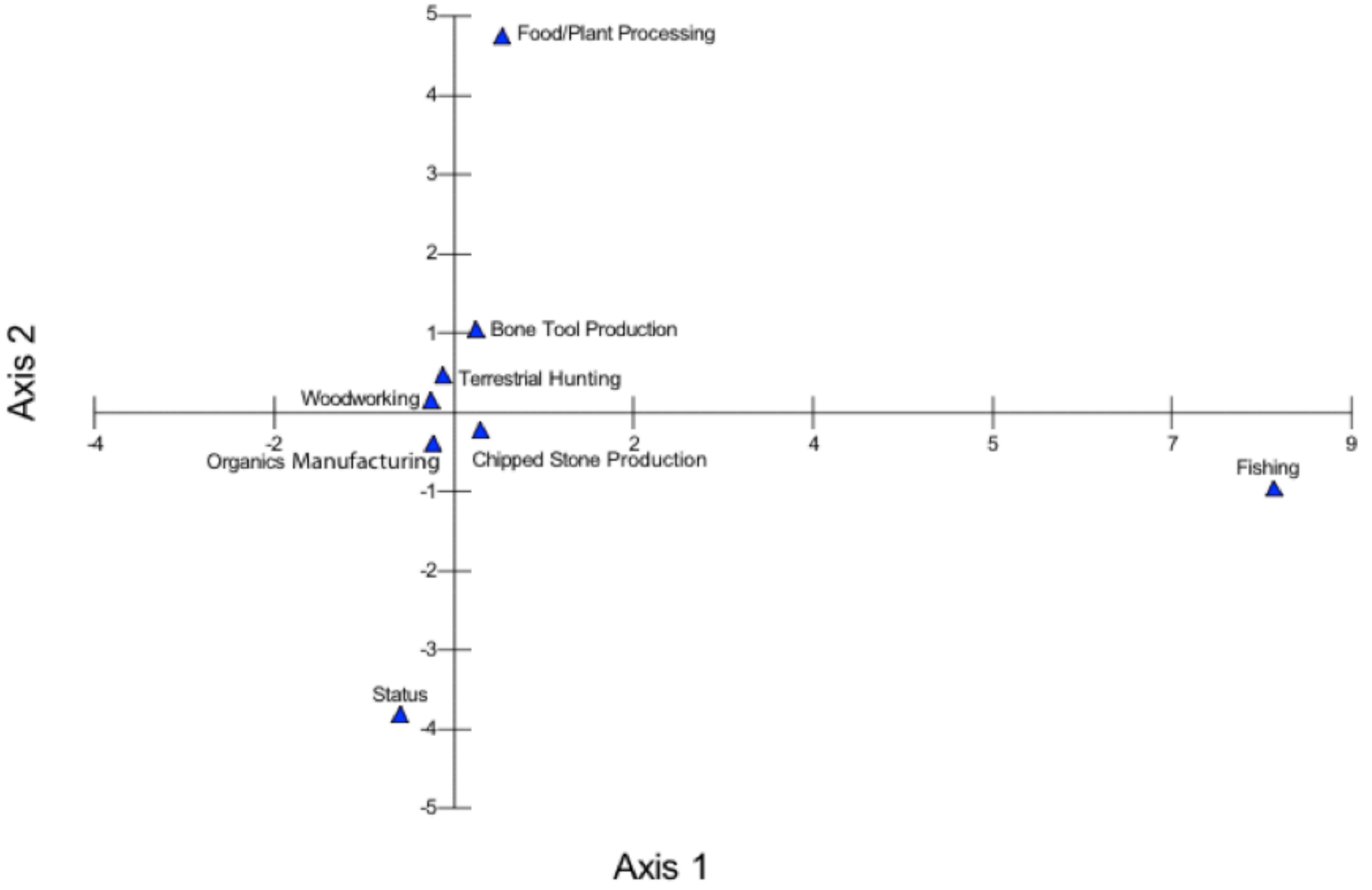


Figure 4.21. Axis 1 and 2 Correspondence Analysis Scores for Cathlapotle House 1 Pits.

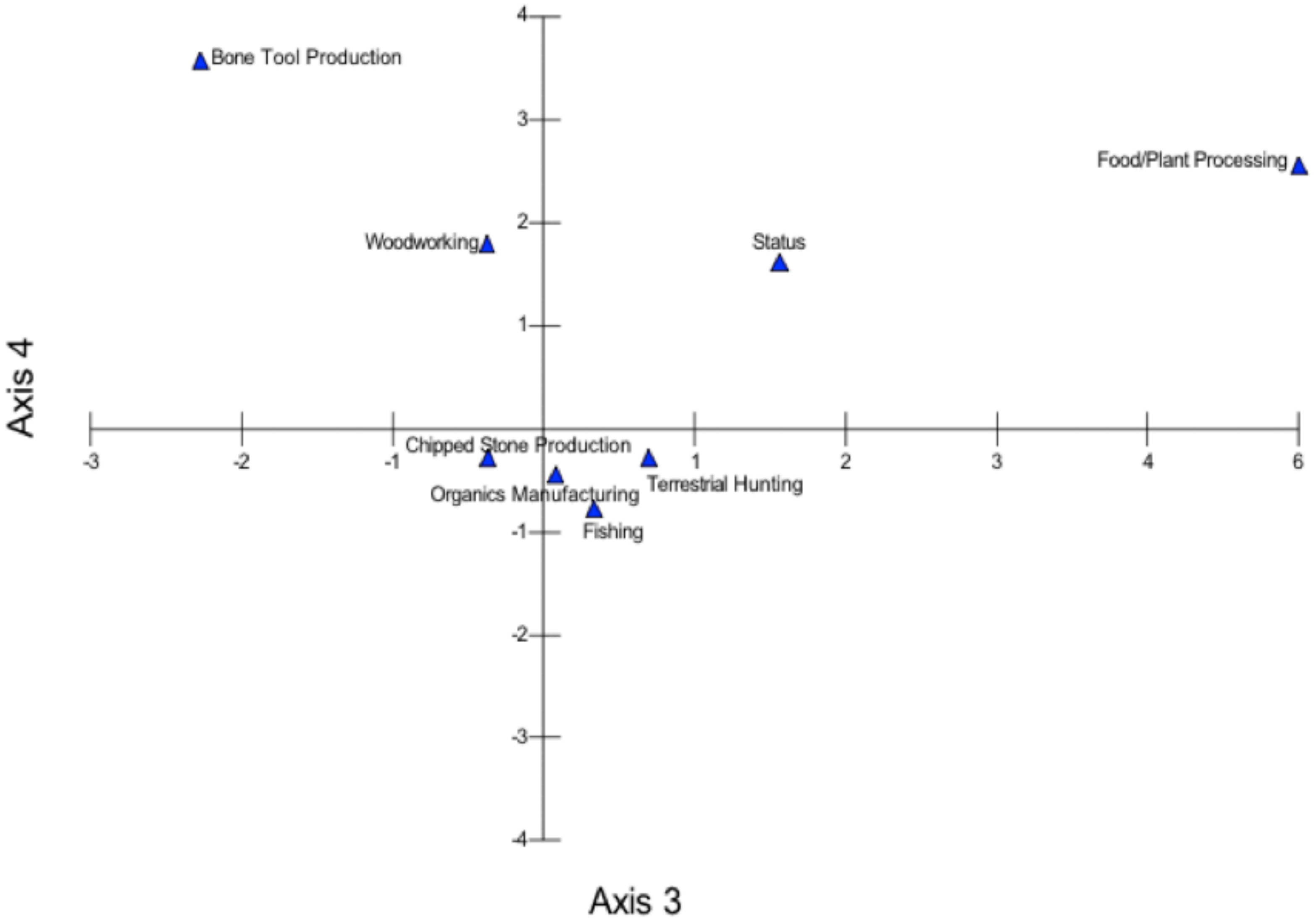


Figure 4.22. Axis 3 and 4 Correspondence Analysis Scores for Cathlapotle House 1 Pits.

CHAPTER 5
MEIER AND CATHLAPOTLE STORAGE PIT CONTENT PERCENTAGES

Introduction

A primary objective of this study is determining whether there is meaningful spatial patterning in the co-occurrence of various artifact classes in the Meier and Cathlapotle houses that may provide insights into the organization of social and economic activities. In the previous chapter, the correspondence analysis identified spatial relationships among the artifact classes that possibly reflect activity patterns. The CA analysis showed that certain artifact classes were unevenly distributed throughout the households at both sites. However, the correspondence analysis did not explain those distributions. To further investigate these patterns, percentages relative to all artifacts found within the storage pits per analytical area were calculated. The percentages of artifact classes established *where* the uneven distribution of artifact classes occurred within the houses at both sites.

Several other quantitative methods were conducted to explore the spatial distribution of activities within the households. Cluster analysis, including both K-means and hierarchical methods, were used to investigate spatial distributions of the storage pit artifacts. Clustering is a multivariate statistical analysis that in this study uses a distance formula to measure the similarity between the variables. The analysis groups the similar variables together to assist in understanding relationships that might exist among them. Although clustering can be informative, neither clustering method was effective. The cluster analyses did not produce meaningful groups among the household storage pits, probably because of the large number of variables and artifacts at both sites.

Given the difficulties encountered with

Table 4.15. Artifact Class Percentages for the Meier Analytical Areas.

Artifact Class	Northern Pits	Percentage	Central Pits	Percentage
Chipped Stone Production	55	29.89	74	32.74
Fishing	7	3.80	6	2.65
Hunting	17	9.24	26	11.50
Woodworking	27	14.67	26	11.50
Ceremonial	8	4.35	14	6.19
Organics Manufacturing	13	7.07	24	10.62
Bone Tool Production	47	25.54	47	20.80
Plant/Animal Processing	2	1.09	0	0.00
Status	8	4.35	9	3.98
Total	184	100.00	226	100.00

Artifact Class	Southern Pits	Percentage	Total Pits	Percentage
Chipped Stone Production	226	34.56	355	33.36
Fishing	12	1.83	25	2.35
Hunting	96	14.68	139	13.06
Woodworking	58	8.87	111	10.43
Ceremonial	13	1.99	35	3.29
Organics Manufacturing	82	12.54	119	11.18
Bone Tool Production	136	20.80	230	21.62
Plant/Animal Processing	5	0.76	7	0.66
Status	26	3.98	43	4.04
Total	654	100.00	1064	100.00

the cluster analyses and to test the possibility that there is no meaningful spatial patterning of artifact classes across the storage pits, the contents of the pits were grouped into larger spatial units. These units are the standard spatial units used in all comparisons of house contents at Meier and Cathlapotle. These analytical units are the North, Central, and South sections of the Meier house and compartments 1b, 1c, 1d of House 1 at Cathlapotle. Because of the small size of Cathlapotle House 4, the house was not divided into analytical units.

Methods

Tables 4.15 and 4.16 present artifact counts and percentages for the artifact classes at Meier and Cathlapotle. Column percentages were calculated separately for each of the two sites as well as each analytical unit within the houses. Percentages were calculated to ensure consistency between two study sites by controlling for differences in excavation volume between analytical units. The two sites were compared in terms of the relative proportions of artifact classes at each site. Additionally, the artifact classes for each analytical section of the houses were compared. Pie charts were used to illustrate these percentages (see Figures 4.23-4.26). These pie charts displayed a clearer visual representation of the percentages compared to other graphical charts (i.e. bar graphs).

In addition to calculating the artifact class percentages, scatterplots of total artifact counts against excavation volume were produced for each site. At the Meier site, there is little significant relationship between the number of artifacts recovered from the storage pits and the volume excavated (p=.0001, r=0.468). However, at Cathlapotle, the number of artifacts is strongly related to excavated volume (p=.0001, r=0.838).

Results of the Artifact Class Percentages in the Storage Facilities

Table 4.16. Artifact Class Percentages for the Cathlapotle House 1 Analytical Areas.

Artifact Class	H1b Pits	Percentage	H1c Pits	Percentage
Chipped Stone Production	24	64.86	18	42.86
Fishing	1	2.70	1	2.38
Hunting	5	13.51	10	23.81
Woodworking	1	2.70	6	14.29
Organics Manufacturing	3	8.11	2	4.76
Bone Tool Production	1	2.70	5	11.90
Plant/Animal Processing	2	5.41	0	0.00
Status	0	0.00	0	0.00
Total	37	100.00	42	100.00

Artifact Class	H1d Pits	Percentage	Total Pits	Percentage
Chipped Stone Production	220	50.93	262	51.27
Fishing	6	1.38	8	1.57
Hunting	92	21.30	107	20.94
Woodworking	29	6.71	36	7.05
Organics Manufacturing	52	12.04	57	11.15
Bone Tool Production	13	3.01	19	3.72
Plant/Animal Processing	6	1.39	8	1.57
Status	14	3.24	14	2.74
Total	432	100.00	511	100.00

As discussed in the previous chapter, the correspondence analysis identified the relationships between the activity groups at the Meier and Cathlapotle sites. At the Meier site, it was established that the fishing and resource processing were the most distinctive variables on all axes. Woodworking, ceremonial activities, and terrestrial hunting also scored high on the axes for the Meier house. At the Cathlapotle site, the CA axes were also defined by fishing and resource processing activities. Status, woodworking, and bone tool production activities were also strong variables in the CA for the Cathlapotle house. These results suggest that the variables defining the CA axes were activities that may have not been performed by all household members.

Meier and Cathlapotle Activity Classes

The correspondence analysis separated subsistence activities from household maintenance activities. Because the maintenance activities clustered near the axis of the CA, this suggests these activities were widespread in the houses and performed by most household members. In contrast, subsistence activities plotted away from the axes, and therefore, they were not widespread in the households. In the following discussion, the individual activity class percentages are examined to determine where in the houses these activities occurred. Since the CA separated the maintenance activities from the subsistence activities, the activity class percentages have been analyzed according to these general groups. Because of the small number of artifacts for each storage facility, chi-square analysis was not the appropriate. Tables 4.15 and 4.16 show the total percentages of the

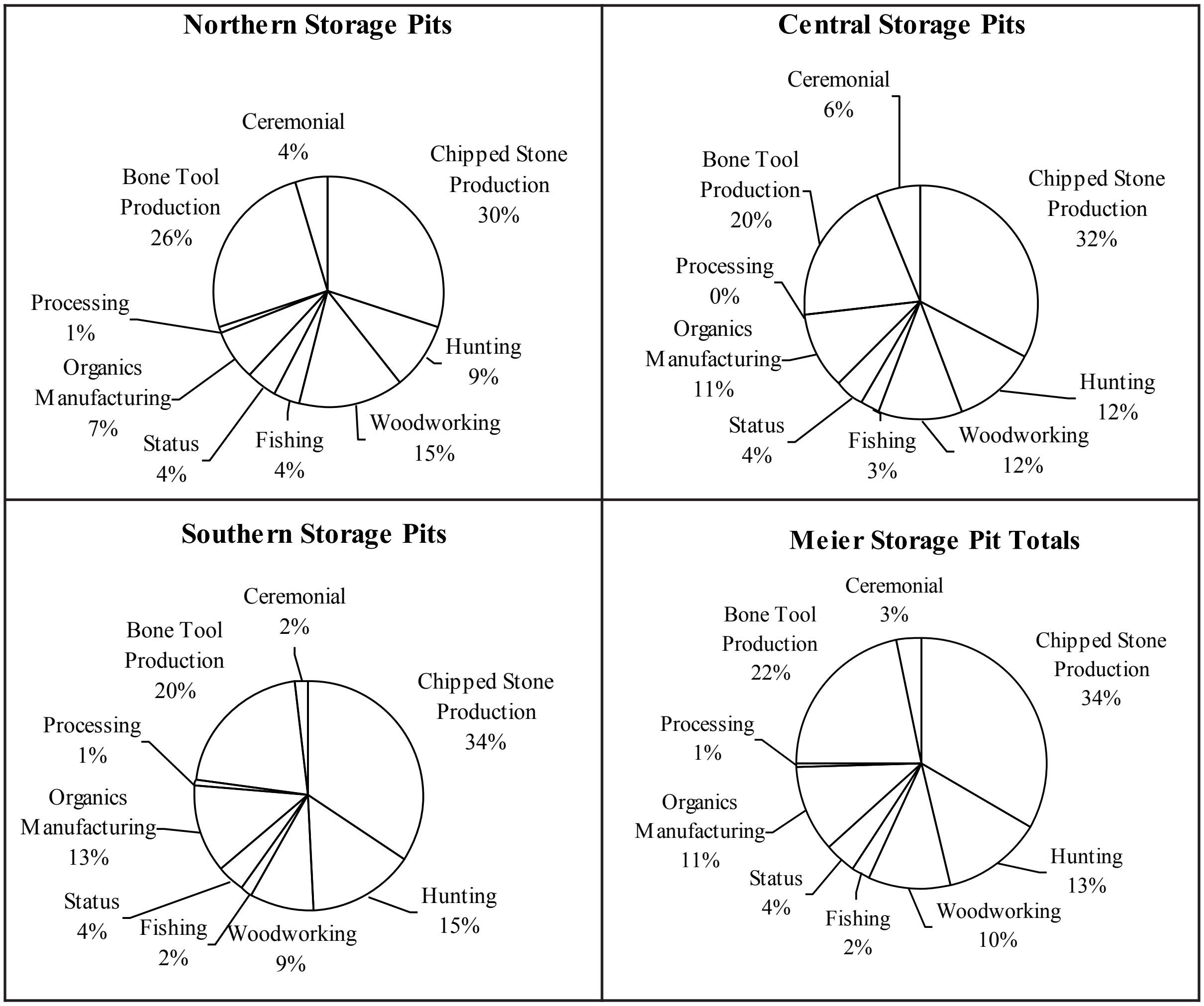


Figure 4.23. Storage Pit Artifact Class Percentages for the Meier House Zones.

artifact classes for the storage pits at the Meier House and Cathlapotle House 1. The tables also illustrate the artifact class percentages for each section of the Meier and Cathlapotle House 1.

