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Building Wooden Houses: The Political Economy of Plankhouse Construction on the southern Northwest Coast of North America.

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Abstract

Household archaeology focuses on what households do. Building and repairing houses is a household task that receives less explicit attention than do other tasks. Through the lens of political economy, we examine how three southern Northwest Coast households organized and orchestrated a complex labor task: building and maintaining their houses, by developing estimates of labor and raw material costs. We then use this analysis to show how house building and maintenance bears on issues of collective action, monumentality, anthropogenic landscapes, the development of concepts of property on the Northwest Coast, and of household continuity across episodes of cultural change. The political economies of Northwest Coast households have been central to theory building about the evolution and nature of sociocultural complexity among complex hunter-gatherer-fisher societies, but archaeological attention has emphasized subsistence. Our analysis does not supplant such models, but rather compliments them.

Keywords: Household archaeology, labor estimates, monumentality, property, anthropogenic landscapes, collective action, Northwest Coast

[C]ollective production beyond the unit of the simple family was necessary. The building and maintenance of the house, which had to be made from heavy cedar planks with stone tools, required a long period of effort (Oberg, 1943, p. 579, referring to the Tlingit).

Building a house in former times was a feat involving control of a considerable amount of manpower, which in turn depended on economic resources to support the people while they worked, with enough surplus to give feasts and other diversions to entertain them...it was not undertaken casually, nor...very often. The old houses are said to last almost indefinitely...over a long period, the entire roof and siding of a house might be renewed, and one by one the posts and beams...replaced, but it would still be the same old house that had stood in that place since...the dim epochs of traditional times (Drucker, 1951, p. 72-73, referring to the Nootka (Nuu-chah-nulth)

1. Introduction

We examine how three Northwest Coast households organized and orchestrated a complex labor task: building and maintaining their houses. We use this analysis to show how house building and maintenance bears on issues of collective action, political economy, monumentality, anthropogenic landscapes, the development of concepts of property on the coast, and of household continuity. This paper is in the spirit of Fladmark's (1973) imperative that Northwest Coast archaeology actively test Northwest Coast ethnography and is an exercise in what Ames (2008: 139-140) calls "ropewalk work", following Wylie's nautical metaphor of archaeologists weaving cables of evidence (Wylie, 1989). Before being woven together, the strands forming a cable were laid side by side in ropewalks and tested against each other for strength. Here the cables of evidence are archaeological and ethnographic, as epitomized by the quotes opening this paper.

Household archaeology emphasizes what households do: household production, distribution, transmission or inheritance, reproduction, and coresidence (Douglass and Gonlin, 2012; Wilk and Netting, 1984). Households also build and repair houses, activities materializing the household across time and which intersect with architecture and household function. House building opens a window into the household's political economy by requiring raw materials, labor, skills, organization, and social networks; requirements that can have unexpected ramifying effects. When considering houses, archaeologists usually focus on the social and ideological information derivable from a structure's layout and architecture (e.g. Blanton, 1994; Coudart, 2015; Coupland et al., 2009; Grier, 2006a; Steadman, 2015; Steere, 2017). Surprisingly, household archaeology has shown little interest in house building. For example, Steadman's (2015) encyclopedic treatment of the archaeology of domestic architecture has no sustained treatment of house construction and its implications. Souvatzi's (2008) stimulating study of Neolithic Greek households focuses on households as social process, but not on material processes such as construction. This apparent lack of interest results in part from methodological difficulties. Blanton (1994), for example, in his cross-cultural study of households and houses, tried to look at construction materials but found it difficult to draw comparisons. Labor estimates

can be developed (e.g. Abrams, 1994) and compared, but this has first to be done on a case by case basis, as we do here. It is also results, at least in part, from taking the house qua built object for granted. We hope to change that. To do that, we draw upon household archaeology, political economy and collective action theory. This paper culminates a series of papers on the labor costs of Northwest Coast houses (Ames et al., 1992; Ames, 1996; Gahr, 2006; Shepard, 2017). We were originally concerned simply with labor costs by estimating the board feet of lumber necessary to cover a house as a solid geometric shape (Ames et al., 1992). This subsequently expanded to using these lumber estimates as measures of labor costs relative to house size and household status (Ames, 1996); to modelling the houses' life cycle, and estimating the numbers of people needed to erect houses if they were put up in a single day as was the practice in some parts of the coast (Gahr, 2006). The present discussion expands on the previous work by using mapped structural features (e.g. post and plank molds, wall trenches, etc.) (Shepard, 2017) to reconstruct the houses and their construction histories to estimate the numbers and weights of logs, the person days required to build and maintain the structures, and analyze the houses' architectural stability through time as a measure of household continuity. We show that house construction was a significant undertaking, requiring substantial numbers of workers and materials. We also use these data to show that these particular houses were architecturally stable over their nearly half-millennia uselives.

2. Northwest Coast Houses and Households

Northwest Coast houses were the material expressions of extended, multifamily households. The houses themselves, the focus of this article, were commonly rectilinear post and beam structures (Fig. 1) built most often of Western redcedar (Thuja plicata) with redcedar forming the frame, planks, cladding, roofs, and floors (where floors were planked). Houses varied along the coast, most obviously in their roofs, some places had shed roofs, others gable roofs, but also in architectural details (Suttles, 1990; Vastokis, 1966). Jordan and O'Neill (2010) show this variation closely tracks language differences, although Mackie and Williamson (2003) describe a single village on the west coast of Vancouver Island that had most major variants in a single, seven house village- Hajda (1994) documents variations in house form and size in the Lower Columbia Region, where our research took place. Suttles (1991) enumerates their functions: dwelling, food processing and storage plant, workshop and recreation center, temple, theater, and fortress. While his list is specific to the shed roof houses of southeastern British Columbia and northwestern Washington State, it applies to the whole coast. The houses were where the nittygritty of household production and daily life intersected with social power and spirituality. Finally, they materialized and shaped the social and political dynamics of both their resident households and the village communities of which they were a part (e.g. Suttles 1991) while anchoring them in time and space (e.g. Marshall, 2006).

The households were the fundamental social, cultural, economic, political and legal building blocks of Northwest Coast societies. Membership could range from as few as 15 to well over 100 people. Recruitment varied from matrilineages in the north to greater genealogical flexibility and fluidity farther south, the ambiguity of which led Levi-Strauss (1983) to formulate his concept of House societies (*société à maisons*) among which the perpetuation of the House and its estate was the central organizing principle (see below).

Small rectilinear houses are present in the archaeological record of the northern Northwest Coast by 6500 cal BP (Letham, et al., 2015; Martindale et al., 2017a). Larger houses appear there between 4500 and 3500 cal BP and are present thereafter. Substantial houses appear on the Salish Sea portion of the southern coast by ca 5800 cal BP (Lepofsky et al., 2009; Mason, 2017). There may be a gap in the record there between ca. 5000 and 3500 BP, but that might be attributable to sampling. Large rectilinear surface houses are sporadically present in the record thereafter 3500 BP and are ubiquitous after ca. 2300 cal BP. On the Lower Columbia, houses are present in the record after ca 3000 cal BP, especially so after about 2000 cal BP (Ames and Sobel, 2013, Table 6.2). This local chronology is primarily a function of post-glacial sea level rise and the stabilization of the Columbia River flood plain by 2000 cal BP. In sum, rectilinear houses are present here and there on the coast by ca 6000 cal BP, if not earlier, and are widespread after 3000 cal BP.

INSERT FIGURE 1 ABOUT HERE

Archaeologists have seen these houses and their associated villages as evidence for many things: the development of the Northwest Coast ethnographic pattern (e.g. Matson and Coupland, 1995); of sedentism (e.g. Ames, 1981; Fladmark, 1975); of particular forms of labor organization (e.g. Ames and Maschner, 1999); as sources of social information, such as presence/absence of ranking (e.g. Archer, 2001; Coupland, 1985); of political information (e.g. Marshall, 1989); place-making (e.g. Marshall, 2006); production specialization (e.g. Chatters, 1989; Grier, 2001, Huelsbeck, 1988); as long-term persistence of social identities (e.g. Lepofsky et al., 2009) and of house groups or lineages (Martindale et al., 2017a); of the tension between communalism and hierarchy (Coupland et al., 2009); and of monumentality (Grier, 2006a). Archaeologists less often look at house construction. This mirrors a bias in the ethnographies, where the interest was much more on the social organization within the houses them on the houses themselves. It should be acknowledged though that by the time the ethnographic work was being done, many people were no longer living in plankhouses, and even fewer had probably seen one built. It is also in part a consequence of sampling and taphonomy, which is beyond the scope of this paper. But, in a sense, the existence of houses has been taken for granted and the demands of their construction and maintenance overlooked. For example, in a recent summary of environmental management practices on the coast and the uses of various resources, including wood, the authors list multiple uses for cedar - but not houses (Mathews and Turner, 2017, Table 9.2).

