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Source: *American Antiquity*, Vol. 70, No. 2 (Apr., 2005), pp. 267-293
Published by: Society for American Archaeology
Stable URL: http://www.jstor.org/stable/40035704
Accessed: 17/03/2010 02:18

# CLIMATE CHANGE AND CULTURE CHANGE ON THE SOUTHERN COAST OF BRITISH COLUMBIA 2400–1200 CAL. B.P.: AN HYPOTHESIS

Dana Lepofsky, Ken Lertzman, Douglas Hallett, and Rolf Mathewes

*The Marpole phase of the Gulf of Georgia, SW British Columbia (2400–1200 cal B.P.) is recognized by many archaeologists as a significant period of culture change. Concurrent with this cultural phase is a climatic regime characterized by a substantial increase in forest fires associated with persistent summer drought: the Fraser Valley Fire Period (FVFP). Culturally, the Marpole phase is characterized by the widespread appearance of large houses, standardized art forms, and elaborate burials. Interactions among people of this region intensified and were, as today, economically, socially, and ideologically linked to the lower Fraser River system. Ecologically, the FVFP likely resulted in a regional decline in salmon abundance and/or predictability, especially in small streams and offshore areas, but also more berries and wildlife, and easier overland access via trail networks. The ecological diversity of the lower Fraser region, both terrestrial and riverine, resulted in both more abundant and more predictable resources than surrounding areas during this period of changing climate. We hypothesize that social and economic networks throughout the Gulf of Georgia were solidified during the Marpole phase to ensure access to Fraser resources and allow social buffering of resource uncertainty. We suggest that the differential availability of resources also allowed and encouraged individuals who had access to Fraser Valley resources to gain relatively greater prestige.*

*La Fase Marpole del Golfo de Georgia (2400–1200 cal a.P.) en el Suroeste de British Columbia, Canadá, se reconoce por muchos arqueólogos como un período de cambio cultural importante. Contemporáneo a esta fase cultural, hubo un régimen climático caracterizado por un incremento substancial de incendios forestales asociados con sequías veraniegas persistentes: el llamado Período de Fuego del Valle Fraser (FVFP). Culturalmente, la Fase Marpole se caracteriza por la amplia aparición de casas grandes, formas estandarizadas de arte y entierros elaborados. Las interacciones entre la gente de esta región se intensificaron y estuvieron, como hoy día, económica, social e ideológicamente relacionadas al sistema del Bajo Río Fraser. Ecológicamente, el FVFP pudo ocasionar una disminución en la abundancia y/o predictibilidad del salmón, especialmente en arroyos pequeños y en áreas mar adentro, pero tambien un incremento en bayas y vida silvestre, así como un acceso por tierra más fácil a través de una red de senderos. La diversidad ecológica de la región del Bajo Fraser, tanto terrestre como ribereña, resultó en una mayor abundancia y predictibilidad de recursos que en áreas circunvecinas durante este periodo de clima cambiante. Tenemos la hipótesis de que las redes sociales y económicas en el Golfo de Georgia se solidificaron durante la Fase Marpole para asegurar el acceso a los recursos del Fraser y permitir un amortiguamiento social ante la incertidumbre de recursos. Sugerimos que la disponibilidad diferencial de recursos también permitió y promovió que los individuos que tenían acceso a los recursos del valle del Río Fraser obtuvieran un relativo mayor prestigio.*

While human societies are always influenced by their surrounding natural environments, understanding the nature and extent of this influence on past societies has never been straightforward. In the past few decades, archaeologists have moved away from casting the environment as a major driver of social change to affording it a relatively minor explanatory role. Environmentally based models fell out of favor in part because of the plethora of deterministic models that did not recognize the potential for ancient people to choose among a range of responses to environmental shifts (Brumfiel 1992). The disfavor was further compounded by the fact that the

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American Antiquity, 70(2), 2005, pp. 267–293

distinction between cause and correlation in relations between culture and climate was often not clearly made. In addition, researchers became frustrated with the loose fit between regional-scale paleoenvironmental data and shifts observed in local-scale archaeological sequences. Finally, differences in the resolution of the paleoenvironmental and archaeological chronologies further added to the lack of confidence in environmental change as an explanatory factor (e.g., comments in Jones et al. 1999).