Subsistence Production

Fishing (Line and Aquatic)

In the Meier house, the correspondence analysis (CA) established that fishing was spatially the most distinct activity class. This suggests that certain areas of the house were more involved with this activity than others. Although the percentage of items related to fishing is low, there is a noticeable difference between the different areas in the house. The percentage in the northern section (4 %) of the household is twice as high as the southern portion (2 %) of the house. It is likely that the CA was capturing this difference between the two areas of the household (Figure 4.23).

Fishing artifacts are also uncommon in the artifact assemblages of the Cathlapotle House 1 storage pits. Fishing artifacts are relatively evenly distributed in the household storage pits. Compartment 1b of the house contains the highest percentage of fishing (3 %) items followed by the compartment 1c (2 %) and compartment 1d (1 %) areas of the house. These percentage differences are captured on Axis 1 of the correspondence analysis (Figure 4.24).

Terrestrial Hunting

The correspondence analysis identified

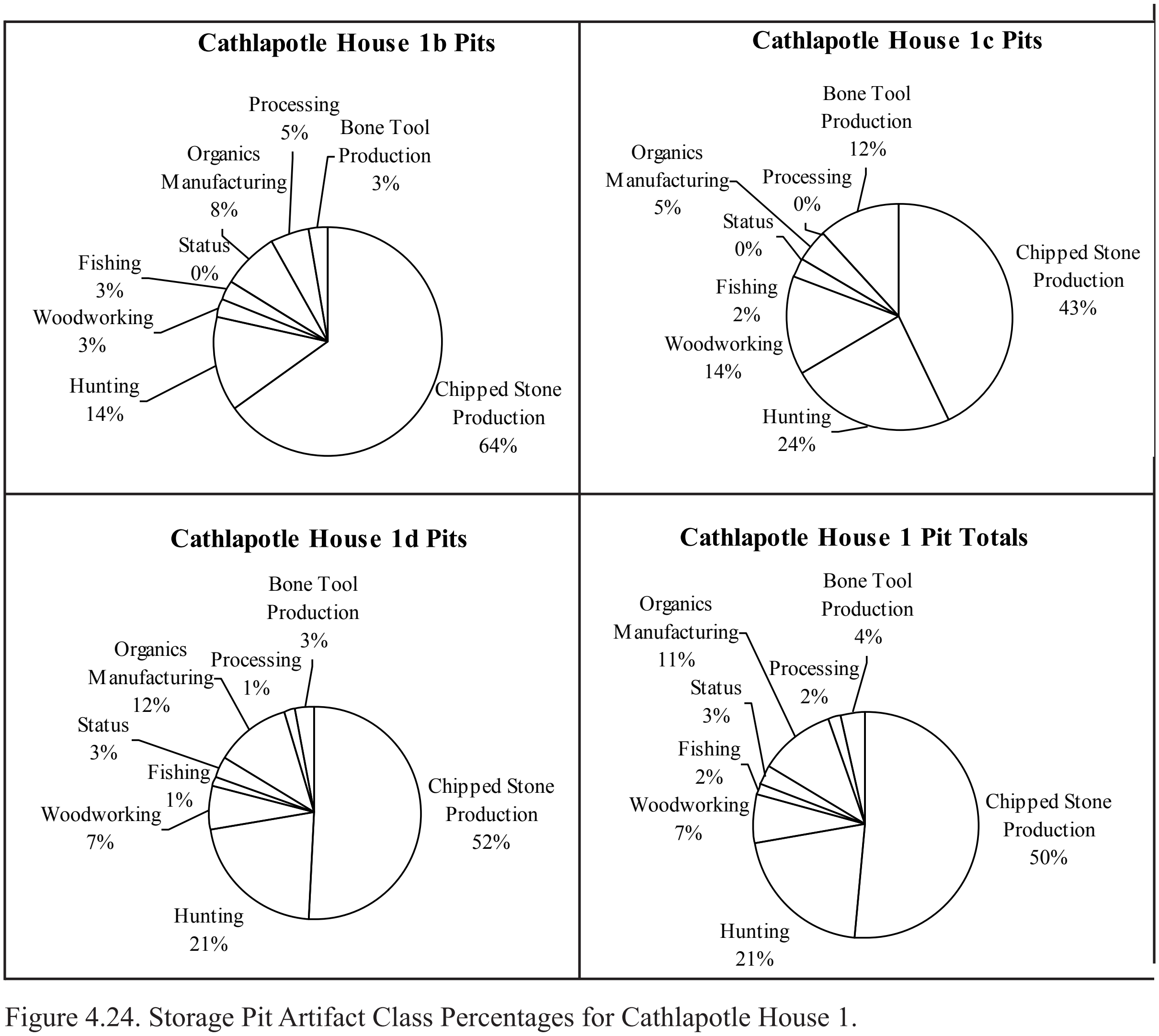


Figure 4.24. Storage Pit Artifact Class Percentages for Cathlapotle House 1.

terrestrial hunting as unevenly distributed in the Meier house. According to the percentages, the terrestrial hunting activity class is highest in the southern portion (15 %) of the house. In the central and northern sections of the house, terrestrial hunting comprises 12 % and 9%, respectively, of the artifact assemblages in the storage facilities (Figure 4.23).

Because there is only one artifact type in this activity class, T-tests were generated to establish whether the percentages for terrestrial hunting were significant at Meier (Table 4.17). At the 0.05 significance level, the terrestrial hunting activity class is nearly indistinguishable in the northern and central zones of the Meier house (t=1.206, p=0.053). When testing the differences in the hunting class between the northern and southern sections of the house, it was found that the differences are statistically significant (t=2.232, p=0.014). The difference is in the higher projectile point numbers in the southern end of the plank house. The t-tests of the hunting class for the central and southern zone storage pits of the house indicated that there is not a significant difference (t=1.405, p=0.082).

In Cathlapotle House 1, terrestrial hunting contributes a large percent to the storage pit artifact assemblages. Terrestrial hunting has the highest percentage in the central (H1c) portion (24 %) of the household followed by the southern (H1d) (21 %) and northern (H1b) (14 %) sections of the house (Figure 4.24).

T-tests were also created to determine the significance of the terrestrial hunting percentages in the Cathlapotle House 1 storage pits (Table 4.18). At the 0.05 significance level, it was found that the terrestrial hunting class differences between H1b (north) and H1c (central) was not significantly different (t=1.417, p=0.089). The t-tests of the hunting class for the northern and southern zone storage pits indicated that there is a significant difference (t=2.016, p=0.026). The difference is found in more projectile points in the southern portion (1 d) of House 1. There is also a significant difference between the number of projectile points in the southern (1 d) and central (1 c) areas of House 1 (t=1.682, p=0.059). There are more points in the south than the central area of the house.

Resource Processing

In the Meier house storage facilities, activities related to resource processing are minimal. In both the northern and southern areas of the house, only 1% of the artifacts in the storage pits relate to processing activities. Resource processing is absent from the central area of the house. This activity class is only minimally represented in the storage pits because this class only includes lithic mortars/bowls and pestles (Figure 4.23).

In Cathlapotle House 1, only 2% of the storage pit artifact assemblages relate to resource processing. Resource processing is substantially higher in the northern (H1b) storage pits compared to the central (H1c) and southern (H1d) areas of the house. The higher percentage of resource processing in the north (H1b) is illustrated on Axis 3 of the correspondence analysis (Figure 4.24).

Maintenance Activities

Woodworking

The correspondence analysis indicated that woodworking was an important activity in the Meier household. It was the only maintenance activity that produced high scores on Axis 3 & 4. The activity class percentages show that woodworking activities were most evident in the northern section (15 %) of the household. This suggests that woodworking was a specialized activity for individuals with higher status. The percentages of woodworking for the central and southern zones were 12 % and 9 %, respectively (Figure 4.23).

Woodworking has the highest percentage in the central (H1c) portion (14 %) of Cathlapotle House 1 and the lowest percentage in the northern (H1b) section (3%) of the house. Woodworking activities are most evident in the high status areas (H1c and H1d) of Cathlapotle House 1. These results are similar to the pattern found at Meier (Figure 4.24).

Chipped Stone Production

In the Meier house, chipped stone production and its products dominated artifact assemblages found in the storage pits, confirming the CA findings that all household members per-

Table 4.17. Terrestrial Hunting Test of Significance for the Meier Site.

t-Test: Two-Sample Assuming Unequal Variances

	Terrestrial-N	*Terrestrial-S*
Mean	0.607142857	1.846153846
Variance	1.506613757	13.23076923
Observations	17	26
Hypothesized Mean Difference	0	
df	69	
t Stat	-2.231653595	
P(T<=t) one-tail	0.014444347	
t Critical one-tail	1.667237939	
P(T<=t) two-tail	0.028888695	
t Critical two-tail	1.994944796	

t-Test: Two-Sample Assuming Unequal Variances

	Terrestrial-C	*Terrestrial-S*
Mean	1.04	1.846153846
Variance	1.873333333	13.23076923
Observations	25	52
Hypothesized Mean Difference	0	
df	72	
t Stat	-1.40467262	
P(T<=t) one-tail	0.082209111	
t Critical one-tail	1.666294338	
P(T<=t) two-tail	0.164418223	
t Critical two-tail	1.99346232	

t-Test: Two-Sample Assuming Unequal Variances

	Terrestrial-N	*Terrestrial-C*
Mean	0.607142857	1.04
Variance	1.506613757	1.873333333
Observations	28	25
Hypothesized Mean Difference	0	
df	49	
t Stat	-1.206385766	
P(T<=t) one-tail	0.116730611	
t Critical one-tail	1.676551165	
P(T<=t) two-tail	0.233461222	
t Critical two-tail	2.009574018	

Table 4.18. Terrestrial Hunting Test of Significance for the Cathlapotle Pits.

t-Test: Two-Sample Assuming Unequal Variances

	Terrestrial-N	*Terrestrial-S*
Mean	0.25	2.555555556
Variance	0.407894737	46.36825397
Observations	20	36
Hypothesized Mean Difference	0	
df	36	
t Stat	-2.015603141	
P(T<=t) one-tail	0.025676628	
t Critical one-tail	1.688297289	
P(T<=t) two-tail	0.051353256	
t Critical two-tail	2.02809133	

t-Test: Two-Sample Assuming Unequal Variances

	Terrestrial-C	*Terrestrial-S*
Mean	0.833333333	2.555555556
Variance	1.787878788	46.36825397
Observations	12	36
Hypothesized Mean Difference	0	
df	42	
t Stat	-1.436684033	
P(T<=t) one-tail	0.079107826	
t Critical one-tail	1.681951289	
P(T<=t) two-tail	0.158215652	
t Critical two-tail	2.018082341	

t-Test: Two-Sample Assuming Unequal Variances

	Terrestrial-N	*Terrestrial-C*
Mean	0.25	0.833333333
Variance	0.407894737	1.787878788
Observations	20	12
Hypothesized Mean Difference	0	
df	14	
t Stat	-1.417358742	
P(T<=t) one-tail	0.089124034	
t Critical one-tail	1.76130925	
P(T<=t) two-tail	0.178248067	
t Critical two-tail	2.144788596	

formed chipped stone activities to some degree. Chipped stone production percentages are slightly higher in the central and southern storage facilities, 32 percent and 34 percent respectively, compared to the northern pits (Figure 4.23).

Similarly, chipped stone production was the most common class in Cathlapotle House 1. Chipped stone production represents approximately 50 % of the artifact assemblages in the storage pits. However, chipped stone production is higher in the northern (H 1b) storage pits (64 %) compared to the central (H1c) (43 %) and southern (H1d) (52 %) storage facilities (Figure 4.24). These results suggest that there were more general maintenance activities in the northern (H1b) section of the Cathlapotle house and southern (H1d) section of the Meier plank house.

Organics Manufacturing

In the Meier plank house, the percentage of organics manufacturing or hide processing in the storage facilities is highest in the southern area of the house (13 %). The percentage of tools related to organic manufacturing in the southern storage facilities is nearly twice that of the northern pits (7 %) (Figure 4.23).

In Cathlapotle House 1, organics manufacturing has the highest percentage (12%) in the southern (H1d) portion of the house. The northern (H1b) storage pits have 8 % organic manufacturing items followed by 5 % in the central (H1c) portion of the plank house (Figure 4.24).

Bone Tool Production

Bone tool production was a common activity in the Meier house, with a slightly higher percentage in the northern sections (26 %) of the household compared to the central and southern section (20 %). Axis 4 of the CA captured this slightly uneven distribution of bone tool production in the house.

In Cathlapotle House 1, bone tool production is not as evident as in the Meier house. In the northern (H1b) and southern sections (H1d) of the house, 3% of the storage pit artifacts relate to bone tool production. The central (H1c) storage pits contain approximately four times (12%) the amount of artifacts related to bone tool production (Figure 4.24). The high percentage of bone tool production in the central (H1c) portion of the house was depicted on Axis 3 and 4 of the correspondence analysis.

Status and Ceremonial Activities

In the Meier house, ceremonial activities were a significant variable for the correspondence analysis. The CA suggested that there was an uneven distribution of these activities in the household. The class percentages revealed that the central zone of the house contained the highest (6 %) frequency of artifacts related to ceremonial activities, approximately three times the number of ceremonial items compared to the southern zone of the house (2%). In contrast, status items are evenly distributed in the Meier household, representing 4 % of the artifact assemblage in the north, central, and southern areas of the house (Figure 4.23). The even distribution of this artifact class explains why the status class was not a significant variable on the CA axes. These results challenge expectations that status items would be located in the high status end of the household.

In the Cathlapotle House 1, status items (n=23) are not as evident as the Meier plank house. However, the correspondence analysis established that the status class was one of the most distinctive variables for House 1. It scored highest on Axis 2 and relatively high on Axis 3 and 4, capturing the uneven distribution of status items in the house. The southern pits (H1d) are the only storage facilities that contain status related items. Only 3 % of the storage pit artifact assemblage consists of status items (Figure 4.24). These status items are located in the suspected high status area of the house (H1d).

Comparison of Meier and Cathlapotle House 1 Artifact Percentages

Figure 4.25 compares the total artifact class percentages for the storage pits at both Meier and Cathlapotle House 1. Chipped stone production represents the most common artifact class at both sites, although the chipped stone percentage is substantially higher at Cathlapotle. Terrestrial hunting also represents a large portion of the assemblages at both sites, although the percentage class is higher at Cathlapotle. The percentage of bone tools is high at Meier but low at Cathlapotle.

At both sites, organics manufacturing and woodworking have similar percentages. The remaining artifact classes each represent less than five percent of the Meier and Cathlapotle storage pit assemblages. In general, the Meier storage pits are taxonomically more diverse than the Cathlapotle pits.

Comparison of the Artifact Percentages at Cathlapotle House 1 and 4

In Cathlapotle House 4, there are only a small number of storage pits with artifacts. The total assemblage for the House 4 storage pits is 55 artifacts. The samples were too small to analyze using the north, central, and southern analytical areas of the house. Therefore, artifact class percentages were determined for the entire house and compared to Cathlapotle House 1 (Figure 4.26). The distribution of artifacts across artifact classes in the storage pits is almost identical for both houses.

The storage pit artifact assemblages in Cathlapotle Houses 1 and 4 are 50 percent chipped stone production. Terrestrial hunting is roughly 20 percent of both assemblages and organics manufacturing 11 percent. Woodworking represents approximately 6 percent of the assemblages at both houses. The major difference in the artifact class percentages is that 16 percent of the pit contents at House 4 are status-related and House 1 has only 3% of status items, keeping in mind that small size of the House 4 artifact assemblages. It is unclear whether the overall scarcity of items is a sampling issue or whether the storage facilities in House 4 were cleaned out.

Summary

In Chapter 5, the correspondence analysis isolated certain production and consumption activities that were unevenly distributed in the Meier and Cathlapotle houses. In this chapter, percentages were used to identify where in the houses these activities were located. Table 4.19 provides a summary of the spatial organization of the activities in both households.