3. The Sites: Meier and Cathlapotle

The three plankhouses examined in this study are located in the Wapato Valley of the Greater Lower Columbia River Region (GLCRR) of western North America (Fig. 2) (Boyd et al., 2013; Hajda, 1984). Anthropologically, it is considered part of the southern sub-region of the Northwest Coast culture area (e.g. Suttles, 1990). At contact, the GLCRR was densely occupied. Boyd (1999b, 2013) estimates a population of 15,000 for the entire GLCCR with 55 recorded plankhouse villages (Zenk et al., 2016), of which 21 were in the Wapato Valley and immediate environs. These villages had 154 houses (Hajda, 1984). There are two Lewis and Clark-based population estimates for 17 of those villages (Boyd and Hajda, 1987; Hajda, 1984); a low

estimate of 3400, and a high estimate of 8040 (Table 1), which is Lewis and Clark's published estimate (see Boyd and Hajda, 1987 for a discussion of these estimates). These high populations were sustained by a very productive environment. The Wapato Valley encompasses the Columbia River, its flood plain, and adjacent upland plateaus. The flood plain contains numerous wetlands, sloughs, ponds, lakes and levees dominated by wetland and riparian vegetation; the rolling uplands by prairies dotted by oak (*Quercus sp.*) and Douglas fir (*Pseudotsuga menziesii*) copses. The uplands merged into the foothills of the Cascade Mountains to the east, and the Coast Range to the west, both mantled by the Northwest rainforest (see Butler and Martin, 2013; Ellis, 2013; Gahr, 2013; and Sobel et al., 2013 for detailed discussions of this environment and principle resources).

INSERT TABLE 1 ABOUT HERE

Two of the houses discussed here are part of the Cathlapotle village archaeological site (45CL1) near Ridgefield, WA (Fig. 3); the third is in the Meier archaeological site (35CO5) (Fig. 4) near Scappoose, OR. Both sites are on the Columbia River floodplain in the greater Portland, OR-Vancouver, WA metropolitan area. They are about 8 km apart, albeit separated by the Columbia River. Meier was excavated between 1987 and 1991 by Portland State University's Wapato Valley Archaeological Project (WVAP) under Ames' direction. The site contains remains of at least one plankhouse which was ca. 30 x 14 meters (m), associated middens and "yards", exterior non-midden deposits. The site dates between ca. 950 cal BP (A.D. 1000) and A.D. 1810, but the excavated house is dated between ca 550 cal BP (A.D. 1400) and A.D. 1810 (Ames and Brown, 2018), having a uselife of about 410 years. There is indirect evidence of one or more earlier houses. The house originally had a planked floor, but at some point in the eighteenth century, the cellar was allowed to fill in, and the planked floor replaced by a clay floor. The excavations produced large and rich artifactual assemblages. The excavations and their results are described in Ames et al., 1992; Ames and Henry, 2017a-e; and Smith, 2008.

INSERT FIGURE 2 ABOUT HERE

WVAP excavated at Cathlapotle from 1991 to 1996, under Ames' direction. Cathlapotle has six large plankhouses in two parallel rows (Fig. 3). The houses are represented on the ground surface by deep depressions. While the entire site was tested, sampling focused on Houses 1 and 4 and their associated middens (Fig. 3). The excavations and their results are described in Ames et al., 1999; Ames and Henry, 2017a - e; Smith, 2008; and Sobel, 2017. House 1 is the largest, its depression is ca 56 x 10m, House 4 one of the smaller houses at 12 x 8m. Four of the houses were segmented into compartments (smaller houses built end to end). House 1 is one of these; we sampled the three southern compartments (House 1B-D). Except for augering, we did not sample 1A. The Cathlapotle houses also have subfloor storage pit complexes/cellars, but not as elaborate or extensive as Meier's (Ames et al., 2008). These were located beneath sleeping platforms; the houses had earthen floors. Cathlapotle was established ca. 600 cal BP (A.D. 1350) and abandoned in the 1830s. While House 1 was established at ca. A.D. 1350, House 4 appears to have initially built some 60 years later, ca A.D. 1420 (Ames and Brown, 2018). Both were

probably abandoned when the village was. House 1 had a use-life of some 480 years and House 4 of ca 415 years. Cathlapotle was visited and extensively described by the Lewis and Clark expedition on March 29, 1806 (Moulton, 1991); Meier is not among the 21 historically documented villages in the Wapato Valley.

During excavations, structural features were recorded, and hand-drawn onto maps. Sobel (2017) redrew some of the feature maps in AUTOCAD[@] and Shepard subsequently redrew and entered all of the structural feature maps and data into ARCGIS[@]. This analysis is based on Shepard's maps (Fig. 5-7), not all of which are reproduced here. They are available in Shepard (2017) as is all of the supporting data.

INSERT FIGURE 3 ABOUT HERE

INSERT FIGURE 4 ABOUT HERE

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4. Political economy, collective action, House societies, labor, household continuity, monumentality, anthropogenic landscapes, property, and the appearance of large houses.

The political economies of Northwest Coast households are central to research and theorizing on the development of social complexity, including permanent inequality, among what are called transegalitarian, middle-range, or non-state (Stanish, 2017) complex societies. Despite this, and with rare exceptions (e.g. Ames, 1995; Angelbeck, 2017; Grier, 2001; Grier and Kim, 2012; Oberg, 1943), Northwest Coast research is rarely couched in explicitly political economic terms, although it touches on issues of political economy, including the roles of slaves, of high status individuals, and specialists in production and status (e.g. Ames, 1995, 2001, 2008; Burley, 1980; Chatters, 1989; Donald, 1997; Hajda, 2005; Ruyle, 1973); of surplus production and exchange (e.g. Huelsbeck, 1988); of obsidian as a prestige good (Sobel, 2006, 2011); of gender (e.g Moss, 1993, 1999; Pratt, 1999; Walter, 2006); and of property (Grier, 2014; Letham, 2017; Matson, 1985; Trosper, 2009). In the broader anthropological literature, discussions of Northwest Coast political economy often rest on selective and essentialized readings of the region's ethnographic literature (e.g. Johnson and Earle, 2000). Among coastal researchers, the focus overwhelmingly has been on the subsistence economy and its socioeconomic implications (e.g. Ames, 1994, 2005; Angelbeck, 2017; Angelbeck and Cameron, 2014; Butler and Campbell, 2004; Carlson, 1983; Coupland et al., 2001; Donald and Mitchell, 1975; Fladmark, 1975; Matson, 1983; Moss, 2011, 2012; Moss and Cannon, 2011; Schalk, 1977). This results from many factors, including a social syllogism in many traditional Northwest Coast societies in which food = wealth =

prestige, and a formerly widely held assumption that intensification of salmon production and storage was a, if not the, prime mover in social change on the Northwest Coast and elsewhere in the Pacific Northwest (e.g. Carlson, 1983; Fladmark, 1975; Matson and Coupland, 1995). Interest in the scale and organization of production emphasized the labor required to capture and process salmon for storage and the relationship between high status and the coordination and organization of subsistence production. The assumption of the processual primacy of salmon has been undermined by an explosion of research into the diverse range of subsistence resources constituting the region's resource base (e.g Moss and Cannon, 2011), and on traditional methods to increase resource and patch productivity and stability (e.g. Deur and Turner, 2005). Interest in political economic issues has taken a back seat, with some exceptions (e.g. Grier and Kim, 2012). That results in part from a need for thoughtful assimilation of this new data into discussions of subsistence, and in part to sometimes withering criticisms of the very notions of intensification and social complexity, and their value in Northwest Coast studies (e.g. Moss, 2011, 2012). It is not our purpose here to respond to those criticisms beyond asserting that explaining the evolution of complexity, especially inequality, remains a major task of the social sciences in general and archaeology in particular (e.g. Kintigh et al., 2014), and that political economy is an important theoretical and methodological tool for accomplishing that.

Plankhouse construction offers a window into Northwest Coast political economy complementary to the subsistence economy which illuminates related issues including the temporality of houses, which encompasses the length of their use lives and the stability of their internal architecture as a measure of the stability of the occupying households (Grier, 2006b); the need for environmental management to sustainably supply the wood for these dwellings; the scale of the social networks needed to field labor at crucial junctures; the roles of elites in production; the degree of specialization; and property. Our approach to political economy is best captured by Saitta's definition: "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" (Saitta, 2012). We prefer this definition to those focusing on "financing power strategies" (Earle and Spriggs, 2015, p. 516), which is the traditional emphasis of political economy. While Saitta's definition does not preclude considerations of power, it does not inevitably channel analysis towards power strategies. The more traditional approaches also tend to be top down. While our approach is multi-scalar, its point of initiation is bottom up, in line with household studies' methodology.