In recent years, environmentally based explanations for culture change have seen some resurgence in the North American archaeological literature (e.g., deMenocal 2001; Haug et al. 2003; Jones et al. 1999; Sandweiss et al. 1999). This is in large part because of the burgeoning of the various techniques that allow spatially and temporally detailed paleoecological and paleoclimatic reconstructions. Archaeologists have increasingly paired with experts in "paleo-disciplines" to develop paleoenvironmental sequences that are appropriate to particular archaeological times and places (e.g., Hutchinson and McMillan 1997; Moss et al. 2005). Further, as a discipline, we have become more sophisticated in formulating models of culture change that mesh the roles of environmental variability with those of cultural choices (e.g., Dahlin 2002; McGovern 1994; Rosen 1995; Williams 2002).

Making the case for a causal relationship between changes in environment and culture is difficult because it requires demonstrating why people responded to particular environmental shifts. For instance, pre-existing cultural practices such as long-term food storage can buffer negative environmental shifts that are short-lived, infrequent, or mild in their effects such that there is no apparent cultural "response" (Testart 1982). Further, minor cultural adjustments to environmental shifts, especially if they are also short-lived, are less likely to manifest in the archaeological record. Long-term, sustained changes in the environment, particularly if they affect critical resources detrimentally, are both more likely to engender immediate and major cultural responses and are more easily detected by archaeologists. Such detrimental effects to resources are most likely to occur in extreme environments, such as deserts (e.g., Stine 2000). In temperate regions, however, even climatic shifts of long duration may result only in subtle changes to the distribution of resources, which may not have prompted changes in human behavior that left an archaeological imprint.

Potential responses to *increased* environmental productivity are equally varied. Since actions under such circumstances are not driven by concerns of immediate survival, there may be a lag time in responses, or people may choose not to change behavior at all. Conversely, an upturn in environmental conditions can provide the context for significant social changes, such as the emergence of social complexity (e.g., Price and Feinman 1995). Experimentation, intensification of resource production, and increased competition are among the specific cultural responses which have been linked to positive environmental shifts (Cannon 1996; Clark and Blake 1994; Hayden 1995; Prentiss and Chatters 2003).

Finally, given that most preindustrial landscapes are ecologically complex, climatic shifts likely resulted in diverse ecological responses that were stratified over the landscape mosaic. Both positive and negative changes to resource availability for ancient peoples are likely to be found in different locations within a single landscape. For instance, a warming and drying trend may reduce the productivity of low-elevation streams at the same time as it makes nearby high-elevation resources more available and productive. Teasing out the diverse cultural responses requires detailed ecological reconstructions coupled with independent data about the relative importance of various resources in past social and economic systems.

On the Northwest Coast of North America, several researchers have proposed that environmental shifts played a major role in cultural development at various times in the past. Not surprisingly, the environment is a significant component of models about peopling of the region in the early Holocene (e.g., Fladmark 1975; Matson and Coupland 1995:59–65). For the mid-Holocene, Fladmark (1975) proposed that stabilization of sea level and climate, coupled with an expansion of riverine and littoral resources, were central to the development of complex Northwest Coast cultures. The precise timing and ecological details of his model have not held up (Moss et al. 2005), but there does appear to be a relationship between mid-Holocene climate and culture change (Prentiss and Chatters 2003).