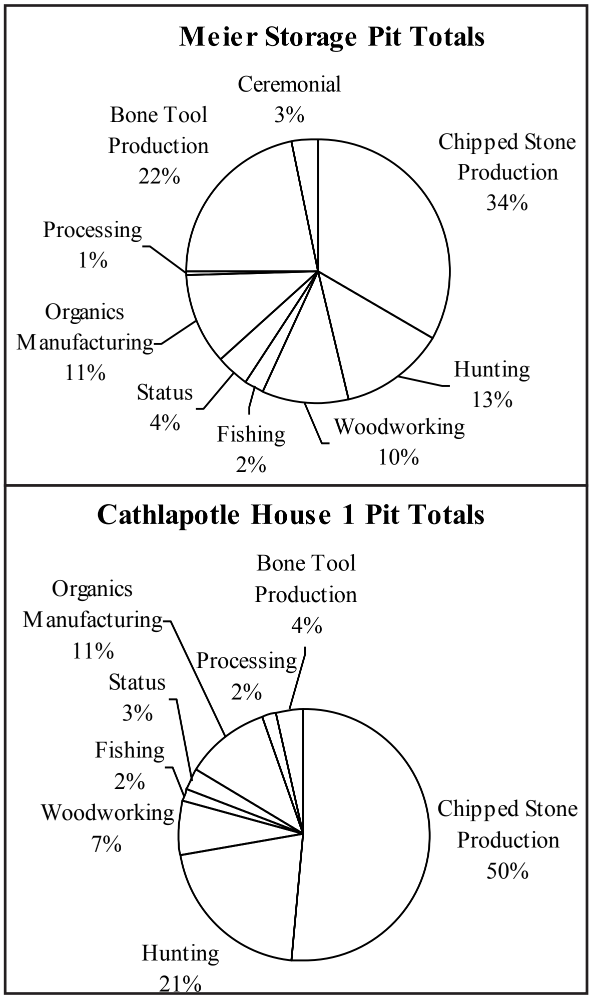


Figure 4.25. Meier and Cathlapotle House I Pit Artifact Class Percentages.

In the Meier house, there are some general spatial patterns of the household activities. Although chipped stone production artifacts dominate the pit contents throughout the house, there are relatively fewer such tools in the northern end of the house. Bone tool production was more common in the north than in the central or southern areas. Chipped stone and bone tool production tools are abundant throughout the storage pits because these were general maintenance activities in which the entire household participated. The lower levels of chipped stone production activities in the north may suggest higher status individuals did not participate in these activities as much as individuals in the lower status sections of the house. The greater abundance of woodworking and fishing (aquatic and line) artifact classes in the northern storage pits suggests household members of high status performed these two activities more frequently. Artifacts related to ceremonial activities are relatively more common in the central storage pits. This is unexpected because it is assumed that ceremonial items would be more abundant in the northern end of the household which is thought to be the higher status end of the houses (Smith 2005). The contents of the southern storage pit represent generalized activities, including chipped stone and bone tool production tools as well as organic manufacturing or hide processing. However, terrestrial hunting tools are also more frequent in the southern storage pits.

In Cathlapotle Houses 1 and 4, there are similar trends as the Meier household. In general, chipped stone production is the most abundant activity class in the storage pits throughout these houses. However, chipped stone production is highest in the northern portion (H1b) of House 1. Based on ethnohistoric data, it is expected that individuals of lower status occupied this section of the house. Similarly to Meier, it appears that members of the lower status sections of the house are performing maintenance activities with greater intensity than the higher status individuals. Tools associated with generalized maintenance activities are abundant in the northern section (H1b) of Cathlapotle House 1, including chipped stone, bone tool production, and resource processing. The artifacts associated with the terrestrial hunting and woodworking activity classes are highest in the central portion (H1c) of this household. The status related items were most abundant in the southern portion (H1d) of the household. This would be expected because it is thought that individuals with the highest status resided in the southern portion of the house (Sobel 2004).

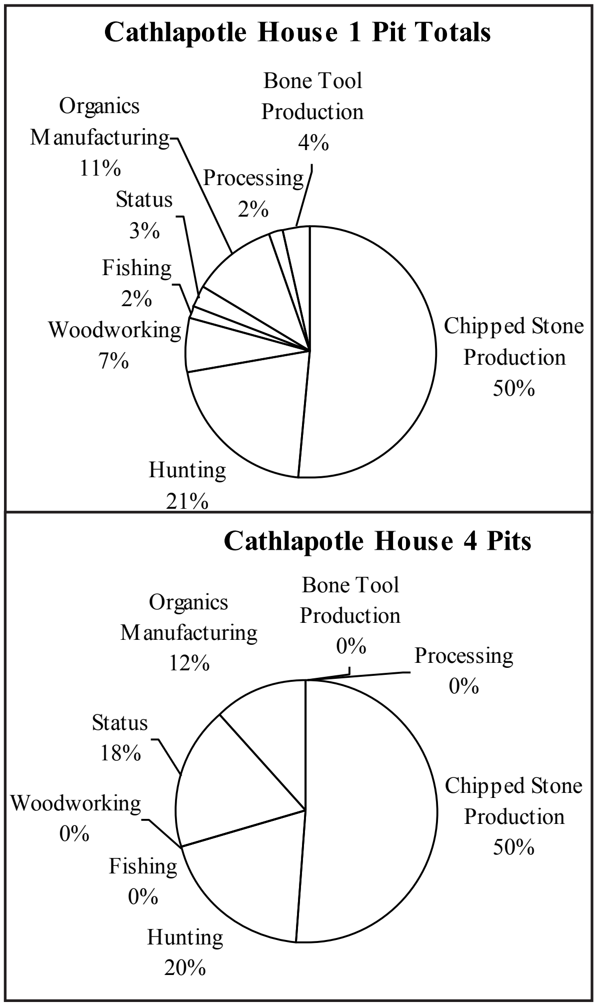


Figure 4.26. Cathlapotle House 1 and House 4 Pit Artifact Class Percentages.

Table 4.19. Summary of the Spatial Organization of Activities for Cathlapotle House 1 and Meier.

Sites	North	Central	South
Meier	Woodworking Fishing Bone Tool Production	Ceremonial	Terrestrial Hunting Chipped Stone Production Organics Manufacturing
Cathlapotle House 1	Fishing Resource Processing Chipped Stone Production	Terrestrial Hunting Woodworking Chipped Stone Production	Organics Manufacturing Status Items

CHAPTER 6
DISCUSSION AND CONCLUSIONS

At the time of first contact with Europeans, the societies of the Pacific Northwest Coast of North America were socially stratified, 'complex' hunter-gatherers (e.g. Price and Brown 1985, Donald 1997). The household was the basic economic unit, exploiting a rich resource base and accumulating surpluses. How household labor was organized to produce these surpluses is not well understood for many portions of the Northwest Coast, including the Lower Columbia River region. These surpluses were stowed in household storage facilities along with the tools of production and consumption. It is plausible that the development of storage facilities had major social and economical implications for Northwest Coast households. The transition to complex Northwest Coast societies may have been the result of storage (e.g. Schalk 1976).

In order to help understand the significance of household storage in the Northwest, the storage pit features from the Meier and Cathlapotle archaeological plank house sites were analyzed. The organization of labor and status differentiation was investigated through the analysis of the indoor storage features and their associated contents. The study had two primary research objectives. Each objective is reviewed below followed by an explanation of the results.

Research Objective #1: Storage Facility Characteristics

The first objective of this research project was to identify and define the characteristics of the indoor storage facilities from two plank house sites in the Lower Columbia River Region. The archaeological literature was reviewed for this study to determine if other Northwest Coast sites (e.g. Paul Mason, Ozette, Tualdad Altu, Dionisio Point, Cla-Cle-Lah) as well as sites from other complex foraging cultures (e.g. Natufian (Christakis 1999), Jomon, Southern California, Eastern North America (DeBoer 1988) contained similar indoor storage facilities. Because these indoor storage facilities are such rare archaeological features for the Pacific Northwest Coast as well as worldwide, there was minimal information regarding such features. Therefore, this study attempted to answer the following question:

- What characterizes an indoor storage facility?

The identification of these storage pits included defining the different storage pit types as well as their size and distribution throughout the three plank houses. Intra and inter site comparisons were conducted between the two archaeological sites.

Meier Site

At the Meier site, 105 separate storage pits were identified and analyzed. The pits vary considerably in size and distribution throughout the household. The southern portion of the Meier house contained a higher concentration of large storage facilities than the other areas of the house. The mean volume for the southern storage pits is almost twice as large as the mean volume for the northern pits. However, the northern section of the house contains a few exceptionally large pits.

The distribution of the storage pits within the household was also examined. At the Meier site, all areas of the household were using the storage facilities. According to the density figures, the storage pits appear to be fairly evenly distributed, however, the central zone contains a slightly higher concentration of pits compared to the northern and southern zones.

Cathlapotle Site

Sixty-eight storage pits were recorded for Cathlapotle plank houses 1 and 4. In general, pit sizes varied considerably. Storage features were larger in House 1 than House 4. Within House 1, the storage pits were largest in Compartment 1 c, the central zone, and smallest in Compartment 1 b, the northern zone. The pattern in pit size for House 4 storage pit features was the reverse of House 1. The storage facilities were largest in the northern section of House 4.

As with the Meier site, all portions of the Cathlapotle households used the storage facilities. There were only slight variations in pit density for each area of House 1. In Cathlapotle House 1, the storage pits were evenly distributed in the northern (1b) and southern areas (1d) of the house. The central area (1c) of the house contained the fewer but larger pits. In Cathlapotle House 4, the storage pit densities were the reverse of House 1. The central zone of the plank house contained slightly more pits than the other household zones.

Meier vs. Cathlapotle

The storage pit facilities are larger in the Meier house than either House 1 or House 4 at Cathlapotle. At Meier, the mean volume of storage pits is 180 liters, whereas the mean volume for the Cathlapotle pit features is 113 liters. Yet, the Cathlapotle site yielded some storage facilities that are as large as the Meier site pits. The largest storage pit features at the Meier and Cathlapotle sites are 1185 liters and 1685 liters, respectively.

As discussed above, the Meier and Cathlapotle plank houses exhibited similar trends in storage pit distribution. The storage pits were fairly evenly distributed in all three plank houses (~1 pit/m^3). This suggests that all areas of the houses were using the storage facilities to some extent.

Post vs. Pit features

Another objective of this study was to distinguish between posthole features and storage pits. Once the volumes were calculated, it was apparent that the variability in size between postholes and storage pits was reasonably substantial at both sites. Postholes were usually much smaller in size with the exception being the corner posts. Corner posts were distinguishable because of their location and contents.

Research Objective #2: Labor Organization

The second objective of this research project was to determine if the spatial distribution of the storage pits as well as their artifact contents could be used as a measure of social differentiation and labor organization within and between the households. This objective is encompassed within the larger theoretical question regarding whether storage was part of the political economy of the household.

This objective helped to answer several questions:

- Were all areas of the household using the storage facilities in the same manner?
- Were particular tasks performed in certain areas of the house?
- Was there variation in pit contents throughout the different areas of the house?
- Did some sections of the house accumulate wealth or status items?

To examine potential labor organization and social differentiation within the three plank houses, a spatial distribution analysis was implemented. The spatial distribution of the storage pits as well as their artifact contents was the focus of this analysis.

Correspondence Analysis and Percentages

The spatial patterning of the storage pit artifacts was analyzed by using correspondence analysis, a multivariate statistical technique. The correspondence analysis (CA) identified which activity classes were uniformly distributed in the households. These classes reflected broad but distinct categories of activities or behaviors carried out by household members. When certain activity classes produced strong results in the correspondence analysis, this established that these activities were unevenly distributed in the households. These activities were plausibly specialized tasks. Although the CA identified which activities were grouped together within the household, it did not indicate where in the house these occurred. Percentages of the activity classes were established to determine where the uneven distribution of activities occurred within the houses.

Meier House Storage Pits

At the Meier house, the correspondence analysis produced results that suggested broad patterns of household activities. The analysis indicated that there was a widespread distribution of maintenance activities within the Meier household, including bone tool production, organics manufacturing, and chipped stone production. Therefore, people of all areas of the household were participating in general maintenance activities to some extent. Maintenance activities were not highly differentiated according to rank. Although all household inhabitants participated in general maintenance activities, the southern end or lower status areas of the house performed these activities with greater intensity.

However, resource acquisition or subsistence activities were relatively unevenly distributed in the Meier house storage pits. These subsistence activities include terrestrial hunting, plant/food processing, and fishing (line and aquatic hunting). The uneven distribution of subsistence activities suggests there was a division of labor within the household. People of different social ranks were engaged in separate tasks. It was found that the southern zone of the house contained a higher concentration of terrestrial hunting activities whereas people in the northern area of the house concentrated more on fishing. The correspondence analysis also demonstrated that there was an uneven distribution of woodworking activities within the house. This suggests that woodworking was possibly a specialized craft within the Meier household. It was found that woodworking was a more prominent craft in the northern or higher status zone of the Meier house.

The correspondence analysis also indicated whether there was a differentiation of status and ceremonial items in the household storage pits. It was found that status/personal adornment items were relatively evenly distributed throughout the household. This distribution is difficult to explain. Although the pits were used to some degree for storage of valuables, it is possible that the storage pits were not used as the primary depository for valuable personal belongings. It is probable that individuals owned additional storage containers in their bench areas for personal belongings rather than stowing them in the communal storage facilities. It is also likely that status items appeared in the southern storage facilities because lower status individuals were involved in the production of these items. Unlike status items, ceremonial items were unevenly distributed in the household. The central and northern areas of the house contained the highest quantity of ceremonial items. This distribution would be expected in the northern area of the house were where high status individuals resided. However, it is unclear why the central area of the house also contained a high concentration of ceremonial items.

Cathlapotle House 1 and House 4 Storage Pits

Because the quantity of artifacts was lower in the Cathlapotle storage pits, it was more difficult to define meaningful relationships among the activity groups. Only Cathlapotle House 1 was used for the correspondence analysis. Analysis of the Cathlapotle House 1 storage pit contents demonstrated there may have a been a division of labor within the plank house, which included resource processing, fishing, bone tool production, and woodworking. Inhabitants in House 1c (central) engaged in proportionately more woodworking, bone tool production, and terrestrial hunting compared to other areas of the house.

Although specialized tasks were performed in House 1c (central portion), status-related items were differentially distributed throughout the Cathlapotle House 1. Artifacts related to status and personal adornment were most common in House 1 d (southern zone) and absent in House 1 b (northern zone). Conversely, House 1 b (north zone) pit contents suggest that the northern area of the house is the low status portion of Cathlapotle House 1. In the northern section (1b) of the house, activities associated with lower ranked individuals including chipped stone production and resource processing activities are more prevalent. The northern section also does not have any status items or artifacts related to woodworking activities.

In Cathlapotle House 1, there was a division of tasks. However, it appears that all members of the household participated to some degree in general maintenance activities. Status items are concentrated in the House 1 d storage pits. Unlike Meier, this suggests that the higher-ranked individuals probably stored their valuables in the household storage pits.

The Cathlapotle House 4 storage pits were depleted in artifact contents. Because of the low artifact counts, CA was not used to analyze the plank house. The Cathlapotle House 4 storage pits were dominated by stoneworking activities. The facilities also contained higher concentrations of status items, terrestrial hunting, organics manufacturing, and woodworking. It is difficult to determine whether there was a higher status section of this plank house. It is possible that smaller Northwest Coast plank houses were not segregated by rank. Current studies are testing this hypothesis (Smith 2004).

Summary and Broader Northwest Coast Implications

This study has contributed to the identification and classification of storage pits within the Northwest Coast region and along the Lower Columbia River. The identification of storage features from the Cathlapotle and Meier sites provide valuable insight to future archaeological projects containing indoor storage facilities in the Pacific Northwest. Generally, the results have demonstrated that there were storage pit characteristics that were similar among all sites. Storage facilities were used to some extent by individuals in all areas of the plank houses. It was found that the storage pits were relatively evenly distributed throughout the plank houses. However, the largest storage facilities are located in the lower status end of the households. This suggests a more intense use of the storage facilities by the residences of the lowest rank in each house. The production activities in the lower status end of the households probably necessitated the larger storage pits found at the Cathlapotle and Meier sites. It is also possible that the presence of storage facilities in the low class area of the house indicates that all classes of household members had personal property.

The spatial analysis of the Meier and Cathlapotle storage facilities suggested several general trends concerning labor organization. At both sites, it was found that all household members, regardless of social rank, participated in the same basic production activities throughout the occupation of the houses. Although all household members participated in these general activities, certain activities were differentiated according to rank within the Meier and Cathlapotle households. It appears that the higher ranked individual participated more in specialized tasks including woodworking and aquatic/line fishing. In contrast, lower-ranked individuals engaged in terrestrial hunting and organics/hide manufacturing.

It is anticipated that these comparisons of the Meier and Cathlapotle storage facilities will assist other archaeological projects recovering storage features in the Northwest region. Additionally, it is hoped that this study will assist future projects in evaluating how storage pits were spatially organized within households. In the future, faunal and botanical remains found in the storage facilities should be integrated with the current results to more fully understand labor organization and social rank within plank houses.

APPENDIX A
STORAGE PIT CONTENT TABLES

Meier and Cathlapotle Storage Pit Contents (9 Variables).