This definition helps bridge political economy and collective action theory (e.g. DeMarrais and Earle, 2017) with collective action's interest in non-coercive leadership (e.g. Blanton and Fargher, 2016; Stanish, 2017). Northwest Coast leadership was, in the main, non-coercive, with chiefs having the power to organize, but not power over organizations or individuals (Ames, 1995). Sustained house construction and maintenance over centuries presented Northwest Coast households and communities with long-term collective action problems, as encapsulated in the epigrams opening this paper, and as discussed below.

On the Northwest Coast, Houses sustained collective action. Collective action is simply "a group of people working towards a common goal" (Stanish, 2017, p. 7). However, sustained, long-term collective action is not so simple (see Blanton and Fargher, 2016; Carballo et al., 2012; Stanish, 2017 for thorough treatments of the issues; Thompson et al., 2018 for a relevant

application). Conflicts between the goals of individuals and of the group are at the root of the problems (Carballo et al., 2012). The common goals typically involve managing resources of some kind where there are "incentives to act selfishly" (Blanton and Fargher, 2016, p. 30) and misuse the resources. To successfully solve this over the long-term, groups must encourage cooperative behavior and deal with free-riders. For Carballo et al. (2017, p. 106-107), this is achieved via the "four Rs": reciprocity, reputation, retribution, and rewards. Blanton and Fargher argue it is achieved through the development of "effective institutions" (2016, p. 40). Stanish (2017, p 6) maintains that sustaining collective action in "complex non-state societies" (those lacking coercive leadership) necessitates "ritualized economies". These are economies in which the cultural norms supporting collective action are inculcated and transmitted across generations via ritual, which may be sacred or secular. Northwest Coast Houses filled this role.

Levi-Strauss' definitions of House societies are sufficiently ambiguous, particularly when coupled with differing translations, to support a literature of exigesis. We use three, Gillespie (2000a, 2000b, 2007) and Marshall (2006), but also see Ames (2006a). Gillespie emphasizes

[T]he maintenance of an estate by a *personne morale*, a long-lived entity subject to rights and obligations. The "language" of kinship and/or affinity is employed to achieve these twined goals by providing the means to legitimate the intact transfer of the estate across generations of house members. As for the people who must maintain the house, they assume a physical and social place - they are given an identity for themselves and a framework for interacting with others – by their membership within or attachment to a house (2000b, p. 27)."

The estate includes both the material and non-material wealth managed by the House. On the Northwest Coast, for example, estates could include both resource extraction localities and songs. The House estate ultimately depended on its political economy, which provided the surpluses funding the House's actions (Beck, 2007, p. 6). Levi-Strauss (1983) stressed that Houses were most visible in their interactions with others, and that Houses were both internally and externally hierarchical in those interactions. In contrast, Marshall (2006, p. 38) focuses on the Northwest Coast House defining itself "on the basis of place, particularly residence within a house, while maintaining open and flexible kinship systems and fluid memberships. This reflects the centrality of the physical house manifesting the social House on the Northwest Coast, and that while people came and went, the House persisted. Marshall (2006) stresses that the House defined itself by building, occupying and repairing particular houses in particular places, essentially making and fixing places across time. These places are essential parts of the House estate. The houses were polysemous entities; their interiors materializing both the sociopolitical/spiritual order of the House (e.g. Marshall, 1989 Sobel, 2017), while MacDonald (1983) argues they were cosmograms. Repair and maintenance was thus not just repair and maintenance, but a means by which the internal order of the House could be negotiated, made visible, and replicated or changed. It was also within the House that free rider problems were handled. Thus, while the immediate collective action problems addressed here are the construction and maintenance of plankhouses, the larger collective action problems are the reproduction and perpetuation of the House, and the management of its estate.

Our route into these issues is estimates of the labor and material costs of plankhouses. Estimating such costs has a long history in anthropology and archaeology and has primarily, but not exclusively (e.g. Morgan et al., 2018), concerned monuments and palaces (e.g. Abrams, 1994; Abrams and Bolland, 1999; Banning, 2011; Erasmus, 1965; Ortmann and Kidder, 2013), rather than domestic or vernacular architecture. While we argue below that Northwest Coast houses are monumental constructions, our initial interest was in the material and labor requirements of Northwest Coast plankhouses during their use lives and how this informed the nature and scope of household production, particularly in terms of the potential role of elites and whether specialists were required (Ames, 1995).

Reconstructing the scale and complexity of house building tasks would suggest the degree to which leadership was necessary. Abrams and Bolland (1999) argue that coordinating leadership is required in major projects only where there are constraints or bottlenecks in the construction process. They assume a generalized or unspecialized labor force. In contrast, Stanish (2017) argues that to be effective such cooperative labor projects require both coordinating leadership and a specialized labor force. While the ethnographic literature of the Northwest Coast sporadically mentions specialization (e.g. Allaire, 1984; Mitchell and Donald, 1988; Oberg, 1943), there has been little archaeological interest in the topic (but see Chatters, 1989). Our own work so far suggests low intensity embedded specialization (Ames, 1995, 2017; Smith, 2008, 2015; Sobel, 2017). As both Oberg and Drucker state in the epigrams introducing this paper, house building on the coast was a major cooperative labor project (e.g. Stanish, 2017) and labor estimates provide a sense of the scales of the project and of the social ties needed for its completion. It is well established that Northwest Coast households were not completely selfsufficient, requiring sometimes extensive networks to access resources (e.g. Suttles, 1960), and to undertake other projects (e.g. Grier et al., 2017) including building houses (e.g. Oberg, 1943). Labor estimates are a means of assessing the cost and the scale of those networks. Network scale includes numbers of people, the area drawn upon (e.g. Stanish et al., 2018), and time or temporality.

Grier (2006a, 2006b; Grier et al., 2017) analyzes the multi-scalar temporal dimensions of households, house building and other such projects under the rubric of temporality. Temporality at the household level encompasses transmission and household reproduction. Temporality for Grier (2006b) is not simply the use-life of a house but is a measure of the occupying household's ability to reproduce itself across generations. His methodology includes establishing the chronology and temporal duration of the house and household. Northwest Coast households theoretically could reproduce themselves organizationally over long periods (Ames, 2006a). Ames showed, using a simple demographic model, that some households could last a millennium. He credited this to a combination of good management, especially of risk, and good luck. Grier measured transmission at the Dionisio Point site in the Salish Sea region by modeling radiocarbon dates and looking at the use of domestic space within the houses through time, as measured by the distribution of tasks. The Wapato Valley Archaeological Project (WVAP) has also done that (e.g. Smith, 2008). Here we analyze the placement of architectural elements through time to measure the architectural stability of the houses as one proxy for the organizational stability of the households. We ask whether the labor we document was fielded by the same household over several centuries. Temporality also encompasses tempo and mode

(Grier et al., 2017); whether a collective project is done cumulatively over a long period, or whether it is done in short pulses. The quote from Drucker epitomizes both; houses are built in enormous, yet rare bursts of labor, but are maintained over long periods of time by regular, relatively small inputs. created by the same, long-lived House. One consequence of these is monuments.

Scholars increasingly recognize that construction of monuments (e.g. Saunders et al., 1997) and monumental landscapes are not limited to agriculturalists (e.g. Grier and Schwandron, 2017). On the Northwest Coast, there are complex stone alignments (e.g. Supernant, 2017) and defensive works (Angelbeck, 2016; MacDonald, 1984; Moss and Erlandson, 1992), in addition to massive shell middens which represent significant landscape modifications (Grier, 2014; Grier et al., 2017; Letham, 2017; Martindale et al., 2017b). We posit here that Northwest Coast houses and villages (as collections of houses) are monumental constructions. This argument is not new with us, having been made by others (e.g. Grier, 2006a), most forcefully by MacDonald (1983).

Monumentality is often taken simply to mean size, a clear implication of "monumental architecture" as a marker of civilizations (Childe, 1950): civilizations build big things. Northwest Coast houses were the biggest structures on the coast; some many score meters long. However, the question might arise "were they big enough?" to be monumental. Childe (1950, p. 12) also stressed that monumental structures "symbolized the concentration of the social surplus". We show below that, in terms of raw material and labor demands, houses were big enough to qualify as monumental as well as representing a concentrated social surplus. Also, according to the Oxford English Dictionary (OED) (1971) monuments need not be big; they need to be commemorative, of historical significance and enduring. Northwest Coast houses fit those requirements (e.g. Grier, 2006a; Marshall, 2000). However, explicit (e.g. the OED) and implicit to many definitions is a sort of lithocentricism: an expectation that true monuments are only built of stone, not shell or dirt or wood. One need only contrast the different national profiles and heritage management histories of places in the USA such as Pueblo Bonito with its elaborate stone architecture and of Cahokia with its earthen mounds to see this. We show that wooden monuments can be demanding of materials and skill, and they can be enduring over long periods of time. However, their endurance can require a great deal of wood.