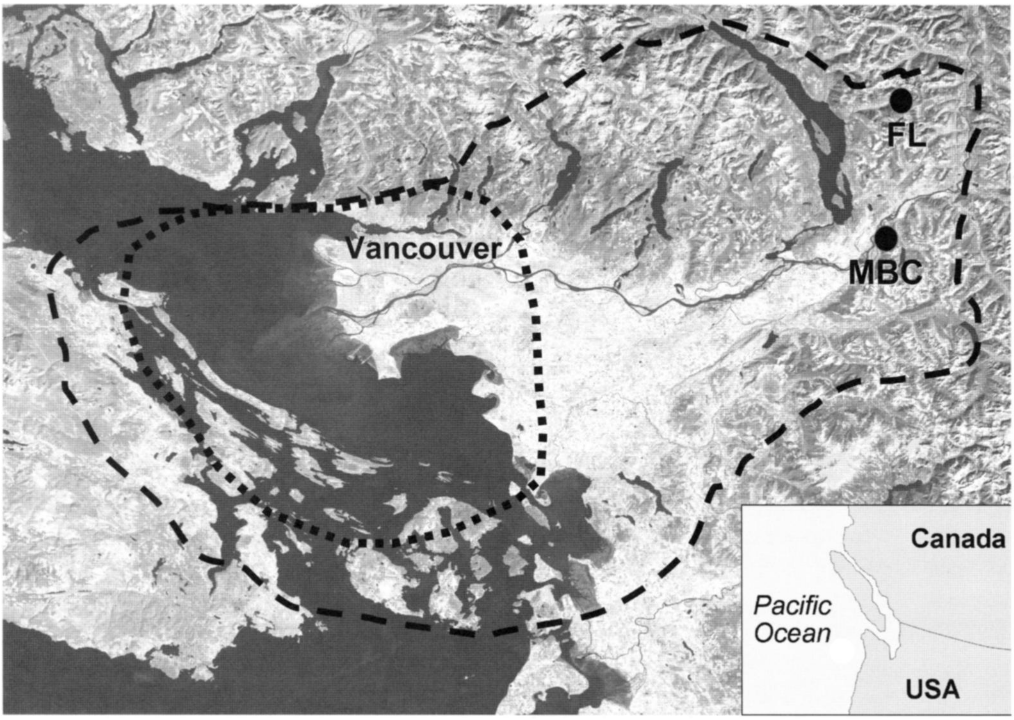


**Figure 1. Gulf of Georgia region (coarse dashed line) showing two study sites where paleoecological data were collected (FL = Frozen Lakes, MBC = Mount Barr Cirque). The finer dasher line delimits the general location of archaeological sites with confirmed Marpole components (after Clark 2000). Image downloaded from ftp://ftp-geogratis.ccrs.nrcan.gc.ca/.**

Of particular importance was the mid-Holocene establishment of western redcedar, without which many aspects of Northwest Coast culture would not have been possible (Hebda and Mathewes 1984). Finally, pertaining to more recent prehistory, Mitchell (1971:71) suggested that a shift to cooler, moister climate was in part responsible for the cultural florescence characteristic of the Marpole phase, and Clark (2000) posited that this cultural shift was caused by a major earthquake. While we differ with these latter researchers in our interpretation of the paleoecological record, we also see a link between culture and environmental change during the Marpole phase, our focus in this paper.

We will explore the relationship between culture and climate change in a spatially and temporally defined area: the Gulf of Georgia region in southwestern British Columbia, from 2400–1200 cal B.P. (Figure 1). The Gulf of Georgia is one of the best-documented regions in the Northwest Coast, and the Marpole phase is probably the most-studied phase in the Gulf of Georgia. Archaeologists have long recognized the distinctiveness of the phase (Borden 1950, 1951; Carlson 1960) and considerable attention has been paid to understanding its development. Many researchers equate the Marpole transition with the development of complex socioeconomic systems similar to those observed among early historic Northwest Coast societies (Burley 1980; Matson and Coupland 1995; Mitchell 1971; cf. Carlson 1991). Though aspects of social and economic complexity are found in earlier phases, it is not until the Marpole phase that there is widespread evidence of status ascription, specialization, multifamily houses, and well-developed art forms linking the people of the Gulf of Georgia region into a tightly integrated social and economic system (Grier 2003).