Meier Frequencies

CAT. #	Chipped Stone	Terrestrial	Woodworking	Fishing	Status	Organic Manuf.	Process	BoneProd	Ceremony	Row Sum
379/A/N	4	0	0	0	0	0	0	3	0	7
450/A/N	2	0	0	0	0	1	0	2	0	5
453/A/N	1	2	0	2	0	1	0	4	0	10
457/A/N	1	0	0	0	0	1	0	2	0	4
397/B/N	1	0	0	0	0	0	0	0	0	1
409/C/N	0	0	0	0	0	0	0	0	0	0
463/C/N	0	0	0	0	0	0	0	0	0	0
468/C/N	0	0	0	0	0	0	0	0	0	0
382/D/N	1	0	0	0	0	0	0	0	1	2
455/D/N	2	0	5	0	2	4	0	10	3	26
475/E/N	0	0	0	0	0	0	0	1	0	1
438/F/N	0	0	0	0	0	0	0	0	1	1
444/F/N	8	3	1	1	0	1	0	6	0	20
444a/F/N	0	0	8	1	1	0	1	1	0	12
447/F/N	4	0	3	0	0	1	0	2	0	10
352/H/N	0	0	0	0	0	0	0	1	0	1
354/H/N	1	4	0	0	1	0	0	1	2	9
355/H/N	4	3	2	0	0	2	0	6	0	17
425/H/N	2	0	0	0	1	0	0	1	0	4
354b/H/N	0	0	0	1	0	0	0	0	0	1
357/H/N	9	0	2	0	1	0	0	3	0	15
29b/I/N	1	2	3	0	0	0	0	1	0	7
29c/I/N	0	0	1	0	0	1	0	0	0	2
29f/I/N	1	0	0	0	0	0	0	0	0	1
28a/I/N	0	0	0	1	0	0	0	0	0	1
462/J/N	4	0	0	1	0	0	0	2	0	7
465/J/N	0	0	0	0	0	0	0	0	0	0
460/J/N	11	3	1	0	2	1	0	1	1	20
26/K/C	4	1	2	0	2	1	0	2	0	12
28b/K/C	0	1	0	0	0	0	0	0	0	1
29a/K/C	4	0	1	0	0	0	0	1	0	6
29d/K/C	1	0	0	0	0	0	0	2	0	3
29e/K/C	6	2	1	0	0	1	0	9	1	20
476/L/C	0	0	0	0	0	0	0	0	0	0
319/N_O/C	9	2	2	0	0	1	0	1	1	16
321/N/C	10	4	3	1	0	5	0	4	1	28
330/N/C	0	1	0	0	0	0	0	1	2	4
340/N/C	2	0	1	0	0	0	0	0	0	3
343/N/C	0	0	0	0	0	0	0	0	0	0
93/Q/C	12	5	4	1	0	2	0	3	5	32
115/Q/C	3	3	4	0	1	2	0	1	1	15
126/Q/C	0	0	0	0	0	0	0	1	0	1
156/Q/C	5	2	2	0	0	1	0	2	0	12
216/Q/C	0	0	2	0	0	1	0	1	0	4
228/Q/C	1	0	1	0	0	0	0	0	0	2
246/Q/C	0	0	0	0	0	0	0	0	0	0
21/R_X/C	4	2	1	3	4	7	0	6	0	27
37/R/C	7	1	1	0	0	1	0	6	1	17
27y/R/C	3	0	1	0	1	2	0	2	0	9
27z/R/C	1	1	0	0	1	0	0	4	2	9
111/S_Y/C	2	1	0	1	0	0	0	1	0	5
204/S/C	0	0	0	0	0	0	0	0	0	0
253/S/C	0	0	0	0	0	0	0	0	0	0
13/W_R_X/S	8	3	1	0	0	1	0	5	0	18
14/W/S	1	0	1	0	0	0	0	1	0	3
24/X/S	0	1	0	0	2	2	0	11	0	16

CAT. #	Chipped Stone	Terrestrial	Woodworking	Fishing	Status	Org. Manuf.	Process	BonePr	Ceremony	Row Sum
60/Y/S	0	0	0	0	0	0	0	0	0	0
178/Y_I2/S	6	1	0	0	0	7	0	5	0	19
192/Y/S	0	0	0	0	0	1	0	0	0	1
250/Y/S	1	1	0	0	0	0	0	1	0	3
260/Y/S	0	0	0	0	0	0	0	0	0	0
71b/Y/S	2	1	0	0	0	3	0	2	1	9
38a/Z/S	4	14	2	0	0	1	0	3	1	25
38b/Z_Y/S	20	1	1	0	0	4	0	8	0	34
38B1/Z/S	1	0	0	0	0	1	0	0	0	2
38B2/Z/S	0	0	0	0	0	0	0	0	0	0
38B3/Z/S	0	0	0	0	0	0	0	0	0	0
39/Z/S	0	0	0	0	0	0	0	0	0	0
66/E2/S	0	0	0	0	0	0	0	0	0	0
168/E2/S	0	1	0	0	0	0	0	0	0	1
92/G2/S	19	2	3	0	1	3	0	2	1	31
155/G2/S	1	0	0	0	0	0	0	0	0	1
30-482/H2_X/S	29	11	13	4	6	6	0	24	3	96
31/H2_L2/S	15	1	0	0	2	4	0	11	0	33
35/H2/S	19	10	5	3	6	7	3	12	0	65
36/H2/S	25	3	15	2	1	11	0	12	1	70
71/I2_Y/S	4	5	0	0	0	0	0	2	1	12
102/I2/S	0	0	0	0	0	0	0	0	0	0
82/I2/S	1	0	0	0	0	0	0	0	0	1
103/I2/S	0	0	0	0	0	0	0	0	0	0
104/I2/S	7	3	0	0	0	4	0	1	0	15
105/I2/S	0	0	0	0	0	0	0	1	0	1
106/I2/S	0	0	0	0	0	0	0	0	0	0
108/I2/S	1	1	1	0	0	0	0	0	0	3
152/I2/S	0	1	0	0	0	1	0	0	0	2
58/K2/S	0	0	0	0	0	0	0	0	0	0
88/L2/S	22	8	1	2	1	6	0	8	1	49
154/L2/S	1	0	0	0	0	0	0	0	0	1
237/L2/S	0	0	0	0	0	0	0	0	0	0
274/L2/S	3	1	0	0	0	0	0	0	0	4
275/L2/S	0	0	0	0	0	0	0	0	0	0
276/L2/S	0	0	0	0	0	0	0	0	0	0
277/L2/S	0	0	0	0	0	0	0	0	0	0
278/L2/S	0	0	0	0	0	0	0	0	0	0
279/L2/S	0	0	0	0	0	0	0	0	0	0
280/L2/S	0	0	0	0	0	0	0	0	0	0
281/L2/S	0	0	0	0	0	0	0	0	0	0
282/L2/S	0	0	0	0	0	0	0	0	0	0
284/L2/S	0	0	0	0	0	0	0	0	0	0
306/M2/S	7	3	3	0	0	0	1	1	1	16
310/M2/S	0	0	0	0	0	0	0	0	0	0
328/M2/S	0	0	0	0	0	0	0	0	0	0
333/M2/S	5	6	0	0	0	5	0	2	1	19
Col. Sum	357	139	110	25	43	119	6	230	35	1064

Cathlapotle House 4 Frequencies

Cat. #	ChipSPr	BonePr	TerHunt	Wdwrk	Fishing	Status	Organics	Process	Row Sum
00341	0	0	0	0	0	0	0	0	0
00419	0	0	0	0	0	0	0	0	0
00428	0	0	0	0	0	0	0	0	0
00465	0	0	0	0	0	0	0	0	0
00226	0	0	0	0	0	0	0	0	0
00227	0	0	0	0	0	0	1	0	1
00266	0	0	0	0	0	0	0	0	0
00357	0	0	0	0	0	0	0	0	0
00678	0	0	0	0	0	0	0	0	0
00560	0	0	0	0	0	0	0	0	0
00479	8	0	4	0	0	1	2	0	15
00577	1	0	0	0	0	0	0	0	1
00638	9	0	0	0	0	0	1	0	10
00669	0	0	0	0	0	0	0	0	0
00681	0	0	0	0	0	0	0	0	0
00536	8	0	6	3	0	8	2	0	27
00699	0	0	0	0	0	0	0	0	0
0712A	0	0	0	0	0	0	0	0	0
00027	0	0	0	0	0	0	0	0	0
00713	0	0	0	0	0	0	0	0	0

Cathlapotle House 1 Frequencies

0339A	0	0	0	0	0	0	0	0	0
00344	2	0	0	0	0	0	0	0	2
0296A	0	0	0	0	0	0	0	0	0
0296B	0	0	0	0	0	0	0	0	0
0296C	0	0	0	0	0	0	0	0	0
00268	111	4	37	12	3	7	23	2	199
00375	0	0	0	0	0	0	1	0	1
00376	0	0	0	0	0	0	0	0	0
00455	2	0	1	0	0	1	1	0	5
00456	0	0	0	0	0	0	0	0	0
00213	3	0	0	2	1	0	1	1	8
00352	0	0	0	0	0	0	0	0	0
00361	0	1	0	0	0	0	0	0	1
00366	0	0	0	1	0	0	0	0	1
00473	0	0	0	0	0	0	0	0	0
00359	3	0	2	1	0	0	0	0	6
00373	18	1	7	1	0	0	1	1	29
00509	10	0	0	3	0	1	4	0	18
00651	0	0	0	0	0	0	0	0	0

Cat. #	ChipSPr	BonePr	TerHunt	Wdwrk	Fishing	Status	Organics	Process	Row Sum
00650	0	0	0	0	1	0	0	0	1
00496	11	0	9	0	1	0	2	0	23
00714	0	0	0	0	0	0	0	0	0
510.01	0	0	1	0	0	0	0	0	1
00591	10	2	9	2	0	2	4	0	29
00674	2	0	1	0	0	0	0	0	3
00010	0	0	0	0	0	0	0	0	0
00073	26	2	13	4	0	0	5	2	52
00135	9	2	0	1	0	0	1	0	13
00167	0	0	0	0	0	0	0	0	0
00173	0	0	0	0	0	0	0	0	0
00174	0	0	1	0	0	0	1	0	2
00176	0	0	0	0	0	1	0	0	1
00188	0	0	0	0	0	0	0	0	0
00191	0	0	1	0	0	0	0	0	1
00468	6	3	0	4	1	0	0	0	14
00594	2	0	1	2	0	0	0	0	5
00608	0	0	1	0	0	0	0	0	1
00616	1	0	0	0	0	0	0	0	1
00728	5	0	3	0	0	0	1	0	9
00663	0	0	0	0	0	0	0	0	0
00224	4	1	4	0	0	0	0	0	9
00365	0	1	1	0	0	0	1	0	3
00412	0	0	0	0	0	0	0	0	0
0250A	0	0	0	0	0	0	0	0	0
0420A	0	0	0	0	0	0	0	0	0
0420B	0	0	0	0	0	0	0	0	0
00120	2	0	0	0	0	0	1	0	3
00168	0	0	0	0	0	0	0	0	0
00183	0	0	0	0	0	0	0	0	0
00077	0	0	0	0	0	0	0	0	0
00558	7	1	0	0	0	0	0	0	8
Cat. #	ChipSPr	BonePr	TerHunt	Wdwrk	Fishing	Status	Organics	Process	Row Sum
00723	1	0	0	0	0	0	0	0	1
00697	0	0	0	0	0	0	0	0	0
00706	3	0	0	0	0	0	0	0	3
00624	2	0	0	0	0	0	0	0	2
00643	0	0	0	0	0	0	0	0	0
00687	0	0	2	0	0	0	0	2	4
0709B	0	0	0	0	0	0	0	0	0
00690	0	0	0	0	1	0	0	0	1
00689	0	0	0	0	0	0	0	0	0
00688	0	0	0	0	0	0	0	0	0
00660	4	0	2	1	0	0	1	0	8
00637	3	0	1	0	0	0	1	0	5
00636	2	0	0	0	0	0	0	0	2
00501	0	0	0	0	0	0	0	0	0
Col Sum	289	19	117	39	8	23	63	8	566

APPENDIX B
CORRESPONDENCE ANALYSIS SCORES

Correspondence Analysis: Meier House

Imported Data
Analysis begun: Tuesday, April 6, 2005 3:09:12 PM
Analysing 9 variables x 74 cases
0 variables and 31 cases have dropped from their orignial data
Some or all were dropped due to their sums being zero
Data will be transposed before analysis
Tolerance of eigenanalysis set at 1E-7

Scores scaled by species

Eigenvalues

	Axis 1	**Axis 2**	**Axis 3**	**Axis 4**	**Axis 5**	**Axis 6**	**Axis 7**	**Axis 8**
Eigenvalues	0.155	0.135	0.129	0.112	0.096	0.073	0.053	0.028
Percentage	19.816	17.337	16.462	14.314	12.329	9.395	6.768	3.579
Cum Percentage	19.816	37.153	53.615	67.928	80.258	89.653	96.421	100.000

CA variable scores

Cat. #	**Axis 1**	**Axis 2**	**Axis 3**	**Axis 4**	**Axis 5**	**Axis 6**	**Axis 7**	**Axis 8**
379/A/N	-0.161	-0.647	0.045	-0.088	0.352	-0.470	-0.075	0.134
450/A/N	-0.218	-0.596	0.177	-0.254	0.033	0.061	-0.179	0.199
453/A/N	-0.442	0.482	1.092	0.158	0.048	-0.234	-0.397	0.091
457/A/N	-0.262	-0.543	0.316	-0.520	-0.128	0.098	-0.283	0.250
397/B/N	-0.041	-0.809	-0.381	0.810	0.676	-0.088	0.240	-0.004
382/D/N	1.790	0.379	-0.044	-0.449	1.814	0.647	0.204	0.215
455/D/N	0.037	0.219	-0.069	-0.844	0.143	0.165	-0.072	-0.061
475/E/N	-0.321	-0.431	0.612	-1.285	-0.081	-0.979	-0.494	0.318
438/F/N	3.621	1.567	0.294	-1.707	2.951	1.382	0.167	0.434
444/F/N	-0.097	-0.134	0.205	0.162	0.065	-0.291	-0.178	0.046
444a/F/N	-0.951	1.588	-1.162	-0.255	-0.059	-0.113	0.174	0.373
447/F/N	-0.352	0.009	-0.623	-0.078	0.122	0.018	-0.291	-0.061
352/H/N	-0.321	-0.431	0.612	-1.285	-0.081	-0.979	-0.494	0.318
354/H/N	1.322	0.582	0.352	-0.108	-0.023	-0.086	0.358	-0.234
355/H/N	-0.009	-0.094	0.011	-0.163	-0.274	-0.193	-0.294	0.054
425/H/N	-0.257	-0.374	0.071	-0.219	0.184	-0.256	0.970	-0.531
354b/H/N	-2.773	3.227	3.739	2.082	2.121	0.266	-0.738	-0.150
357/H/N	-0.235	-0.326	-0.359	0.098	0.341	-0.238	0.194	-0.172
29b/I/N	0.016	0.693	-0.738	0.065	-0.398	-0.332	-0.446	-0.244
29c/I/N	-0.573	0.532	-0.849	-0.348	-0.563	1.227	-0.608	-0.082
29f/I/N	-0.041	-0.809	-0.381	0.810	0.676	-0.088	0.240	-0.004
28a/I/N	-2.773	3.227	3.739	2.082	2.121	0.266	-0.738	-0.150
462/J/N	-0.512	-0.125	0.492	0.393	0.666	-0.292	-0.110	0.067
460/J/N	0.234	-0.175	-0.123	0.295	0.174	0.010	0.416	-0.248

26/K/C	-0.214	0.028	-0.231	-0.150	-0.108	-0.019	0.460	-0.430
28b/K/C	1.410	0.698	0.478	1.032	-1.543	-0.651	-0.187	-0.214
29a/K/C	-0.211	-0.351	-0.505	0.263	0.421	-0.219	-0.061	-0.038
29d/K/C	-0.228	-0.557	0.281	-0.587	0.172	-0.682	-0.250	0.211
29e/K/C	0.108	-0.235	0.139	-0.352	0.104	-0.340	-0.222	0.134
319/N_O/C	0.239	-0.133	-0.336	0.330	0.290	0.049	-0.037	-0.025
321/N/C	0.022	-0.001	0.012	0.169	-0.003	0.232	-0.190	0.032

CA variable scores

Cat. #	**Axis 1**	**Axis 2**	**Axis 3**	**Axis 4**	**Axis 5**	**Axis 6**	**Axis 7**	**Axis 8**
330/N/C	2.083	0.850	0.419	-0.917	1.070	0.284	-0.087	0.243
340/N/C	-0.288	-0.018	-0.960	0.414	0.418	-0.053	-0.177	-0.180
93/Q/C	0.533	0.275	-0.086	0.076	0.456	0.152	-0.111	0.015
115/Q/C	0.195	0.441	-0.400	-0.055	-0.181	0.217	-0.025	-0.248
126/Q/C	-0.321	-0.431	0.612	-1.285	-0.081	-0.979	-0.494	0.318
156/Q/C	0.004	-0.074	-0.295	0.206	-0.091	-0.103	-0.184	-0.042
216/Q/C	-0.562	0.549	-0.801	-0.589	-0.327	0.373	-0.636	-0.094
228/Q/C	-0.412	0.378	-1.249	0.216	0.288	-0.036	-0.296	-0.268
21/R_X/C	-0.497	0.205	0.625	-0.134	-0.146	0.403	0.276	-0.247
37R/C	0.098	-0.290	0.005	-0.201	0.267	-0.194	-0.148	0.114
27y/R/C	-0.322	-0.241	-0.085	-0.263	-0.091	0.311	0.225	-0.178
27z/R/C	0.745	0.206	0.397	-0.881	0.464	-0.195	0.256	-0.057
111/S_Y/C	-0.353	0.375	0.814	0.690	0.370	-0.308	-0.188	-0.011
13/W_R_X/S	0.064	-0.304	-0.014	0.136	-0.042	-0.283	-0.129	0.042
14/W/S	-0.382	0.108	-0.629	-0.284	0.165	-0.350	-0.362	-0.072
24/X/S	-0.256	-0.246	0.558	-1.010	-0.347	-0.392	0.087	-0.053
27/X_R/S	0.015	0.051	0.047	-0.097	-0.267	0.084	0.130	-0.019
178/Y_I2/S	-0.157	-0.517	0.221	-0.145	-0.267	0.578	-0.206	0.207
192/Y/S	-0.364	-0.500	0.419	-0.318	-1.027	2.438	-0.385	0.367
250/Y/S	0.349	-0.181	0.237	0.185	-0.316	-0.573	-0.147	0.033
71b/Y/S	0.357	-0.191	0.277	-0.287	-0.053	0.657	-0.187	0.217
38a/Z/S	0.812	0.377	0.139	0.442	-0.697	-0.342	-0.201	-0.093
38b/Z_Y/S	-0.124	-0.570	-0.079	0.156	0.210	-0.014	-0.050	0.094
38B1/Z/S	-0.203	-0.655	0.019	0.246	-0.175	1.175	-0.072	0.182
168/E2/S	1.410	0.698	0.478	1.032	-1.543	-0.651	-0.187	-0.214
92/G2/S	0.031	-0.307	-0.304	0.319	0.279	0.127	0.116	-0.076
155/G2/S	-0.041	-0.809	-0.381	0.810	0.676	-0.088	0.240	-0.004
30-482/H2/S	-0.101	0.126	0.024	-0.072	0.077	-0.129	0.009	-0.140
31/H2_L2/S	-0.165	-0.517	0.123	-0.141	0.077	-0.083	0.128	-0.005
35/H2/S	-0.206	0.205	0.088	0.096	-0.190	-0.060	0.451	0.299
36/H2/S	-0.271	0.046	-0.281	0.000	0.074	0.189	-0.209	-0.045
71/I2_Y/S	0.822	0.080	0.199	0.343	-0.185	-0.349	-0.066	-0.001
82/I2/S	-0.041	-0.809	-0.381	0.810	0.676	-0.088	0.240	-0.004
104/I2/S	0.144	-0.400	0.071	0.414	-0.272	0.413	-0.061	0.074