The large quantities of wood required by these houses must also have shaped the coast's forests. A major development in Northwest Coast anthropology and archaeology is the realization that the coast's peoples significantly shaped their environment. Various plant management methods are currently the best documented (e.g. Boyd, 1999a; Turner, 2014), but management methods may have extended to both fish and mammals (Campbell and Butler, 2010; Thornton et al., 2015). Researchers are also documenting examples of substantial landesque capital (Håkensson and Widgren, 2014) including intertidal zone plant (Deur, 2002, 2005) and clam gardens (Deur et al., 2015; Grosbeck et al, 2014; Lepofsky et al., 2015; Williams, 2006) and terraformed residential sites (e.g. Grier et al., 2017; Lethan, 2017; Martindale et al., 2017b). A dramatic archaeological example of this management is a 3500 year-old wet land wapato (*Sagitarria latifolia*) garden near Vancouver, British Columbia (Hoffmann et al., 2016). While many of these anthropogenic environments were no doubt the direct result of intentional human action, others may have been epiphenomena, at least at first. Trant et al. (2016) show that shell middens have a beneficial effect on forest productivity,

especially that of Western redcedar, a keystone tree in Northwest Coast culture. We argue below that the sheer volume of wood required for plankhouses, among the other uses for cedar, especially over the 6500 years or more that they were built, must have significantly shaped the region's forests and required management for sustainable use over millennia (e.g. Lacourse et al., 2007).

Sustainable resource management has been long recognized as a collective action problem (e.g. Ostrum, 1990). Trosper (2009) argues that property, or proprietorship, formed part of Northwest Coast societies' solution to this problem. This has implications for the development of property concepts on the coast, and by, extension, permanent inequality.

Property has long held a central place in theories of political economy, and it is well documented ethnographically that Northwest Coast households owned estates comprised of both corporeal and non-corporeal property. However, until recently anthropologists and archaeologists have devoted little attention to property since Richardson (1981) surveyed property rules along the coast almost 40 years ago. About the same time, Matson (1985) implicated property in the development of permanent inequality on the coast, but there was little follow-up. Trosper (2009) and Grier (2014) have recently revived property as an issue; Grier built on Gintis' (2007) concept of endowment to argue that concepts of property on the coast grew out of investments in the landscape to increase environmental productivity and in monumentality, ideas that Letham (2017), drawing on Trosper, elaborates. Bettinger (2015) reverses the formula, asserting that concepts of property must exist before such investments are made. In any case, demonstrating the existence of property archaeologically is difficult.

Because political economic thinking among scholars of the coast focuses on subsistence, interest in property focuses on ownership of subsistence resources and resource patches. Except under some extraordinary circumstances (e.g. Wessen, 1988), it is hard to demonstrate that differences in ecofact assemblages among excavated households or sites are a consequence of patterns of ownership and not simply differences in productivity across household catchments. It is also the case that scholars have not looked very hard. The recent thinking on property examines material investments, such as in construction of middens, clam gardens and so on. We extend that thinking to house construction.

Finally, in narratives about the architectural history of the Northwest Coast, the focus is on the social, symbolic and economic implications of the appearance of large houses. The large houses themselves simply appear in archaeological narratives, rather like the Greek goddess Athena emerging fully formed and armored from the brow of Zeus. More broadly, theories and accounts of the origins of sedentism focus on the process and effects of sedentism, with the houses themselves being incidental. But the construction of large plankhouses implies all the aspects outlined above, so their appearance signals significant social and ecological developments in their own right. Different house styles and modes of construction may carry different implications, but building houses has ramifying effects as we detail below.

5.Methods

All data, methods, and calculations used to derive the raw material and labor estimates below are presented fully in Shepard 2017. They combine information from the Northwest Coast documentary record, experimental archaeology, and excavation data, some of which is reviewed below. A few historical documents and ethnographies provide descriptions of labor tasks related to building and maintaining the dwellings (Boas, 1916; Drucker, 1966; Goddard, 1972; Jewitt, 1987; Koppert, 1930; Niblack, 1970; Stewart, 1984; Wilson, 1866). However, using the Northwest Coast documentary record has its dangers (e.g. Ames, 2006a; Grier, 2007; Moss, 2011). One must be careful to not create what is ultimately a false narrative by blending choice tidbits from here and there. However, the technology employed, and constraints imposed by the raw material and architectural features common along the coast argues that with due care, the documentary record can be employed as we do, especially in tandem with the archaeological record (e.g. Ames, 2008).

Another potential source of information is the plankhouses (a.k.a. longhouses) recently erected by Native groups, universities and other institutions, agencies, and archaeologists. The degree to which these can be used as analogues for traditionally constructed houses is questionable since few are built using traditional techniques and tools. Among these are two Chinook-style plankhouses built in the past 40 years. One was a 3 x 4.5m house constructed on an Oregon State park in 1978 (Fagan, 1985); the second an 11.3 x 24m structure erected on the Ridgefield Wildlife Refuge near Cathlapotle in 2005-2006 (Daehnke, 2007, 2017). Both were built with saw-cut logs. Although construction of the first used traditional tools and construction methods, time and material used are not reported. The second was erected using a mix of traditional and modern methods and tools, and had to meet Federal fire and safety codes. Its construction required 246 cedar logs as well as more than 4000 volunteer hours. However, that total does not include felling and moving the trees or erecting the frame, which was done by machine. It does include splitting and adzing planks, preparing the ground for the house floor, as well as other associated tasks and training.

Archaeological excavations of numerous plankhouses on the southern and central Northwest Coast, including Meier and Cathlapotle, also provide information primarily on architectural feature metrics. The most significant archaeological study of household architecture on the Northwest Coast emerged from the remarkable excavations 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 house architecture are not applicable to the GLCRR, as houses in the Ozette area were shed-roofed rather than gabled, archaeological data regarding Makah logging and house building techniques provides a rich picture regarding the myriad activities that were involved in building and repairing plankhouses. Other than wet sites and intact houses, direct archaeological evidence of woodworking and wood harvesting activities related to plankhouses is limited. Our primary sources of data are the Meier and Cathlapotle houses.

6. Building Houses

6.1 The House life cycle

Gahr's (2006) description of the life cycle of Northwest Coast houses frames our discussion. There are three phases: construction, maintenance and demise.

Construction phase: This phase was triggered by the decision to build a new house. According to Drucker (1966), it was not undertaken lightly. Its duration is difficult to judge, but time was bounded by how pressing was the need to complete the new house which in turn depended on whether it was a replacement for a standing, decaying house or a wholly new house. The phase had social aspects, including negotiations with other households for permission to build and the recruiting and organizing of extra-household labor to erect the house when the time to build came. It also involved the selection and accumulation of raw materials, as well as erecting the house.

Maintenance phase: Once erected, houses needed continual repair because of normal wear and tear, decaying structural members, the occasional fire and other catastrophes. Walls were sometimes moved and interiors reorganized.

Demise phase. At some point the house could no longer be maintained. Gahr (2006) discusses instances of households no longer being able to sustain the costs of upkeep, either through improvidence or poor planning, households breaking up, fire and so forth. In such instances houses might be abandoned, or taken down and replaced; in other instances, new communities were established, thus initiating a new construction phase.

6.2 Construction phase

6.2.1 Raw materials

Western redcedar was the dominant construction material. They are a large, swiftgrowing, long lived tree, averaging almost 60 m in height and about 2 m in diameter at the base (Pojar and MacKinnon, 1994; Waring and Franklin, 1979). They grow best below 1000 m 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). Although cedars were present in the GLCRR, they probably did not reach their maximum sizes, as conditions are not as favorable as elsewhere on the coast. Cedar was also likely not abundant in the GLCRR. It is rarely the dominant tree species in Northwest Coast forests anywhere, having a patchy distribution (Deur and Turner, 2005, p. 11). In old-growth forests of western Oregon, for example, cedar populations are small compared to those of other trees (Christy and Alverson, 2011; Harrington, 2003; Poage and Tappeiner, 2005, p. 335). The immediate areas surrounding Meier and Cathlapotle were unlikely to have large cedar stands being largely prairie, wetlands and deciduous forests.

Availability of cedar for building materials was also restricted since quality and size of trees varied considerably as did their suitability for building (Gahr, 2006). For example, trees growing in dense stands or close to water are more likely to have knots or low branches (Stewart, 1984, p. 24). Further restricting the availability of cedar was its use for many other technologies, including boxes and the ubiquitous canoes (Ames, 2002). The inner bark was important in a range of technologies including clothing and baskets (Stewart, 1984). Harvesting inner bark alters the growing patterns of trees, which may render them unsuitable for most construction uses. Turner and Davidson (2004, p. 84) observe that "tremendous quantities" of cedar inner bark were harvested on the Northwest Coast. One study of culturally modified cedar 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), although cedar grows well on abandoned shell middens (Trant et al., 2016).

Despite these issues, 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), although it does eventually rot. Cedar is much less prone than are other GLCRR trees to the volumetric shrinkage that can warp and split wood (Countryman and Kemperman, 2000). 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). Using massive posts and beams in houses mitigated this weakness, minimizing the number of times elements had to be replaced, but increasing the labor required to move and work individual logs. The heavy timbers, by virtue of their size, also inhibited burning. Cedar is fire resistant, but extra-large timbers would produce slow burns, rather than conflagrations, although both the Meier house and Cathlapotle House 1 partially burned at least once.

In summary, while using cedar in structures had many benefits, issues existed. Cedar is prone to distortion from weight stress. Small building elements such as planks needed to be replaced frequently because of rot. Furthermore, cedar trees were not unlimited resources; they may have been quite scarce in and around villages, especially considering their high demand for a variety of technologies. As Gahr (2006, p. 65) observes, "[I]n the midst of towering forests, there was a paradoxical scarcity of ideal lumber". Consequently, in some areas, households had property rights in trees and redcedar was evidently managed (Turner 2014, vol 2, p. 184-185).

6.2.2 Quantities of wood required.

The amount of lumber used for roof, siding, and floor planks in the Meier and Cathlapotle houses were estimated in board feet (12"x12"x1") based on estimated surface areas of roofs, siding, and floors. Using differing combinations of wall and roof heights yielded a range of possibilities (Table 2). The table's figures should be considered underestimates (Shepard, 2017). For scale, a modern 2400 ft² North American house requires about 16,000 board feet for framing (Idaho Woods Production Commission, 2018).

TABLE 2 ABOUT HERE

To estimate the amount of material and trees used for post and beams, structural element metrics and counts were used. (Shepard, 2017, Appendix B), since board feet calculations eliminate the curved portions of posts and beams. Meters of circular wood needed for posts and beams was translated into trees required (Table 3). To calculate trees needed for initial construction, meters of posts and beams were combined with board feet needed for planking.

TABLE 3 ABOUT HERE

6.2.3 Construction phase labor estimates

A summary of person days involved in initial construction of plankhouses is difficult. We were unable to quantify many activities; Table 4 contains our best effort. Although this presentation is incomplete and rife with estimations, it is clear from these data that a significant investment of labor was required to obtain materials for and to build houses. A production sequence allows delineation of tasks associated with plankhouse construction and maintenance (see Shepard, 2017 Chapter 6 for detail and sources). We skip many significant expenditures of labor, time and resources, including pre-construction planning, ceremonies and prayers associated with tree felling and construction, as well as costs of recruiting, organizing and deploying workers. Ethnographic and historical accounts demonstrate that these activities required much labor, time and other resources (Gahr, 2006). We also ignore labor spent on tool and equipment (e.g. ropes) manufacturing and repair. 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.

TABLE 4 ABOUT HERE.

Planning: We have no basis to estimate the amount of time devoted to planning.

6.2.4. Procuring Materials

The first step in obtaining building material was locating and selecting cedar trees of appropriate sizes and quality. It is difficult to quantify the time and effort required searching for and selecting the numerous trees needed for posts, beams and planking. We propose below that houses owned cedar stands, which would have saved some time, but finding suitable trees may have been time consuming because of cedar distribution and growth characteristics, although it is likely locating and monitoring suitable trees was embedded in other forest activities.

Felling trees was next; felling required both effort and skill. Rough estimates of time spent felling trees were calculated based on the experimental archaeology studies (Shepard, 2017, Appendix B) and an eight-hour work day. Koppert (1930, p. 10) implies group size for felling was about 10 people, while Jewitt (1987) writes that 2-3 people were involved in felling. 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, person days were also estimated (Table 4). Importantly, these figures do not account for interior furnishings such as benches. After felling, the trees were stripped of tops, limbs and bark. They were then hauled from the felling location to a watercourse down which logs were floated to the house site. 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 5).

TABLE 5 ABOUT HERE

The labor invested in moving logs is suggested by two sources. Chittenden (1884), reporting on his survey of Haida Gwaii (aka Queen Charlotte Islands), found trails up to two and three miles long constructed for moving cedar logs from the stands. These trails bridged streams and were corduroyed across marshes. 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 significant time was devoted to hauling logs needed for initial construction: 3060-12,600 person days at Meier, 930-4,200 at Cathlapotle House 4 and 4680-20,400 at Cathlapotle House 1. However, because only Koppert provided data regarding moving logs, we decided these numbers were too speculative to include in final labor calculations. However, even if partially accurate, they, taken with Chittenden, demonstrate that transporting logs was a major task associated with house construction and later for house maintenance.

After logs were transported to the water, log drivers guided the logs down the watercourse to the building site. Many coastal villages were located on small islands and so logs needed to be floated or towed across open water. Once the tree arrived at the village's beach, it had to be dragged to the building site. This would likely be accomplished by hundreds of workers pulling the log with strong rope.

Once logs were transported to the village site, they were shaped and adzed. Planks for walls and roofs were split either from large logs using wedges or directly from standing trees, although this was probably rare in the GLCRR. During house construction, systems of ropes, scaffolding and complex levers were used to raise posts and beams. 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, p. 374). These methods required not only physical strength, but also a great deal of coordination and planning.

6.2.6. Preparing Materials

Both the building site and materials needed to be prepared for building. Prior to construction, the house site was prepared by clearing vegetation, flattening or excavating the house site, and perhaps demolishing the house to be replaced. Along the coast, villages were often, but not always, on shell middens with leveled terraces to accommodate house rows (e.g. Martindale et al., 2017a). In some instances, more extensive terraforming was required (e.g. Letham, 2017). On the northern coast, the interiors of higher status houses were sometimes excavated to create capacious internal spaces one or more levels deep. Post holes and wall trenches were also excavated. The Cathlapotle houses were set into depressions, while the Meier house may have had a shallow depression. Additionally, these houses had deep cellars or storage pit complexes (Ames et al., 2008) which extended at least a meter below the floor of the house. Meier and Cathlapotle are on alluvium; the Cathlapotle depressions and cellars were excavated into a silt-clay; the Meier cellar into an indurated Pleistocene gravel bar. House depression depths of .3 and 2 m were used to generate labor estimates for the Meier and Cathlapotle excavations (Ames et al., 1999; Hajda, 1994, p. 179; Smith, 2008). 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 (Shepard, 2017). Although estimates encompass wide ranges, they demonstrate that a great deal of labor was needed to excavate the

underground portion of these plankhouses, pits and corner post holes. 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. Since the Meier and Cathlapotle cellars distinctive features of Wapato Valley houses (Ames et al., 2008), some portion of these labor estimates is not applicable elsewhere on the coast. A great deal of earth moving occurred as the plankhouse itself, any interior excavations, wall trenches, and postholes were all excavated.

Other crucial tasks including preparing frame members (e.g. notching posts), and splitting and adzing planks. Post, beams and many planks were adzed. Mauger (1978) reports that half of all planks at Ozette were adzed, including all roof and bench planks. Adzing is the final step in finishing wood surfaces, analogous to sanding. A small adz is used to trim long, shallow flutes lengthwise along the object. Considering the large number of planks, posts and beams needed for construction, this would represent a considerable output of time and labor. The effort at the Ridgefield plankhouse, provides a sense of this; some 420 person days were invested in splitting and adzing planks, and shaping posts and rafters, using a mix of traditional and modern equipment and methods. Not all planks were adzed.

6.2.7. Construction

Our understanding of house raising techniques is mainly 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 (e.g. Stewart, 1984). Raising the massive corner posts, eave supports, and ridge supports entailed the efforts of large numbers of people. Gahr (2006) uses two historical accounts of house construction to calculate the number of people needed to erect one dwelling in a single day (Table 6), the practice on some parts of the coast, but seemingly not in the GLCRR. However, the estimates give a sense of the scale of the task and of the cooperative labor pool needed to accomplish it. These can be taken as maximal estimates of the cooperative labor pool. She estimates that one person is needed for every 0.19-0.33 m² of house area. Revised household population estimates based on a floor area/person index for Cathlapotle (Ames, 2008) suggests manpower needs 7 to 12 times greater than household populations (Table 1). Table 6 places Gahr's estimates in context using Lewis and Clark's low and high population estimates for the Wapato Valley (Table 1). While erecting House 4 would have required a majority of the entire Cathlapotle village, House 1 and Meier would draw upon a significant portion of the regional population.