105/I2/S	-0.321	-0.431	0.612	-1.285	-0.081	-0.979	-0.494	0.318
108/I2/S	0.196	0.484	-0.673	0.488	-0.322	-0.241	-0.260	-0.250
152/I2/S	0.523	0.099	0.449	0.357	-1.285	0.893	-0.286	0.076
72/K2/S	-0.081	0.250	-0.337	-0.235	-0.214	-0.486	-0.397	-0.069
88/L2/S	0.047	-0.174	0.183	0.301	0.047	0.035	-0.015	0.002
154/L2/S	-0.041	-0.809	-0.381	0.810	0.676	-0.088	0.240	-0.004
274/L2/S	0.321	-0.433	-0.166	0.865	0.121	-0.229	0.133	-0.057
306/M2/S	0.216	0.341	-0.529	0.313	0.079	-0.189	0.274	0.593
333/M2/S	0.495	-0.087	0.241	0.230	-0.433	0.382	-0.140	0.084

CA Case Scores

	Axis 1	**Axis 2**	**Axis 3**	**Axis 4**	**Axis 5**	**Axis 6**	**Axis 7**	**Axis 8**
Chipped Stone Pr.	-0.041	-0.809	-0.381	0.810	0.676	-0.088	0.240	-0.004
Hunting	1.410	0.698	0.478	1.032	-1.543	-0.651	-0.187	-0.214
Woodwork	-0.782	1.565	-2.118	-0.378	-0.100	0.016	-0.832	-0.531
Fishing	-2.773	3.227	3.739	2.082	2.121	0.266	-0.738	-0.150
Status	-0.623	0.553	0.434	-1.212	-0.537	0.133	3.894	-2.434
Organics	-0.364	-0.500	0.419	-0.318	-1.027	2.436	-0.385	0.367
Processing	-1.440	3.194	-1.792	0.373	-1.413	-0.905	6.082	10.995
Bone Tool Pr.	-0.321	-0.431	0.612	-1.285	-0.081	-0.979	-0.494	0.318
Ceremonial	3.621	1.567	0.294	-1.707	2.951	1.382	0.167	0.434

Correspondence Analysis: Cathlapotle House 1

Imported Data

Analysis begun: Tuesday, April 6, 2005 3:05:38 PM

Analysing 8 variables x 44 cases

0 variables and 45 cases have dropped from their orignial data

Some or all were dropped due to their sums being zero

Data will be transposed before analysis

Tolerance of eigenanalysis set at 1E-7

Scores scaled by species

Eigenvalues

	Axis 1	**Axis 2**	**Axis 3**	**Axis 4**	**Axis 5**	**Axis 6**	**Axis 7**
Eigenvalues	0.280	0.164	0.156	0.123	0.095	0.072	0.061
Percentage	29.410	17.286	16.429	12.924	9.981	7.558	6.412
Cum Percentage	29.410	46.696	63.125	76.049	86.030	93.588	100.000

CA Variable Scores

Cat #	Axis 1	Axis 2	Axis 3	Axis 4	Axis 5	Axis 6	Axis 7
00227	-0.210	-0.385	0.089	-0.443	0.535	2.060	1.749
00612	-0.109	0.180	-0.412	-0.446	-0.497	-0.529	0.138
00479	-0.184	-0.168	0.114	-0.264	0.131	-0.083	0.039
00577	-0.109	0.180	-0.412	-0.446	-0.497	-0.529	0.138
00638	-0.119	0.123	-0.362	-0.446	-0.394	-0.270	0,299
00536	-0.230	-1.093	0.525	0.453	-0.100	-0.242	-0.057
00344	-0.109	0.180	-0.412	-0.446	-0.497	-0.529	0.138
00268	0.002	-0.008	-0.029	-0.101	-0.057	0.010	0.026
00375	-0.210	-0.385	0.089	-0.443	0.535	2.060	1.749
00455	-0.240	-0.735	0.355	0.001	0.117	-0.094	0.322
00213	1.088	0.438	0.493	0.450	-0.733	0.392	0.150
00361	0.220	1.059	-2.529	3.579	2.529	-0.945	1.063
00366	0.268	-0.226	-0.420	1.799	-1.860	1.867	-1.742
00359	-0.087	0.104	-0.018	-0.017	-0.133	0.085	-0.622
00373	-0.097	0.328	0.024	-0.086	-0.020	-0.225	-0.086
00509	-0.093	-0.235	-0.182	0.044	-0.480	0.387	0.219

CA Variable Scores

Cat #	Axis 1	Axis 2	Axis 3	Axis 4	Axis 5	Axis 6	Axis 7
00650	8.225	-0.957	0.370	-0.774	0.588	-0.283	0.145
00493	-0.159	-0.172	0.089	-0.048	0.248	0.288	0.081
00496	0.197	0.071	0.129	-0.395	0.334	-0.042	-0.246
510.01	-0.231	0.155	0.772	-0.281	1.277	0.113	-1.201
00591	-0.142	-0.148	0.027	0.181	0.329	0.091	-0.076
00674	-0.150	0.171	-0.017	-0.391	0.094	-0.315	-0.308
00073	-0.085	0.298	0.080	0.038	0.008	0.039	-0.065
00135	-0.037	0.240	-0.700	0.346	-0.057	-0.209	0.259
00174	-0.221	-0.115	0.431	-0.362	0.906	1.087	0.274
00176	-0.542	-3.804	1.739	1.621	-0.234	-1.587	0.788
00191	-0.231	0.155	0.772	-0.281	1.277	0.113	-1.201
00468	0.664	0.171	-0.812	1.034	-0.161	0.084	-0.201
00594	0.017	0.013	-0.178	0.485	-0.688	0.558	-0.882
00608	-0.231	0.155	0.772	-0.281	1.277	0.133	-1.201
00616	-0.109	0.180	-0.412	-0.446	-0.497	-0.529	0.138
00728	-0.161	0.109	0.039	-0.391	0.209	-0.027	-0.129
00224	-0.127	0.266	-0.121	0.075	0.627	-0.290	-0.354
00365	-0.074	0.276	-0.556	0.951	1.447	0.409	0.537
00120	-0.143	-0.009	-0.245	-0.445	-0.153	0.334	0.675
00558	-0.068	0.290	-0.676	0.057	-0.119	-0.581	0.253
00723	-0.109	0.180	-0.412	-0.446	-0.497	-0.529	0.138
00706	-0.109	0.180	-0.412	-0.446	-0.497	-0.529	0.138
00624	-0.109	0.180	-0.412	-0.446	-0.497	-0.529	0.138
00687	0.124	2.456	3.168	1.137	-0.248	-0.340	0.586
00690	8.225	-0.957	0.370	-0.774	0.588	-0.283	0.145
00660	-0.105	0.052	-0.054	-0.124	-0.095	0.255	-0.230
00637	-0.154	0.062	-0.075	-0.412	0.064	0.117	0.192
00636	-0.109	0.180	-0.412	-0.446	-0.497	-0.529	0.138

CA Case Scores

	Axis 1	**Axis 2**	**Axis 3**	**Axis 4**	**Axis 5**	**Axis 6**	**Axis 7**
Chipped Stone Pr.	-0.109	0.180	-0.412	-0.446	-0.497	-0.529	0.138
Bone Tool Pr.	0.220	1.059	-2.529	3.579	2.529	-0.945	1.063
Hunting	-0.231	0.155	0.772	-0.281	1.277	0.113	-1.201
Woodworking	0.268	-0.226	-0.420	1.799	-1.860	1.867	-1.742
Fishing	8.225	-0.957	0.370	-0.774	0.588	-0.283	0.145
Status	-0.542	-3.804	1.739	1.621	-0.234	-1.587	0.788
Organics	-0.210	-0.385	0.089	-0.443	0.535	2.060	1.749
Processing	0.480	4.758	5.564	2.554	-1.773	-0.792	2.373

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PART V

POSTSCRIPT TO ARCHITECTURE, FIRE AND STORAGE: CATHLAPOTLE AND MEIER FEATURES

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The purpose of the postscript in this report series is to briefly update their contents in light of subsequent work. Some of the theses and reports were finished as long as 20 years ago. Many report basic data and therefore require no or little updating while others do. Work on some topics is still in progress and our understanding of them is in flux. As of this writing (2014) final statistical and spatial analyses of some of the data generated by the Wapato Valley project are still in process.

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Douglass and Gronlin's (2012) dimensions and issues of Household archaeology discussed in the Introduction provide a convenient framework for discussing and teasing apart the various issues addressed in these three reports. The teasing apart is somewhat artificial but lends clarity to the discussion.

Household Form, Function, and Domestic Architecture

We assume in our work that the households occupying these houses are coterminous with the structures; they do not span multiple houses. However, the issue for the WVAP is whether separate households occupied the individual compartments within Cathlapotle's compartmentalized structures such as House 1. Smith (2008) and Sobel (2014) treated each compartment as a separate household for analytical reasons without resolving the question. Sobel inferred that the entire compartmentalized houses, such as House 1, were Houses (see Ames 2006) and therefore single households, but the issue remained open. These reports do not address the issue but some of their results are germane to the question.

What are our expectations for the archaeological record if each house compartment or segment is an independent, functioning household? One expectation is that they should be modular; that is each is more or less identical in function and form to the others. Thus, for example, the hearths should be essentially the same; storage pits uniformly distributed, production and consumption activities redundant from one house segment to the next. This is in essence the argument Coupland et al. (2009) make when they argue that communalism was weak in the Meier house, which they interpreted as having essentially identical hearths along its hearth row and a uniform distribution of storage pits, suggesting equal access to stores. For them, each hearth represents a hearth group that shares a common house but having weak ties to the other hearth groups in the dwelling, i.e. separate households. They also infer that House level leadership at Meier was weak based on the admittedly small number of prestige goods recovered. Additional support for their position is the clear evidence from both sites that all house segments do everything; there is no production specialization at the house segment level which is the exclusive province of a particular house segment. In contrast, if the house segments are parts of a larger household or House, than we expect the segments not to be identical modules, but with differences in their functions reflecting their contribution to the larger entity. Differentiation in hearths, differential distribution of storage pit numbers or volume, some degree of production specialization – especially specialization complimentary to specialization in other house segments – would be taken as evidence for the segments being part of a larger entity. Both sets of expectations are blurred by status differences with attendant differences in production and consumption and by production differences which may relate to specialization at the community level rather than household level. They are also blurred by preservation, site formation processes and sampling. Despite this blurring, some patterns emerge.

Gardner-O'Kearny found more evidence for internal differentiation in terms of hearth sizes among the hearths and associated faunal remains at Meier with its open interior then at Cathlapotle with its separate compartments although the differences at Meier are not isomorphic: the hearths in the Meier north and central sections are more alike, while the associated faunal remains for the central and southern sections are more alike. The southern section of that house has the massive processing hearth, while the hearths in the north are small and lack the associated indurated ash deposits. They also lack clear evidence for hearth boxes. In Cathlapotle, while the hearths may be similar in size, they differ in other ways. In House 1, Houses 1d and 1c have hearth boxes, the hearth in 1b is directly on the floor with no box. The hearths in House 4 are formally less variable. According to Butler, the storage pits are uniformly distributed in all the houses, but their volume varies among and within the houses, with the largest pits at the south end of the Meier house. Also at Meier, shell lined pits are limited to the north end of the house. In Cathlapotle House 1, there are differences in the placement of pits among the compartments. House 1d has storage features flanking both sides of the central hearts, while Houses 1c and 1d have pits only along the eastern wall. There are none on the west side. We determined this by augering the compartments and not finding storage pits. In contrast, Shepard found no differences in architectural fittings among the compartments and none of any significance among the houses and between the sites. Butler, like Sobel (2014) and Smith (2008), also found differences in production focus among household segments, which will be discussed below in the discussion in specialization.

At this point, the question seems to be still open. However, it is clear that the house segments, at least in Cathlapotle House 1 and Meier, are not modular: i.e. each identical to the other segment. However, none of the differences rises individually to the level of strong statistical significance; some are not significant at all. The current research issue then is whether the patterns of segmentation and differentiation continue as we are able to examine all recovered artifacts and fauna or if they dissipate into homogeneity. Interestingly, the patterns of internal differentiation seem stronger at Meier than Cathlapotle.

Shepard's inference about labor organization and specialization will be discussed below in the appropriate section. Here I wish to address domestic architecture and transmission, both in the sense of inheritance or wealth transmission and in the sense of biological and cultural transmission as the latter has been recently developed by various theoreticians but perhaps most especially by Richerson and Boyd (e.g. 2005). Shepard's study makes it clear, if ever there was any doubt, that these houses represent considerable material wealth. She does not have comparative data for several houses to warrant calculating Gini Indices, of the sort I developed in the Postscript to Sobel 2014. But that is not my purpose here. I do present Gini Indices based on storage volume below. Rather it is to suggest the houses and the knowledge and skills they embody represent more than one form of inherited wealth. Bowles et al. (2010) distinguish among three types of wealth: material wealth, which is what we normally think of in terms of wealth; embodied wealth and relational wealth, neither of which are material things. Embodied wealth includes knowledge, physical and mental skills and health. Relational wealth is social networks. It is quite evident from Shepard's report that the houses represent considerable embodied wealth. They also represent relational wealth, given that their construction draws on social networks extending well beyond the household (Gahr 2006). This wealth is also inherited, or transmitted. Embodied wealth is probably transmitted via the sorts of transmission mechanisms specified in cultural transmission theory (e.g. Direct and Biased Transmission [Richerson and Boyd 2005]) while relational wealth is created and maintained through kinship, marriage, exchange and the other strategies for constructing and maintaining social networks that Anthropologists have studied for more than a century. From this perspective, wealth inheritance becomes central to the long-term persistence of the household, beyond simply constructing and maintaining a building.

Issues of biological reproduction are also implicit to Shepard's report: where does all this labor come from? One possibility is that it is slave labor (Ames 2008). Some of it is pulled together via social networks for particular labor-intensive tasks (Gahr 2006) but these households seem to require a fairly large consistent number of people to function successfully. Thus, the more fundamental question here, which these studies do not address, is how these large households work demographically. Put another way, how does the household demographic cycle play out in a large multigenerational household (Ames 2006)? Answers to that question are also crucial to questions of cultural inheritance and transmission. Those answers are also obviously germane to economic organization, including economic organization.

Economic Organization, Households as Primary Producers and Specialization

The economic organization of the Meier and Cathlapotle houses has been a central issue for the WVAP since its inception (Ames 1995, 1996, 2006, 2008; Smith 2008, Sobel 2014; Ames et al. 2008). These three studies strengthen some conclusions and add important data and ideas to others.

The large storage pit cellar complexes described by Butler and discussed elsewhere by Ames (Ames 2008, Ames et al. 2008) are our most dramatic evidence concerning the scale of production and food storage in these households. Table 5.1 presents data on the size of the features based on Butler, including the overall storage volume/house and storage volume/m^2 of floor area. In both, volume is presented in liters (l). Overall storage volume is the total potential storage space available in the house. Storage volume/m^2 of floor area is a proxy for the amount storage available per capita, since floor area is also a standard proxy for household population. Taken together, these allow us to assess the storage potential for each household and infer whether it is mainly for household consumption or represents a potential surplus. The volumetric estimates in Table 5.1 are smaller than those in Ames et al. 2008 (Table 5.2). Those are based on the total available volume in the subfloor features while Table 5.1's figures for Meier and Cathlapotle are based on Butler's estimates which are based only on the sizes of the recorded storage pits. Butler's figures are useful here because they allow more direct comparison with Clahclellah. I note here that the estimate of the number of liters/m^2 for Cathlapotle House 4 in Table 5.2 seems too high, but even if it is cut in half, it raises interesting issues discussed below. The overall House 1 estimate of total storage capacity includes the area of the unexcavated H1a. To achieve that total estimate, House 1a would need a total storage potential of almost 23000 l, almost equal to the total of the three excavated segments (26034 l). This seems quite unlikely but for the moment I will let the estimate stand. The other estimates are well founded. While it is unlikely the potential total available storage volume of any house was ever completely devoted to food storage, the estimates do suggest each household's capacity to produce processed foods and a surplus. It should also be noted that these estimates do not include the space under the house roofs which were also used to store and cure foods. Ames et al. (2008) estimate the available volume under the Meier roof for storage at 907,000 l, giving the Meier house a total storage potential of 1,034,000 l or 1034 m^3.