The question arising from this is what are the labor demands if longer than a day in taken to build the house? We answer that question by dividing the median person days for building each house (Table 4) by some proportion of the house populations (Table 1) since not all house members will be involved in house construction. We use Cook's ratio of 1:4 for estimating the proportion of men in North American Native populations between the ages of 15 and 50 (Cook, 1976a, 1976b). It is quite likely that both women and men were members of house building work groups; Cook's ratio is simply a means to make an estimate. Using that ratio, a minimum estimate for Meier is a team of 50 taking 42 (eight-hour) days; Cathlapotle House 1 a team of 38 taking 91 days, and House 4 a team of 10 taking 64 days. We regard these estimates with some

skepticism. Our estimates (Table 4) do not include all tasks, especially moving logs, which took considerable labor, nor splitting and adzing. The size of the needed labor pool would depend on how much time was available to build the house, but, over and above that, certain tasks, such as moving logs, called upon labor beyond the house (e.g. Vastokas, 1966). It is quite unlikely, for example, that 10 people would be enough for the major tasks associated with erecting even a small house such as House 4, which is actually a fairly typical Northwest Coast house in size (Ames, 1996). Finally, as we discuss below, while it is likely that even small households such as House 4 might possess house building/repairing skills, they are unlikely to have had the needed specialists. Thus, while Gahr's figures provide a maximum labor pool estimate, we think they provide a better sense of the needed labor pool than do these minimums. TABLE 6 ABOUT HERE

6.3. Maintenance Phase

At Meier and Cathlapotle, as with many Northwest Coast villages, houses stood for centuries, requiring continual inputs of labor and building materials. At Ozette, many planks bear signs of mending and recycling (Mauger, 1978, p. 92-96). The effort invested in repairing and reusing rather than replacing planks suggests obtaining new ones was difficult and time consuming. Standing remains of a mid-19th century Nuu-chah-nulth plankhouse provides additional data on repair (Smith et al., 2005). Beams not exposed to the ground were in relatively good condition compared to elements in the soil. Corner posts had considerable rot, and building elements needed to be replaced more frequently if they contacted the ground or bore a heavy load. Cutting dates based on dendrochronology suggest elements were continually replaced as they became structurally unsound. In addition to on-going maintenance, there was sometimes need for significant repair and renovation. Cathlapotle Houses 1 and 4 were repaired after suffering major flood damage (Hodges, 2017) and Meier and House 4 had walls moved. Meier and Cathlapotle House 1 each partially burned at least once.

Gahr (2006, p. 73) considers many aspects of plankhouse repair in her analysis of the plankhouse-life cycle, and stresses an "enduring commitment of labor and materials" was required. 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) use excavation data to estimate that each Meier house element, depending on its size, would need to be replaced at a minimum of 5 times over the house's 400 year use-life, and probably closer to 20 times. Shepard (2017) increased the precisions of those estimates by applying information from forestry studies to data from features at Meier and Cathlapotle to estimate replacement rates. We estimate that a plank with base dimensions of 40 cm x 7.6 cm would need to be replaced every 20 years. This figure was used to approximate planking material needed over the houses' existence (Table 7).

TABLE 7 ABOUT HERE

We also estimate material needed for post replacement, although rates of post replacement were more difficult to determine. It is likely that deteriorating posts would be monitored and quickly replaced, as failure in posts and beams (unlike wall planks) could be catastrophic. We used this calculation to approximate the number of trees used over each house's lifespan for repairs, 400 years for Meier and Cathlapotle House 4, and 454 years for Cathlapotle House 1. These calculations yielded a large total number of trees needed for repairs of planks, posts and beams ranging from hundreds of trees for a smaller house to a number potentially approaching 1500 trees for a larger house (Table 8). The annual demand for logs was not high, but the cumulative effect was, and it was ongoing.

TABLE 8 ABOUT HERE

Replacing these elements would entail considerable effort and skill in addition to locating, felling and transporting trees for new posts and planks. Removing and replacing a rotting post from a standing structure is, for example, a difficult task (Reynolds, 1995). The mechanics of replacing a corner post or ridge beam in an inhabited plankhouse would have been challenging. Since the largest 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 - might have been relatively rare in any given house, but needed regularly through-out the valley. 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, especially since they were in an active flood zone. Hearths were continually maintained and cleaned (see Gardner-O'Kearny, 2017). 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.

6.4 Demise Phase

The Meier and Cathlapotle houses were vacated as a result of Euroamerican contact, most likely of the introduced epidemic diseases which decimated the Native population of the GLCRR between the 1770s and the 1830s (Boyd, 2013). Thus there was no demise phase in Gahr's sense (Gahr, 2006). It is possible, in the absence of colonialism and diseases, these houses and households may have persisted for many more years.

7. Structural Continuity.

We use structural continuity as a proxy for the temporal stability of the households occupying these houses, that all of this cumulative labor was fielded by the same, long-lived social entities. Since household groups were inextricably linked to plankhouses, change in the physical house structure would indicate possible shifts in social organization. Structural continuity was measured in three ways: The degree to which structural elements had similar vertical, and horizontal positions through time, and the compass orientations of plankmolds (Shepard, 2017). These analyses were based on fine scale maps. Structural elements generally retained their vertical and horizontal positioning through time in the houses. Conservation of element placement was especially strong in central house areas. The maps did pinpoint 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, where it is possible the house underwent a significant change in length during its lifespan. The Meier house also may have been substantially altered, as evidenced from a wall trench placement indicating that the house was shortened by at least one meter. Its long axis also shifted slightly early in its uselife and a major hearth at its south end was either shifted or expanded midway through the house's use-life (Ames et al., 1992). Plankmold orientations also indicate house structural continuity, although these results were affected by small sample size and possible outliers, which may have inhibited detection of trends. But there are no clear instances of shifting house orientations over time. Overall, evidence of changing house attributes is the exception rather than the norm. Despite some minor modifications, houses were overall remarkably stable in structural appearance over the centuries and many generations, even in the face of fire and flood (see above).

Results of this project strengthen previous assessments (Ames et al., 1992; Smith, 2008) that these 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 (e.g. Grove, 1988, p. 231-239) as well as demographic, economic and technological changes in the protohistoric period (Ames, 2017; Ames and Brown, 2018; Boyd, 1999b; 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.

8. Discussion

8.1 Political economy and social scale

Plankhouse construction and maintenance were complex, demanding tasks, the labor requirements for which often exceeded the capacities of a single household. While the houses were invested with multiple symbolic meanings, at a minimum they represented a household's capacity to field and manage considerable labor and material. They also tangibly represented the scale of the household's social networks since much of the labor, as our estimates show, had to be recruited well beyond the household. Construction of Cathlapotle House 1, and of Meier, may have called upon a significant portion of the regional population. Cathlapotle House 4, on the other hand, was within the capacity of the Cathlapotle village to build. Since these networks were based on reciprocal relationships, houses also embodied the household's obligation to, if nothing else, participate in other house raisings. It is also likely, for reasons discussed below, that households building a house would need to call on others for logs.

It is unlikely this labor was the generalized, unskilled labor envisioned by Erasmus (1965), and Abrams and Bolland (1999); rather we envision it to be the specialized labor described by Stanish (2017). However, we distinguish between skilled and specialized labor. Our conception of skilled labor is that most people are competent in the basic skill sets needed to function well in a particular technology/economy. This accords, for example, with Turner's (2014) description of the knowledge needed to tend and harvest plants being widespread among First Nations people, i.e. it was a skill. Our data for Meier and Cathlapotle show that essentially all technological and production activities occurred throughout all the houses (Ames, 2017;

Smith, 2008, 2015). For example, all household segments hunted terrestrial mammals. However, overlying that was a degree of specialization or at least occupational emphases. Thus, mammal hunting was a particular focus in the southern portions of Cathlapotle House 1 and Meier, while there is no such focus in House 4. We hypothesize that similarly the basic skills needed to build a house were widely shared, but that there were certain skills that were more efficiently deployed through embedded specialization (Ames, 1995) or which required considerable time and energy to acquire. Turner (2014, Vol. 1, 33), for example, observes that people were vigilant about how cedar was harvested, and close attention was paid to "ecological and genetic diversity and spatial variation in populations." This knowledge would be critical for knowing which stands had timber suitable for house construction, which for making canoes, and which for bark harvesting. Expertise in selecting suitable trees beyond this base knowledge would likely be highly prized, given the costs of selecting the wrong tree, in the same way and for the same reasons that expertise in canoe making was highly prized – the high cost of failure (Ames, 2002).

We suspect house-building expertise was available at the regional level, but not necessarily at the household level. Basic house building skills were no doubt well dispersed through the broader community. While each of these three houses were built only once in almost a half-millennium, the Lewis and Clark census (Hajda, 1984) enumerates 154 houses in the Wapato Valley in 1806, some smaller than those analyzed, some much larger, as much as 123 m long. Given that, it is certain that houses were constantly being built and repaired across the valley. Thus basic house building skills had to be common, being called upon somewhere in the valley regularly, although perhaps not regularly in any given household. However, given the volume of materials, the complexity of the tasks, the numbers of people involved, and the need for coordination, expertise beyond basic skills would be necessary. Given that these were ongoing, never ending tasks, specialists are likely, especially given the life span of these houses. Whether this coordination was a task of the household's elite, or construction specialists (or both), we don't know, although it seems likely to have been the job of members of the elite (Ames, 1995) as was pulling in and holding the labor (but see Vastokas, 1966). One of the roles of the GLCCR elites was the cultivation of social ties, sometimes across long distances (Hajda, 1984). Finally, and simply restating much of the foregoing, house building shows how the political economy of some Northwest Coast households extended well beyond the individual household, encompassing significant portions of their region.

8.2 Anthropogenic environments

Considerable attention has been paid to Native management and shaping of Northwest Coast environments (e.g Deur and Turner, 2005). In this literature, ownership and management of cedar stands is mentioned (e.g. Blukis Onat, 2002; Turner, 2014), but, to our knowledge, is nowhere elaborated. We argue that the timber requirements of house construction both shaped cedar stands, and necessitated some form of management, including ownership. House construction obviously required large numbers of logs. Using the median estimates for the number of logs represented by Cathlapotle Houses 1 and 4, the 154 Wapato Valley houses would have required some 3000 to 14,000 trees (Table 3) to build. House repair cumulatively also demanded large numbers of trees, although not on an annual basis for individual structures (Table 8). However, ongoing repair of 154 houses would annually require between 150 and 600 logs. We argue these demands obliged household ownership of cedar stands to ensure access to trees as needed, coupled with forms of cedar silviculture for managing stands to ensure a sustainable supply of appropriately sized and shaped trees. Given the needs for cedar not only for houses, but for ubiquitous and numerous canoes (Ames, 2002), carvings, baskets and other items, it seems highly unlikely that finding appropriate trees was left to chance, particularly in light of the relative rarity of cedar trees (see above) and of the very well documented management of other plants and habitats (e.g. Turner, 2014). Ownership and management of trees and stands would be crucial to sustained use, especially over millennia. One reviewer of this paper raised the possibility of a trade in cedar logs, similar perhaps to the trade in canoe hulls (Ames, 2002) that would have eased potential shortages in logs. While an important possibility, it seems unlikely that would solve the problems of access and sustained use. He also suggested that we overestimate the use of cedar in building these houses, that too is an important possibility, but it does not, to us, reduce the need for an active syliculture. In any case, it is likely that cedars were managed as a "common pool resource" (Ostrom, 1990), that is resources that "generate finite quantities of resource units and one person's use subtracts from the quantity of resource units available to others (Ostrum, 2000, p. 29-30)" with long-term sustainable use the management goal. Defining who has exclusive rights to the resources is fundamental to its management (Ostrom, 2000, Table 1; Trosper 2002). On the Northwest Coast, such rights were usually vested in the household. However, it seems likely that an adequate long-term supply of logs depended on reciprocal ties, especially when a house was built, or major renovations undertaken. It could be argued that managing cedars would be difficult because they are a very long-lived tree. However, cedars are a relatively fast-growing tree, and management no doubt involved shaping the habitat to encourage desired growth characteristics (Blukis Onat, 2002). Still, the temporal horizon of management strategies was certainly decades, if not centuries.

8.3. Property

It is well documented ethnographically that households owned both the structure of their houses and the ground on which they stood. One could argue alternatively that this ownership is a consequence of the enormous investment the houses represent, or that the investment is a consequence of ownership (e.g. Bettinger, 2015). Grier (2014) has recently posited that the property rights along the coast developed hand in hand with environmental management practices. For our purposes, these are chicken-egg arguments. We propose that the presence of these houses, especially those too large for the household itself to build, is *prima facie* evidence for the existence of property rights, both because of the expense of the houses themselves and because their persistence over millennia minimally required ownership and management of cedar stands. Thus, we argue property rights existed on the northern Northwest Coast by 3500 cal BP, with the presence of nulti-house villages with large houses, and on the southern coast by 3500 cal BP with the presence of large post and beam houses.

8.4 Continuity

Our analyses support Drucker's claim that Nuu-Chah-Nulth houses essentially stood from time immemorial. The three Chinookan structures examined in this study stood for 400 or more

years and were abandoned only when their households were swept away by epidemics Otherwise, these houses and households could have persisted much longer. During those 400 plus years, exterior walls were occasionally shifted and in one case (Meier) interior arrangements altered, but the basic frameworks and interior organization of the houses remained unchanged through the on-going replacement of posts and planks. This indicates the durability of both the houses and the occupying Houses. Ames (2006b) suggests that some houses on the coast could persist for a millennium and explores the implication of that. Not all houses were occupied this long. House 2 at the well-documented village of Dionisio Point in the Salish Sea of southwestern British Columbia was occupied for perhaps 200 years (Grier, 2006b), and the coast's archaeological record is replete with abandoned houses and villages. However, given the investment houses and villages represented and the potential long use-life of houses, a decision to abandon was likely just as serious as the decision to build a house.

Continuity extends beyond a particular house. Along much of the Northwest Coast, the interior layouts of houses remained consistent across at least three millennia and some villages were occupied for at least that long if not much longer. The houses in the 2000 year old village near Cathlapotle had the same interior arrangements as the Meier and Cathlapotle houses (Ames et al., 2008).

8.5 Appearance of houses

Archaeological narratives generally speak casually of the first appearance of houses, including large houses. Some houses do represent small investments (e.g. Ellis, 2006), but others require large investments in material and labor well beyond the capacity of the household itself. Large wooden houses, and other wooden structures, also bring in their train other requirements, such as forestry management and control. We do not imply all these things must be in place before large houses could be built, but rather they must develop for the practice to persist. The same sorts of organizational questions need to be asked about the appearance of labor-intensive houses as are being asked about, for example, the construction of large earthen mounds in the Southeastern United States (e.g. Kidder, 2011).

8.6 Monumentality

Archaeological discussions of monumentality inevitably focus on presently visible monuments or ruins, particularly those of stone. We have a strong tendency to privilege stone, even easily worked limestone, over earth, shell or wooden monuments such as wood henges; these are essentially invisible, unless they are still standing and actively maintained as are certain ancient Japanese wooden temples. Otherwise, they rot away, and can be archaeologically invisible, save for some exceptional circumstances, such as the Ozette site. In some instances, the disappearance was intentional. Northwest Coast commemorative ("totem") poles were expected to eventually fall, rot, and disappear, to be replaced with another. As a consequence, we argue, assessments of monumentality tend to ignore or underplay wooden structures, especially domestic ones.

Scholars recognize monuments along at least a couple of dimensions. One, following the OED, is that they be commemorative, of historical significance and enduring. The other is that they represent a great deal of effort and skill; in other words, they have to be monumental. We

have documented the effort and skill invested in Northwest Coast plankhouses in this paper, i.e. their monumentality. However, to reinforce the point, it is useful to compare Northwest Coast houses with monumental stone monuments generally attributed to hunter-gatherers, in this case those at the Anatolian Prepottery Neolithic (PPN) site of Gobekli Tepe. The site is located in south central Turkey and is famous for its symmetrical arrangements of massive, T-shaped limestone monoliths, the most firmly dated examples of which date to ca. 7500 BC (Banning, 2011). The monoliths are incorporated in oval structures about 10x15m in size (Banning, 2011). The excavator, Klaus Schmdt (Banning, 2011; Schmidt, 1998), interprets them as open-air temples while Banning suggests they may be houses, albeit symbolically rich ones. The monoliths are well carved and many bear sculpted images. Banning estimates low and high mass or weight ranges of five of them, which range from 740 to 10,800 kg (Banning, 2011, Table 1) with a median (including both low and high mass estimates) of 5450 kg, or about 5.5 metric tons, which he estimates would require 14 - 17 people to move from the nearby quarry to the building site. At 5.5 metric tons, the wood in the Meier house is equivalent to between 6 and 15 monoliths, depending on whether the house was floored or not, Cathlapotle House 4 to 2 - 5 monoliths and House 1 to 11 - 25 monoliths (remembering our estimates do not include House 1A). The structures illustrated by Banning (Banning, 2011, Figures 2 and 3) have as few as one monolith and as many as 14. Banning's labor estimates do not include preparation of the site, construction of the circumferential walls nor the roofs in his house reconstructions, or the total labor invested in all of the Gobekli Tepe monoliths, so his estimates are minimums. However, a reasonable conclusion is that the costs for the Meier and Cathlapotle houses are at least equivalent to the costs of the individual Gobekli Tepe structures in labor, skill and coordination. They were also equivalent in symbolic content; we know the interiors of Chinookan houses, like all Northwest Coast houses, were spiritually charged; large houses at least had richly carved and painted interiors and were the venues for both quotidian and ceremonial activities. Indeed, Banning uses Northwest Coast houses to illustrate symbolically charged and costly domestic structures. One major difference is that Northwest Coast houses were made of western redcedar and the Gobekli Tepe monuments were of limestone. A second difference is that standing stone monuments do not require the constant input of effort that do wooden ones, effort which would be a continual reminder and renewal of the monument's meaning. A third difference is that once maintenance ceases, wooden monuments rapidly disappear, while stone ones can last millennia.