These estimates raise important issues about the relationships among food processing, storage, household size and status among these households. At this point, the issue is food processing and household size, with total storage volume an indicator of the overall importance of food processing and storage in the household economy, and storage volume/floor area a measure of the relationship between storage capacity and household size. By either measure, Meier is clearly much more heavily invested in producing and storing processed foods than the sampled Cathlapotle households. It is a reasonable inference that Meier is producing a significant surplus of food, perhaps for exchange. More interesting, though, is that while Cathlapotle House 1 is second in overall storage potential (with the caveat noted above), it and House 4 are virtually tied for storage potential/floor area and House 4 has more storage potential/floor area than any of the three individual House 1 house segments for which we have sound data, including H1d. Comparing the Cathlapotle and Meier houses, only Cathlapotle H1b approaches the Central section of the Meier house in total storage potential, while only House 4 overlaps it in l/m^3. There are also strong intra-house contrasts, particularly in the Meier house, where the South section has significantly higher total volume and l/m^2 than the North or Central sections. The differences within Cathlapotle House 1 are clear, but not as dramatic.

These patterns are paralleled by the distributions of fire cracked rock (FCR) or thermally altered rock (TAR) (Tables 5.3 and 5.4). The tables present the FCR data as total kg, kg of FCR/m^3 of excavated volume and kg of FCR/m^2 of floor area, a measure comparable to l/m^2 of floor area, in this case measuring thermal processing (and heating)/capita. FCR/m^3 is a rough measure of overall thermal processing and heating. As with storage, the difference between Meier and Cathlapotle is marked. While Cathlapotle is richer in kinds of thermal features (various sorts of hearths, ovens etc.) than Meier, Meier literally has tons of FCR, much of which is concentrated in the South section of the house, with its large processing hearth. The North end was secondarily involved and the Central portion of the house the least. Part of this contrast between the two sites may be a consequence of the availability stone for heating but that can only account for a small amount of the differ-

Table 5.1. Pit volumes and volumes/m^2 for Meier, Cathlapotle and Clahclellah.

Status Rank	House	House Segment/Floor	N Pits	Area	Area Excavated	Estimated Total Pits	M Pit Volume L	Estimated Total Pit Volume L	Liters/m^2 Floor Area
	Meier		105.0	491.7	109.0	473.7	179.5	85021.2	172.9
1		North	28.0	141.6	28.0	141.6	130.1	18415.7	130.1
2		Central	25.0	134.1	37.0	90.6	132.8	12032.8	89.7
3		South	52.0	216.1	44.0	255.3	228.6	58368.9	270.2
	Cathlapotle								
	H1		68.0	526.0	86.0	415.9	117.0	48661.1	92.5
2		H1a[i]		160.0					
4		H1b[ii]	20.0	66.0	10.0	66.0	50.7	3346.2	50.7
3		H1c[ii]	12.0	113.0	15.0	45.2	166.9	7543.9	66.8
1		H1d	36.0	187.0	61.0	110.4	137.3	15152.5	81.0
	Cathlapotle								
	H4		21.0	92.0	28.0	69.0	122.1	8424.9	91.6
	Clahclellah								
1.5	H18	2/3	9.0	106.7	106.7	9.0	144.6	1301.1	12.2
		2/2	10.0	110.2	110.2	10.0	325.2	3251.9	29.5
		2/1	10.0	85.0	85.0	10.0	392.8	3927.5	46.2
3.5	H75	3/2	13.0	84.4	84.4	13.0	206.5	2684.1	31.8
		3/1	16.0	84.4	84.4	16.0	200.7	3211.5	38.1
5	H193	4/3	13.0	70.4	70.4	13.0	90.8	1180.4	16.8
		4/2	18.0	70.4	70.4	18.0	143.4	2580.7	36.7
		4/1	17.0	76.5	76.5	17.0	265.9	4521.0	59.1
1.5	H209	5/3	6.0	88.0	88.0	6.0	188.4	1130.2	12.8
		5/3	12.0	84.0	84.0	12.0	330.9	3970.2	47.3
6.5	H559	6/2	10.0	55.9	55.9	10.0	148.1	1036.7	18.5
		6/1	16.0	72.8	72.8	16.0	377.2	5281.3	72.5
6.5	H535	7/2	7.0	47.4	47.4	7.0	115.4	1153.5	24.3
		7/1	14.0	47.4	47.4	14.0	183.2	2931.9	61.8

i The H1a figures are estimates based on the mean number and volume of pits in Cathlapotle House 1.
ii. The estimates for H1b and H1c reflect these two house segments had storage trenches only along one wall.

Table 5.2. Data from Ames et al. 2008, Table 1.

Site	Houses	Size m	Area m^2	Estimated Trench Volume m^3	Liters	Liters Floor/m2
Meier						
	1	14.9 x 33	491.7	127	127000	258.3
Cathlapotle						
	H1	10 x 41	410	92	92000	224.4
	H1b,c,d	10.x 31	310	67	67000	216.1
	H4	8 x 13	104	52	52000	500.00
Clahclellah				Total Pit Volume m^3		
	H18-3	9.7 x 11.0	106.7	1	1301	12.19
	H18-2	10.2 x 10.8	110.16	3	3252	29.52
	H18-1	8.5 x 10.0	85	4	3928	46.21
	H75-2	nd		3	2684	
	H75-1	nd		3	3211	
	H193-3	8 x 8.8	70.4	1	1180	16.76
	H193-2	8.0 x 8.8	70.4	3	2581	36.66
	H193-1	9.0 x 8.5	76.5	5	4521	59.10
	H209-3	8.8 x 10.0	88	1	1130	12.84
	H209-2	8.0 x 10.5	84	4	3970	47.26
	H559-2	6.5 x 8.6	55.9	1	1037	18.55
	H559-1	8.0 x 9.2	73.6	5	5281	71.75
	H535-2	nd		1	1154	
	H535-1	nd		3	2932	

Table 5.3. Distribution of FCR by weight at Meier

	House Segment			Exterior\Midden
	South	Central	North	
kg	16695.8	4435.2	7979.4	3678.1
excavated vol m^3	62.8	21.6	29.8	46.1
kg/m3	265.9	205.8	267.8	79.8
Excavated area m^2	44.0	37.0	28.0	
kg/m^2	379.5	119.9	285.0	

Table 5.4. Distribution of FCR by weight at Cathlapotle

	House\House Segment						Exterior\Midden
	House1 Total	House 1b	House 1c	House 1d	House 4	House 6	
kg	710.4	53.3	64.9	592.1	401.2	108.0	717.3
excavated vol m^3	88.0	6.7	12.6	68.7	43.3	14.0	85.0
kg/m3	8.1	8.0	5.2	8.6	9.3	7.7	8.4
Excavated area m^2	86.0	10.0	15.0	61.0	28.0	8.0	
kg/m^2	8.3	5.3	4.3	9.7	14.3	13.5	

ence. Meier sits directly on Missoula flood gravels; portions of the cellar were excavated into the gravels, so cobbles for cooking and heating were readily available. Cathlapotle does not sit directly on gravel. However, there is a large basalt outcrop perhaps 200 m behind it. Thermal processing and heating was simply not as important in Cathlapotle Houses 1 and 4 as they were at Meier. They were more important in H1d than the other House 1 segments and more important in Houses 4 and 6 than House 1. I am not arguing storage and thermal processing were unimportant in House 1; they were probably quite important; but they were the least important of the three sampled houses. Given the small areal sample of House 6, its figures need to be treated with caution.

I do not have FCR data for Clahclellah, but the 1/m^2 of storage suggest another marked difference in production scale. Only three of the Clahclellah house floors exceed the lowest Cathlapotle figure (H1b) and two more are close to it. The rest are much smaller. The mean l/m^2 for Cathlapotle is 75.5 l, for Clahclellah it is 36.3 l. Meier's mean for its three segments is 163.3 l, suggesting a difference in scale that is also a difference in kind. The Clahclellah data are somewhat more nuanced than the Meier or Cathlapotle data. The differences in storage capacity from floor to floor in the same houses may be hinting at temporal changes in economic emphasis, household size, or maybe duration of occupation which are not visible at either Meier or Cathlapotle. The scale of processing/storage at Meier suggests the hypothesis that these were community scale production specializations at Meier.

There are other likely community-level production specializations or emphases at Meier and Cathlapotle. At Meier, these were deer hunting, and wood and bone working (Smith 2008, Fuld 2011); at Cathlapotle, elk hide working (Smith 2008, Sobel 2014) and elk hunting, although that was part of a focus on cervids including both deer and elk. There do not appear at present to have been household or intrahousehold level production specializations in the classic sense of the term. There were, however, areas of production focus or emphasis. Butler notes several of these. At Meier, terrestrial hunting in the South, line and aquatic hunting, woodworking and ceremonial activity in the North. At Cathlapotle, she suggests H1c's occupants specialized in hunting, wood working and bone tool production, while the specialization in H1d was high status. Sobel (2014) comes to somewhat different conclusions, suggesting that people in H1d also specialized in hunting rather than the people in H1c. Sobel's sample was larger and she is probably correct. Butler is probably correct about Meier (Smith 2008). Cathlapotle is more ambiguous. Fuld's (2011) study of the Cathlapotle bone and antler assemblage found little evidence for specialization in bone tool manufacture there. However, Butler's inferences deserve reexamination and further testing. Shepard suggests specializations centering on house construction and tree management along with woodworking. Her ideas follow a line of thinking I have been developing for investigating specialization in the Northwest Coast households. One thread of the line was the proposal for the existence of embedded specialists (Ames 1996), specialists whose activities were part of their household role, rather than being exchanged for patronage or other products. Another thread of the line was that woodworking and carpentry were central to Northwest Coast life and their tools, if not their products, are generally durable. Consequently, woodworking would be a good avenue for investigating economic and craft specialization on the coast. The Meier and Cathlapotle data sets provide the opportunity to pursue the issue farther than we have but Shepard's work suggests new directions. At its essence, her argument is that these structures are not really possible without production and knowledge specialists (who are likely to be the same person) as well some form of environmental management. One would expect such individuals to be in every household – embedded specialists – but the alternative seems equally possible, that there were essentially community level house construction specialists who performed their craft whenever houses needed building, solving Shepard's problem of how the knowledge persisted even when households weren't building new houses. These would also be specialists in the classic since of the word. This might explain why Meier is relative rich in wood working tools and Cathlapotle is poor in such tools; Meier housed woodworking\ house building specialists and Cathlapotle did not. One might object that the relative lack of wood working equipment at Cathlapotle is a sampling issue. This could be true, but if so, it implies that woodworking was a household level specialization and we did not sample that house.

One issue yet to be pursued here is household inequality and differentiation. The data available to do that is storage capacity. Gini indices and curves were constructed using total storage volume and l/m^2 (Figures 5.1 - 5.4). Total available storage volume produces the strongest evidence for household level inequality, storage volume per capita produces stronger evidence than household size as measured by floor area (Sobel 2014), but not as strong as total storage. If total available storage capacity is a proxy for the household's capacity to produce a surplus, then it may be measuring household inequality. However, rather than saying it is THE measure, I prefer the hypothesis that there was inequality among households both in status and in economic production, and that inequality was variable from community to community or at least region to region. Inequality is weakly expressed at Clahclellah – it could be argued that it was an egalitarian village – but strongly expressed in the Wapato Valley. We are also seeing, following Sobel 2014, very different household social and economic strategies across space. We also see differences through time.

Douglass and Gonlin (2012) felicitously describe "households as portals into societal trends." We have been discussing trends in space by comparing households and communities, but have not yet considered time. Gardner-O'Kearny's analysis of Meier and Cathlapotle's thermal fea-

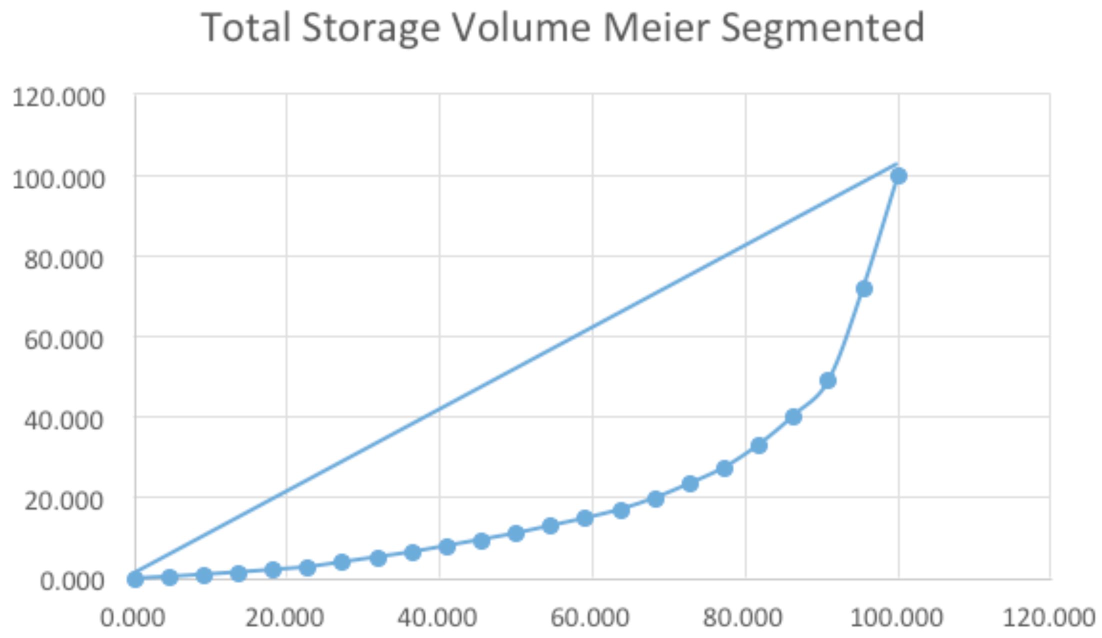

Figure 5.1. Total storage volume with Meier divided into segments. Gini index 62.41.

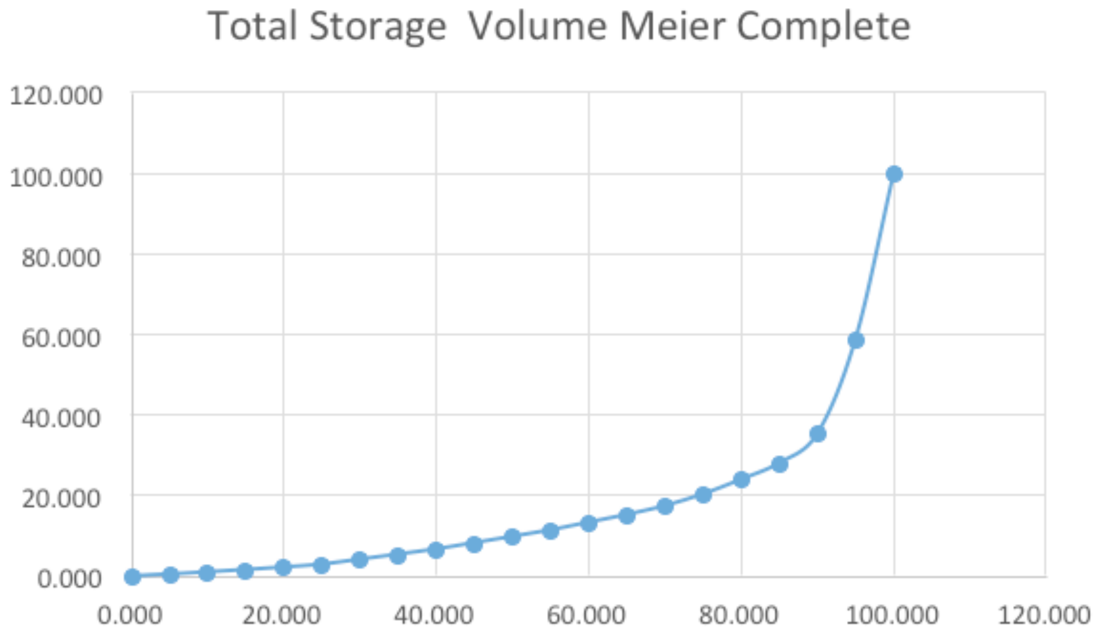

Figure 5.2. Total storage Volume with Meier complete. Gini Index = 68.44.

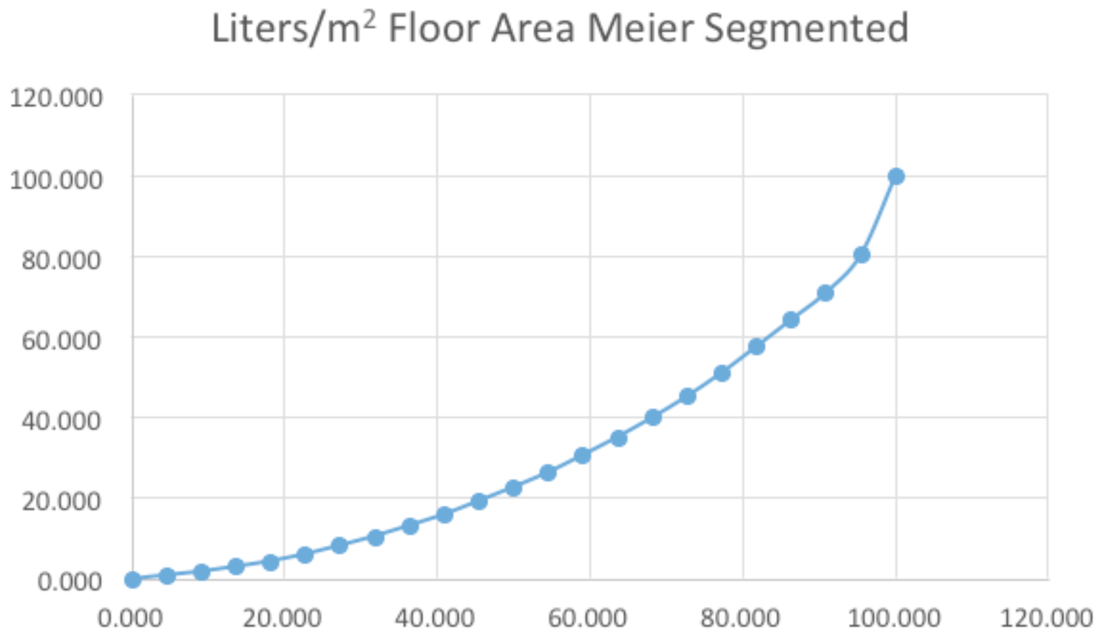

Figure 5.3. Liters\m^2 Floor Area Meier divided into segments Gini index = 40.12.

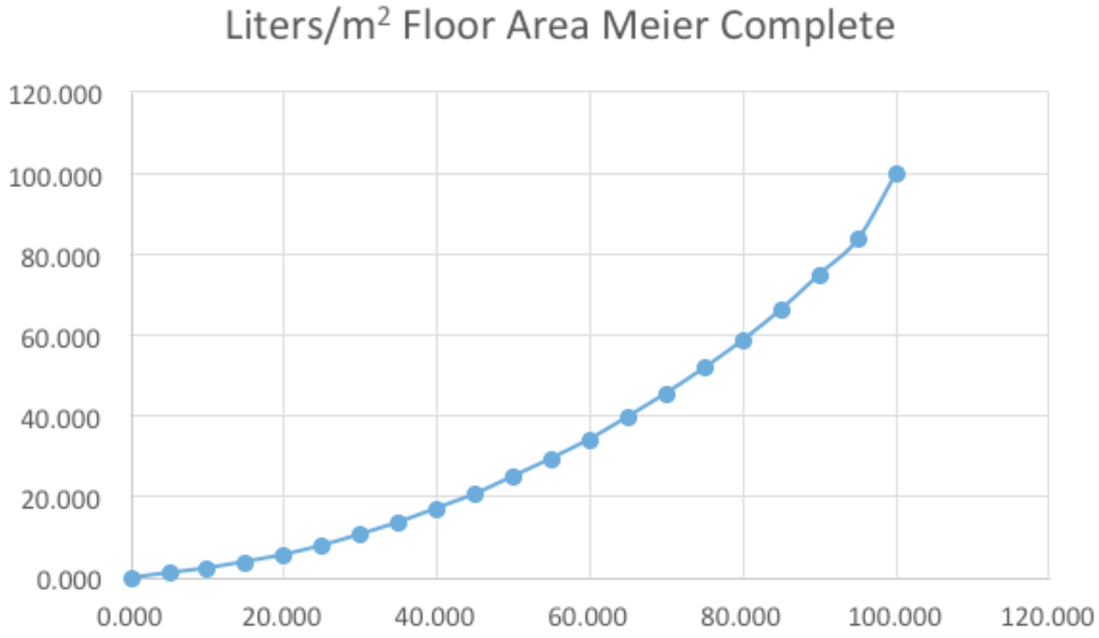

Figure 5.4. Liters\m^2 with Meier complete. Gini Index = 35.6.

tures and associated fauna tracks changes in economy and household organization across one of the great divides in the history of the world – the European conquest of the Americas and provides us with a nuanced picture. Hearths become smaller and more common; the spatial structure of the households as reflected by hearth placement seems to break down or at least loosen within the houses; mammal procurement intensifies with possibly a greater emphasis on deer and elk but with no diminution of diversity. These trends may have been stronger at Meier.

Our hypothesis for the changing size and spatial arrangement of hearths is that the sampled households took in survivors of the epidemics who were given places within the house but who had to have their own hearths. Intensification in food harvesting may reflect more mouths to feed. It could also reflect increasing demand either for meat or animal products from the fur traders. We have little other evidence at present of household reorganization at Cathlapotle. There is some at Meier. At some point the Meier cellar was allowed to file with dirt. This probably took some time. Our current thinking is that the process began sometime in the late 1600s. As the cellar filled its storage areas turned into pits, the pits analyzed by Butler. Also as it filled, the pathway that ran along the cellar floor was maintained for an unknown length of time. At some point, however, the pathway was packed with midden and FCR and a clay floor laid over it, replacing the house's planked floor (Ames et al. 1992). The pits continued to be active and were probably covered with planks. Our hypothesis for the abandonment of the house's planked floor has long been that the cost of keeping the cellar clear and the floor in place was too high if the household's size was dwindling. The floor required 15000 board feet of lumber. We still don't know when that event oc-

Figure 5.5. Wall trench and pit or post hole, profile GbTo 23, Garden Island, Prince Rupert Harbor, British Columbia.

curred. If it was a consequence of epidemics, then some time after the mid-1770s is the most likely time. In any case, the new small hearths at Meier were on the new dirt and clay floor. This issue will be pursued further in the Postscript to the report on the historic artifacts recovered at Meier and Cathlapotle.

The one issue not yet discussed that is raised by Douglass and Gonlin (2012) is gender. None of these reports addresses or touches on gender, although who was actually performing the labor investigating by them is an important question. There are other such questions relating to gender, for example, how did men and women engage\participate in the fur trade? We know for example that Cathlapotle produced processed elk hides for trade. It is likely the processing was done by women while the elk were harvested by men. At Meier, we suspect wood working efforts increased. We assume that was male work while the massive investment in thermal processing was probably women's work. We can speculate then that the intensity of men's and women's work differed among and within these large households. However, those questions have not been thought through or pursued at this point.

Features redux

One of the goals of these reports and the approach to features taken in the excavations at Meier and Cathlapotle was to build Middle Ranging Theory for the excavation, taphonomy and interpretation of archaeological plank houses (e.g. Smith 2006, 2008). We have succeeded in that to a great extent. We have a large body of data and observations about the record that we have drawn up and presented here. What we have not done is pull all that together in one place. That is well beyond the scope of this Postscript. I was reminded of this goal in July of 2014. With Kevan Edenborough, I had cleaned an erosion face at the Garden Island Site (GbTo 23) in Prince Rupert Harbor as part of a long term research project there. We were going to column sample it. As I studied the face – a classic, complicated shell midden, I recognized a wall trench (Figure 5.5). I was thrilled: what I had learned to see in dirt, I could clearly see in a shell midden. But this knowledge needs to be more widely available. We'll get to that.

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PART VI

VISUALS GALLERY

GALLERY

The purpose of the gallery is to provide visuals generally relevant to the content of the report. The normal rule of archaeological publications is that all figures, including visuals, must be referenced in the text and only visuals referenced in the text can be included. That rule is followed in the reports. However, it seemed valuable to supplement the reports with visuals germane to their contents. To do so, we use a practice of book publishers who place visuals generally relevant to the book but which are not directly cited in the text into blocks of visuals – galleries – which are distributed through the book. We have placed ours at the end. We are using galleries to simplify the production process while still maximizing the information content of the report series.

This gallery contains visuals relating to architectural features, thermal features and storage features. The intent is to give the reader information and a richer sense of these features without necessarily supporting or illustrating particular points in any report.

Figure 6.1. Planks, plank row, posts, and edge of storage pit complex, Cathlapotle House 4.

Figure 6.2. Example of intersecting structural features. A is the storage complex beneath the sleeping platform. B is a large post. C is one of several small visible posts. D is the wall trench.

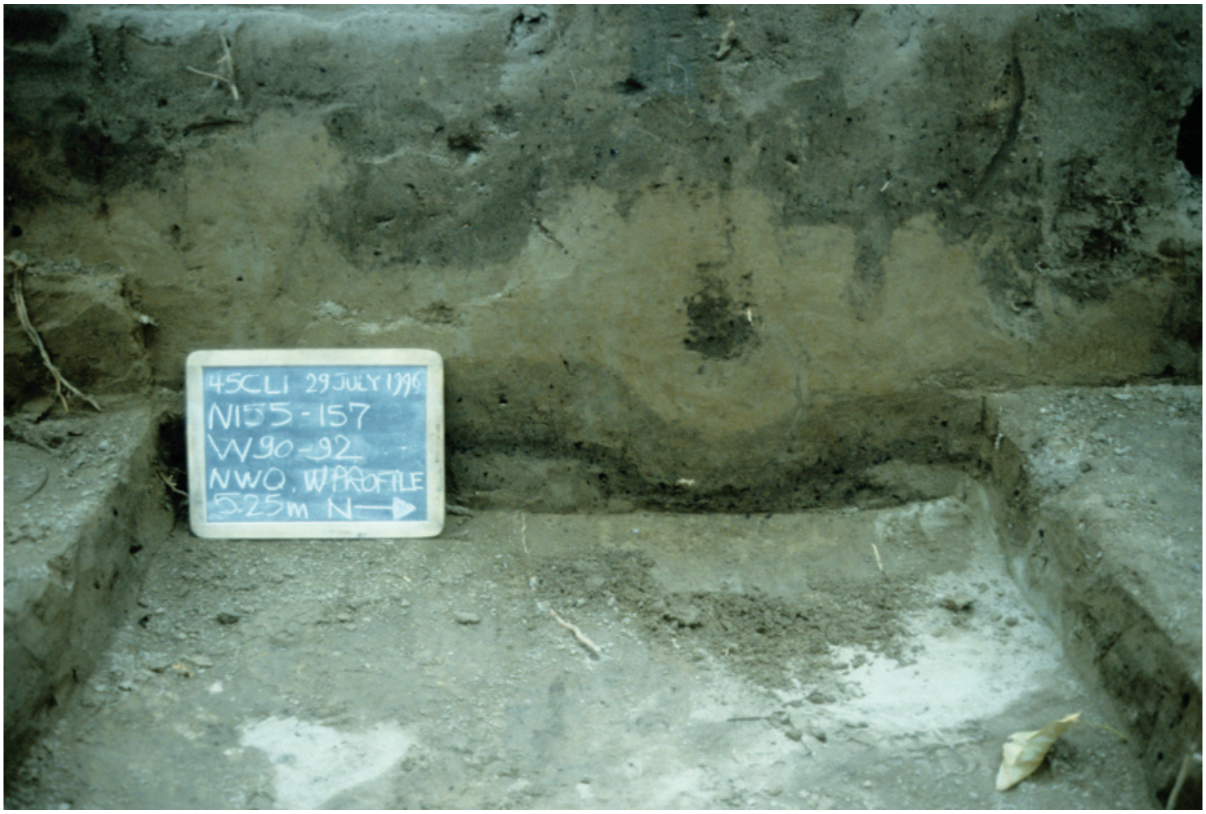

Figure 6.3. Horizontal load-bearing beam, Cathlapotle House 1d. Note the depressed sediment below the beam or post mold. Also note the post mold or pit and the plank molds at the contact between the tan and dark sediment. This is unique but is one of several structural features that do not fit tidily into the model of a post and beam structure. This is also an excellent example of common structural features, such as planks and posts, in profile.

Figure 6.4. Two views of the eave posts for the west wall of the Meier house being exposed. The sediment was sprayed with water and allowed to dry and the individual post holes became visible as they dried. The clusters of post holes produced amorphous features as seen in the sketch.

Figure 6.5. Wall trench truncating a shell lens and overbank sediments, south end of House 7.

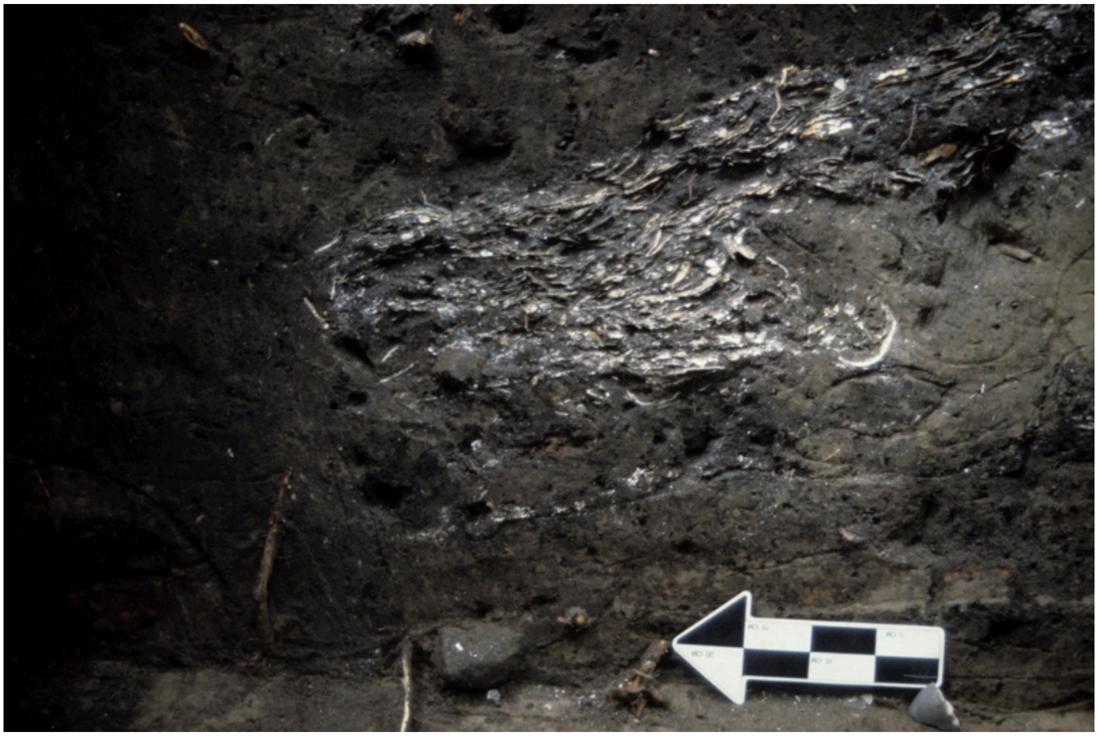

Figure 6.6. Close up of the truncated shell lens at the edge of the wall trench in Figure 6.5.

Figure 6.7. Excavated corner post holes, southeast corner of the Meier house. The boulders were placed in the post holes, under the posts. Note the plank mold between the arrow scale and the mug board. It is aligned with the house's east wall. The post holes were packed with midden material when discovered.

Figure 6.8. Plank molds for timbers supporting the Meier house ridge pole. The timber molds were covered by the large hearth in the southern section of the Meier house. Two of the hearth bowls are visible as is the overlying layer of indurated ash, calcined bone and shell fragments.

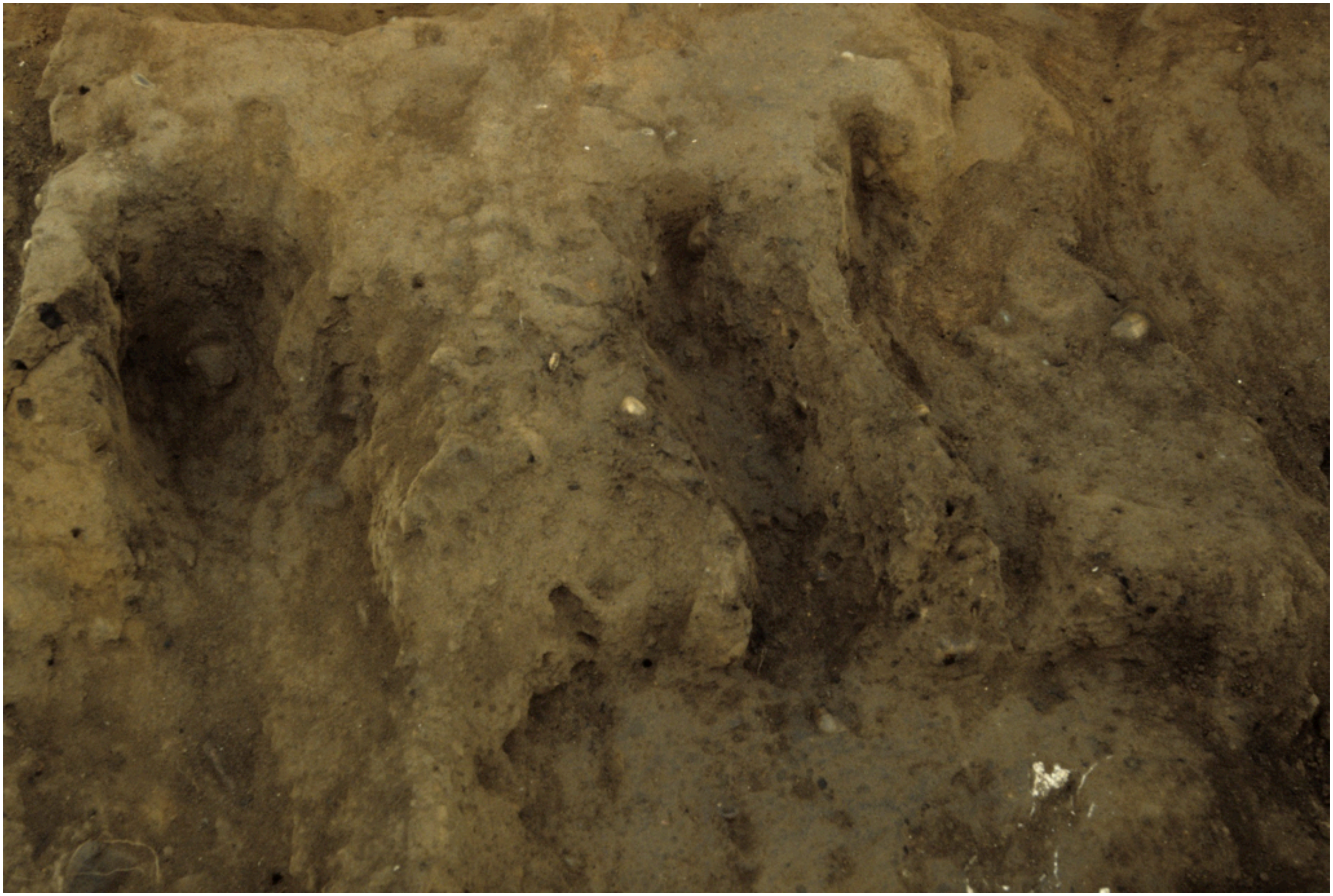

Figure 6.9. Close up of three of the timber molds for the ridge pole support timbers in the Meier house.