8.7 Final comments

We warned above against creating false essentialized narratives about the Northwest Coast by weaving together tidbits of information from here and there. How broadly applicable are our results? Our sample is small, three houses on the Lower Columbia River; the Northwest Coast vast, some 1800 km long. House styles and construction details varied along the coast, which would affect estimates such as ours. Ownership practices varied; in parts of the Salish Sea, for example, individual families owned their planks and took them with them if they shifted Houses (Suttles, 1991). However, a number of our conclusions can be safely generalized. Among them are: constructing these houses required significant amounts of material and labor, however apportioned and, irrespective of architectural differences among house styles. The houses were much more similar than they were different. All documentary sources of which we are aware

comment that large numbers of people were required to construct houses. That labor needed to be skilled and some of it specialized. House construction and repair would have significantly impacted local and regional forests, requiring long-term sylvicultural and stand ownership to ensure sustainability. We also suggest our results can be generalized beyond the Northwest Coast, even where wooden structures were not maintained across centuries. For example, hundreds if not thousands of longhouses were built using oak for structural members across Europe during the Linear Bandkeramik (ca 5500-4900 cal BC) and apparently occupied for periods as short as 20 years (Courdat, 2015, papers in Hoffmann and Smyth, 2013). This must surely have affected European forests while the regular shifting and building of new houses imposed collective action problems on Bandkeramik societies. A second example are Cherokee townhouses which were widespread across the southern Appalachian Mountains of the American Southeast (Rodning, 2006, 2009) from the 15th to 18th centuries AD. Townhouses were large wooden public structures central to Cherokee life, fulfilling many of the roles as did plankhouses for Northwest coast societies, including place-making. However, townhouses were regularly destroyed and rebuilt. Rodning (2009) documents six such structures being built at one site during a century or so. This practice again raises issues around collective action and forest management.

9. Conclusions

Household archaeology tends to overlook the building of houses, emphasizing household functions, and households as social process, with house architecture as both reflecting and shaping those processes. However, building and maintaining houses can provide access into the political economies of households, with ramifications well beyond the individual household, as we have shown here for three southern Northwest Coast houses, focusing on material and labor costs. These led us to a range of implications, including collective action; the control and flow of raw materials for house construction; anthropogenic environments; the potential role of elites; generalized, skilled and specialized labor, and the regional scale of pools of labor and skills; large houses as evidence for the existence of property; the long-term social and cultural continuity reflected by these long-lived structures; and the appearance of houses in the archaeological record potentially bringing all of these topics in their train – houses don't just appear. Furthermore, we have argued that Northwest Coast houses should be viewed as monumental architecture and wooden monuments vis a vis stone monuments.

Northwest Coast archaeologists have emphasized subsistence economy both in considerations of what we are calling political economy, but as also a driver of social and economic change on the coast, especially in the development of social complexity, including inequality. They have also focused on the large Northwest Coast household as a central actor in those developments, household size often being attributed to the labor demands of the subsistence economy (e.g. Ames and Maschner, 1999) and as a marker of social inequality. Our analysis is complementary to those approaches by showing what is required to live in a massive wooden house that may stand for centuries. It also shows that the development of sedentism and moving into permanent houses may not be a simple matter of building houses. For the pattern to persist, house building techniques and skills need to be developed and refined, and a political economy evolved that goes beyond putting up stores to the complex tasks of managing the

growth and acquisition of raw materials for houses. Finally, the archaeological record of house construction at Meier and Cathlapotle shows that Drucker and Oberg were spot on in their descriptions of what Northwest Coast house construction and maintenance entailed, but perhaps even more then they, fine ethnographers that they were, understood,

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Entity	Estimate ^a
Meier	203
Cathlapotle Total	666
House 1B	27
House 1C	47
House 1D	77
House 1 Total ^b	151
House 4	38
Wapato Valley Lewis and Clark Low ^c	3400
Wapato Valley Lewis and Clark High	8040

Table 1 Population estimates for various entities discussed in the text.

^a From Ames 2008

^b Excludes House 1A (unexcavated)
^c Boyd and Hajda 1987

	Surface Area (m ²)	Board Feet	
	Range	Range	Median
Meier with floor	1033 - 1158	33,351 - 37,401	35376
Meier without floor	613 - 738	19,789 - 23, 838	21814
Cathlapotle House 4	210 - 277	6775 - 8,946	7861
Cathlapotle House 1B	149 - 199	4798 - 6419	5609
Cathlapotle House 1C	215 - 280	6954 - 9036	7995
Cathlapotle House 1D	320 - 407	10,339 - 13,155	11747
Cathlapotle House 1 Total*	1098 - 1389	38,699 - 44,867	41783

Table 2Square meters and board feet of planked roof, siding and floors, Meier and Cathlapotle.

*Includes six short axis sides representing compartment dividers. Does not include House 1A.

Table 3

Trees represented in initial house construction, Meier and Cathlapotle. The number of trees represented in the Wapato Valley houses was derived by multiplying the median by 154.

	Siding, Roofing and Flooring*	Posts and Beams**	Total	Median	Wapato Valley Houses
	Range	Range		((154)
Meier with floor	29 - 33	22 - 30	51 - 63	57	8778
Meier without floor	17 - 21	22 - 30	39 - 51	45	6930
Cathlapotle House 4	6 - 8	10 - 13	16 - 21	19	2849
Cathlapotle House 1	31 - 39	47 - 63	78 - 102	90	13,860

* Derived from board feet

** Derived from circular wood calculations

Production Step	Specific Task	Meier	Cathlapotle	Cathlapotle
Troduction Step	Speeme Tusk	melei	House 4	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 unknow	own labor estimates	1,412-2,890	371-791	2,158-4,498
Median		2184	606	3419

Table 4 Person Days associated with house construction tasks.

Table 5 Weight of Wood Material in Metric Tons Needed for Initial Construction, Meier and Cathlapotle.

	Planks for Siding	Posts and Beams	Total	Median
	Range	Range		
Meier with floor	47 - 53	6 - 31	53 - 84	69
Meier without floor	28 - 34	6 - 31	33 - 65	49
Cathlapotle House 4	10 - 13	4 - 16	13 - 29	21
Cathlapotle House 1	50 - 63	12 - 72	65 - 135	100

Table 6

Gahr's estimates of single-day house raising, Meier and Cathlapotle. The low labor estimate is based on 1 person/.19 m² of floor area; the high labor estimate on 1 person/.33 m² floor area (Gahr 2006). See text for discussion on Lewis and Clark's low and high population estimates.

House	Floor Area (m ²)	Low Labor Estimate (Number of People)	High Labor Estimate (Number of People)	% Lewis and Clark Low Population Estimate	% Lewis and Clark High Population Estimate
Meier	420	1,273	2,211	42-72	16-28
Cathlapotle House 1	658	1,994	3,463	65-113	25-44
Cathlapotle House 4	132	400	695	13-23	5-9

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

Total T failing Treeds	ioi ilouse Ellespu	11 (11 uiib, 11001 u
	Board	Feet
	Low Range	High Range
Meier with floor	667,024	748,012
Meier without floor	395,771	476,759
Cathlapotle House 4	135,497	178,924
Cathlapotle House 1	878,461	1,018,470

Table 7 Total Planking Needs for House Lifespan (Walls, Roof and Floor), Meier and Cathlapotle.

	Trees represented siding, roofing and flooring	Trees represented in posts and beams	Total	Median	Logs/Year
	Range*	Range**			
Meier with floor	595 - 666	137 - 625	732-1292	1012	3
Meier without floor	353 - 425	137 - 625	490-1051	770	2
Cathlapotle House 4	116 - 153	39 - 242	155-395	275	1
Cathlapotle House 1 Total	764 - 885	260 - 1395	1024-2280	1652	4

Table 8Numbers of Trees Needed for Replacement of Planks and Posts over the House's Lifespan.

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

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Figure 1 Idealized interior of a Meier/Cathlapotle house. Not to scale; actual pit complexes, for example, are 1 to 2 m deep. Original drawing by Cameron McP. Smith.

Figure 2 Map of the Greater Lower Columbia River Region showing sites mentioned in the text and the location of the Wapato Valley (aka Portland Basin).

Figure 3 Cathlapotle showing positions of houses and excavation units.

Figure 4 Meier showing position of house and excavation units.

Figure 5 Structural features, Cathlapotle House 1.

Figure 6 Structural features Cathlapotle House 4.

Figure 7 Structural feature Meier House.