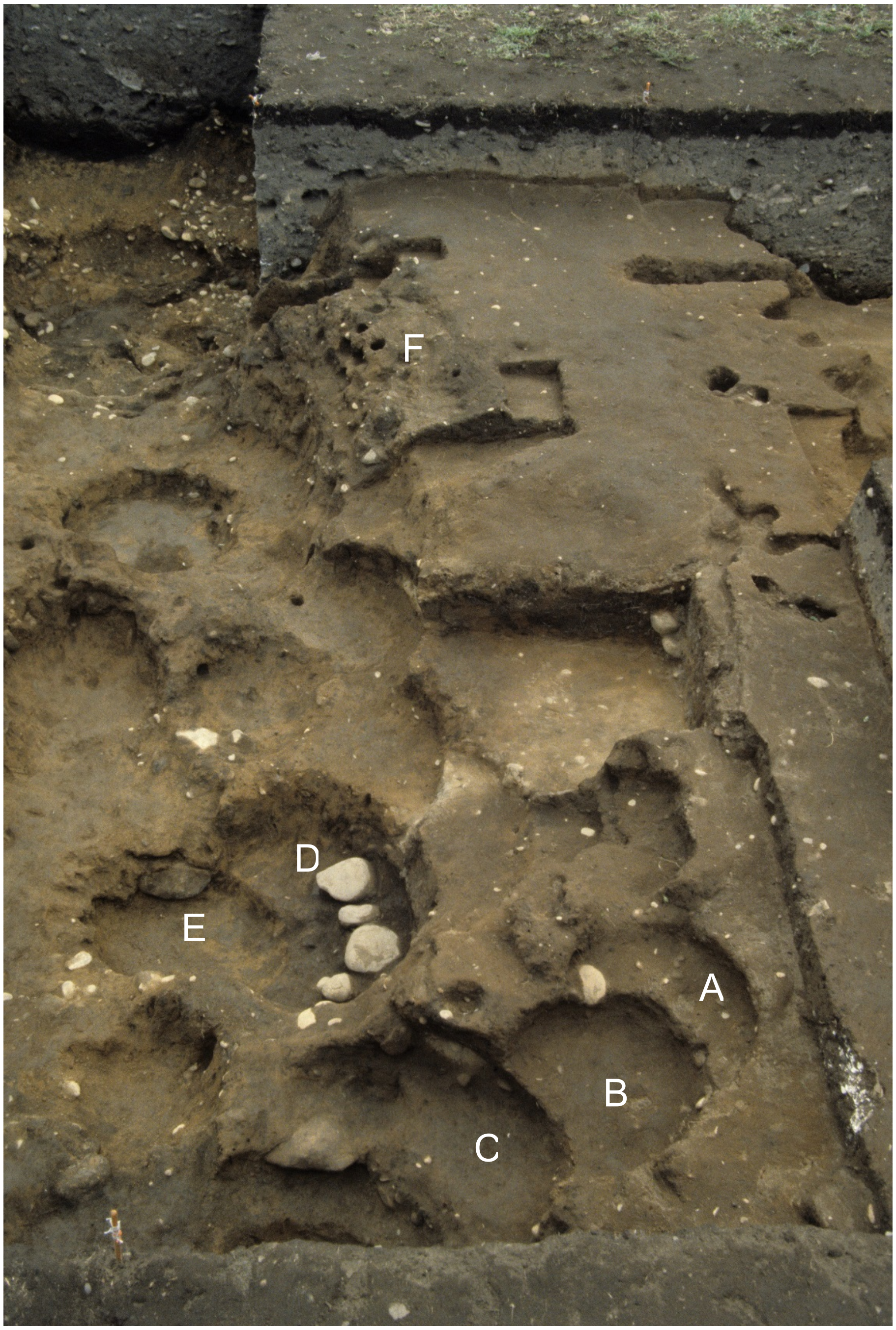

Figure 6.10. Interior post resettings at the Meier house, A – E. The post probably was part of the supports for the sleeping platform. F marks multiple small post or peg molds, probably again related to the sleeping platform.

Figure 6.11. Exposed surface of the indurated ash stratum capping the large hearth in the southern section of the Meier house. This stratum was comprised of ash and calcined bone welded together by heat. It had to be excavated with geologist's picks. The ash abuts the south end of the hearth box just north of the paint brush.

Figure 6.12. Profile of northern edge of the large hearth complex in the southern section of the Meier house. The baked clay hearth bowl and indurated are clearly visible.

Figure 6.13. Profile of hearth bowl in large hearth complex in the southern segment of the Meier house. A is the clay bowl, B a lining of lahar, and C the indurated ash. The bowls are usually about 50 cm in diameter, and lined with lahar or sometimes sand.

Figure 6.14. Excavated corner of the hearth box showing baked clay beneath the hearth complex.

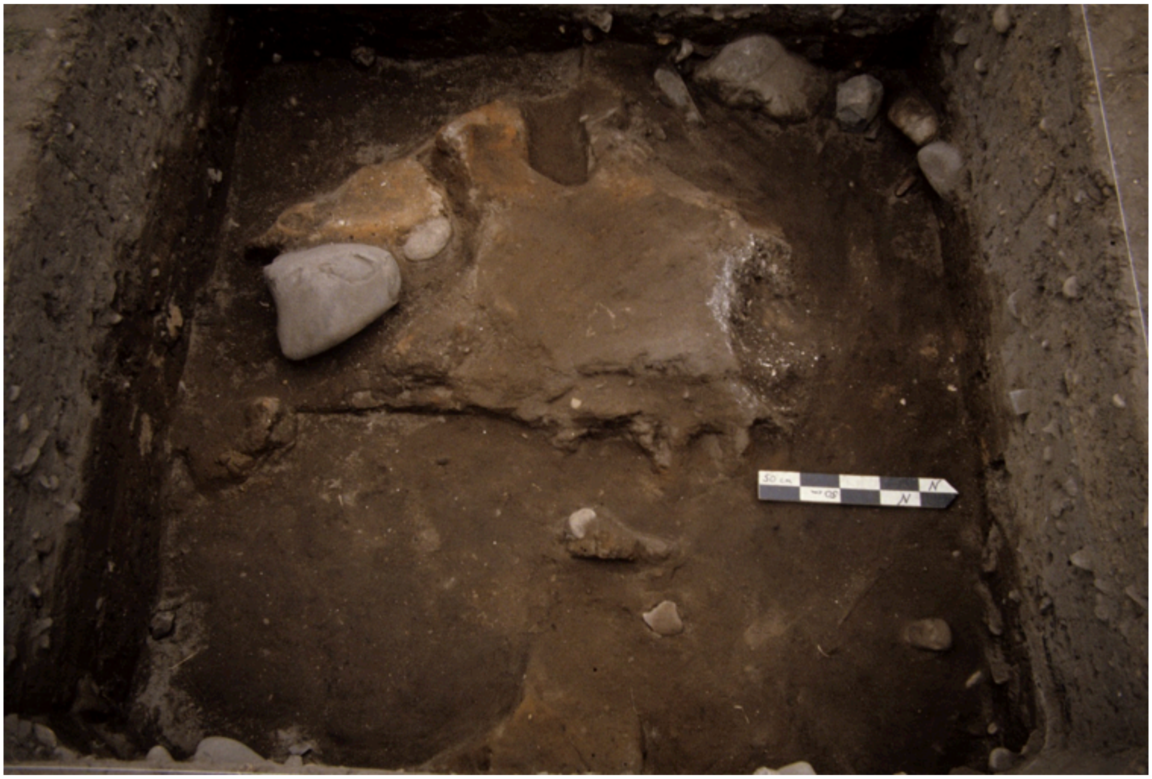

Figure 6.15. Hearth partially dismantled by the Meier house's occupants, central section of the Meier house.

Figure 6.16. A stack of hearth bowls with lahar linings, Cathlapotle House 1d.

Figure 6.17. Close-up of the hearth in Figure 6.16, showing the repeated lahar linings and the hard, baked hearth bowls.

Figure 6.18. Large hearth in northern portion of Cathlapotle House 1d. The hearth is 116 cm x 87 cm. The fire was laid in the dark central portion in a bowl lined entirely with lahar. This is the largest single bowl encountered at either Cathlapotle or Meier. The large hearth complex in the southern section of the Meier house contained multiple bowls, all about 50cm in diameter, set into the hearth box as it filled with ash and other bowls became covered. This bowl also had a thick ash cover.

Figure 6.19. Profile through the hearth box in Cathlapotle H1c. This is the best example of a hearth box. One side of the box are visible in the unit wall at the right where the ash lenses abruptly terminate. The other side of the box is visible in front of the bucket. The hearth complex itself contains a stack of lahar-lined bowls capped with hard indurated ash. Based on our experience at Meier, these baked bowls would be periodically removed and thrown out into the midden and the hearth renewed with a fresh bowl.

Figure 6.20. Hearth, Cathlapotle House 1b. This hearth rested directly on the house's earthen floor and there was no evidence of a box. There clearly was a lahar lined bowl (visible in the upper panel). The bowl is visible in the lower panel.


Figure 6.21. An exterior hearth feature in the Meier midden. As with the interior hearths, it had a bowl or basin, but lacked the lahar lining.


Figure 6.22. An example of the exterior thermal featured termed an “ephemeral fire” in the field to distinguish them from the substantial interior hearth features and the more substantial exterior features at Meier. These were often very thin, hence “ephemereal”. Their intact survival suggested rapid burial.

Figure 6.23. An "ephemeral fire" in profile. They generally lack fire cracked or thermally altered rock.

Figure 6.24. A typically small Cathlapotle hearth oven. As with this one, they were often about 1 m in diameter. Plant macrofossils they contained included charred camas bulbs, and acorn and hazelnut shells.

Figure 6.25. Upper panel: small earth oven in the midden west of Cathlapotle House 1b. Lower panel: the edge of that feature in cross-section. Below it is what may be a pit. Its fill lacked the charcoal and ash usually associated with ovens, so it was probably not another oven.

Figure 6.26. Surface beneath an excavated hearth oven.

Figure 6.27. Exposure of gravels underlying the Meier house and the likely source for the plentiful FCR in the house.

Figure 6.28. Southern segment of the Meier house, 1989 excavations. The multiple rims visible in the picture were constructed from a slurry of the local parent material – the ubiquitous silt-clay – and pit fill. They were probably reinforcing for baskets. In the lower right corner of the picture, the molds for the roof support timbers are visible. The massive hearth was stratigraphically above the timbers and the rims in the area marked by the white lines. It extended into the near unit wall. Another hearth complex is visible in the profile at the other (south) end of the exposure. “A” is the pathway along the cellar floor giving access to the baskets. “B” is a set of rims made from small planks (Visuals Gallery 29). Based on radiocarbon dates, this configuration of the Meier cellar dates to ca. AD 1450 – 1500.

Figure 6.29. A portion of the planked rims on the floor of the Meier house cellar.

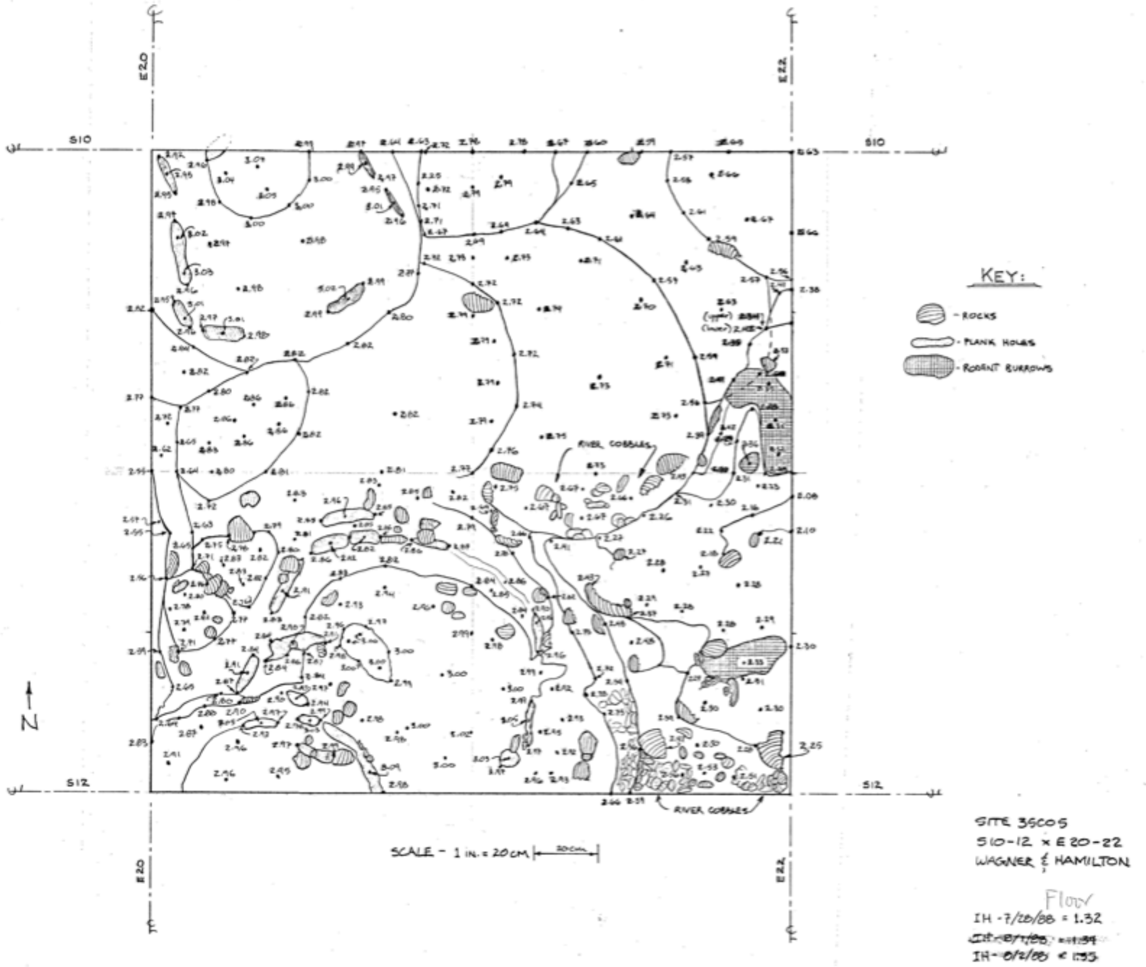

Figure 6.30. Field drawing of part of the planked rims complex showing the size and position of the small plank molds, and their arcuate positioning. Also indicated are the arcuate, overlapping bottoms of excavated pits. This indicates pits were placed in the same positions after the cellar filled with dirt as baskets were placed when the cellar was open. The drawing was made in 1989 by Robert Wagner and Stephen Hamilton. I used the original drawing because it would be difficult to improve on.

Figure 6.31. A portion of the planked rims on the floor of the Meier house cellar.

Figure 6.32. Meier pit or cellar fill. This is typical of the house fill both in color and its complex but hard to discern stratigraphy.

Figure 6.33. Plank mold and pit complex edge, east wall, Cathlapotle House 1.

Figure 6.34. Edge of pit complex/cellar, west side of Cathlapotle House 1d.

Figure 6.35. Excavated storage pits, Cathlapotle House 1d illustrating repeated use and excavation by the house's inhabitants with multiple intersecting pit floors.

Figure 6.36. Pit excavated into beach sands 4 meters below current surface and two meters below the base of the sheet midden in front of House 2. It dates to ca. AD 1450 and was probably excavated when Cathlapotle was established in its present location.

Figure 6.37. Storage pit in profile, Cathlapotle House 1d. Packing of pits with cobbles, ground stone tools and FCR was not unusual.