Our recent paleoecological work in the lower Fraser Valley, in the eastern Gulf of Georgia region, resulted in the identification of a dry, and possibly warmer, climatic period temporally coincident with the archaeologically defined Marpole phase, ca. 2400–1200 cal B.P. Elsewhere we have named this period of climate change the "Fraser Valley Fire Period" because of the increased incidence of wildfires during that time (FVFP; Hallett 2001, Hallett et al. 2003). Here, we hypothesize that the social and economic changes associated with the Marpole phase are linked to the climatically driven environmental shifts associated with the FVFP. During this time, we believe forest fires and the sustained summer droughts associated with them shifted the availability of many resources important to the people of the Gulf of Georgia region. In particular, the ecologically diverse landscapes of the Fraser Valley would have emerged as a source of relatively more abundant, accessible, and predictable resources than elsewhere in the Gulf of Georgia region. We suggest that the intensification of regionalized social and economic relations during the Marpole phase is related to people elsewhere in the Gulf of Georgia region seeking to strengthen their bonds with those who have access to the ecologically productive Fraser system.

In this paper, we outline the components of our hypothesis linking culture and climate change during the FVFP and the Marpole phase. First, we describe briefly the social and economic characteristics of the Marpole phase. This is followed by a review of other models proposed to understand the development of the Marpole phase. We then describe the FVFP, its associated ecological changes, and our hypothesized linkages between these changes and the social and economic systems of the Gulf of Georgia peoples. We end with testable predictions that allow our model to be evaluated with archaeological and paleoecological data.

## The Marpole Phase

### *Spatial and Temporal Context*

The Marpole phase was a highly localized phenomenon, centered on the southern Strait of Georgia (southeast Vancouver Island, the southern Gulf Islands, and the lower reaches of the Fraser River; Figure 1; Burley 1980; Matson and Coupland 1995; Mitchell 1971). Until recently, sites on the southernmost tip of Vancouver Island were also included in the distribution, but a re-analysis of Marpole-aged assemblages demonstrates that these sites are distinct from Marpole (Clark 2000). Some researchers also include sites throughout the Fraser Valley, but the absence of preserved bone and antler, the presence of different raw materials (e.g., quartz), and a generally less well-known archaeological record there, hamper our ability to compare these assemblages with the core Marpole area. Though we focus our discussion here on the better-known Strait of Georgia Marpole sites, the archaeological data we do have (Lepofsky et al. 2000) suggest the social and economic relations associated with the Marpole phase also encompassed the people of the mid- and upper-Fraser Valley.

Our current understanding suggests the Marpole phase dates between 2400 and 1200/1000 cal B.P. Although many archaeologists use the date of 2400 radiocarbon years B.P. for the break between Marpole and the preceding Locarno Beach phase (e.g., Matson and Coupland 1995), a recent reanalysis suggests that the break may be closer to 2200 radiocarbon years B.P. (Clark 2000, figure 7.2), or 2400 cal B.P. (Figure 2a, 2d). Researchers place the termination date of Marpole between 1500 and 1000 radiocarbon years B.P. (e.g., Burley 1980; Matson and Coupland 1995; Mitchell 1971; Thom 1995). The difficulty in assigning a distinct end-date is largely due to the fact that many of the artifactual trends observed in Marpole (e.g., the reduction of chipped stone and the concomitant increase in bone tools) continue without a break into the subsequent phase (Matson and Coupland 1995:518). The problems of multiple intercepts in $^{14}C$ calibration and large standard deviations on the original radiocarbon determinations further compound the problem. Our calibration of radiocarbon dates from secure Marpole sites (from Clark 2000) suggests that the number of Marpole sites drop off after 1250 cal B.P. (Figure 2a, 2d). By 1000 cal B.P., distinctly different styles and abundances of artifacts, and especially burial practices (Thom 1995), are evident.

### *Ecological Context*

A remarkable portion of the entire range of ecological variation of Pacific Northwest ecosystems is represented along physiographic and topographic gradients within the Gulf of Georgia. The combination of the Strait of Georgia lowlands and the mix of ecosystems in the Fraser Valley represent a range of ecological diversity and a concentration of resource opportunities for First Nations almost without equal on the west coast of North America.

Within the Gulf of Georgia, the lower Fraser watershed stands out for its ecosystem diversity. In

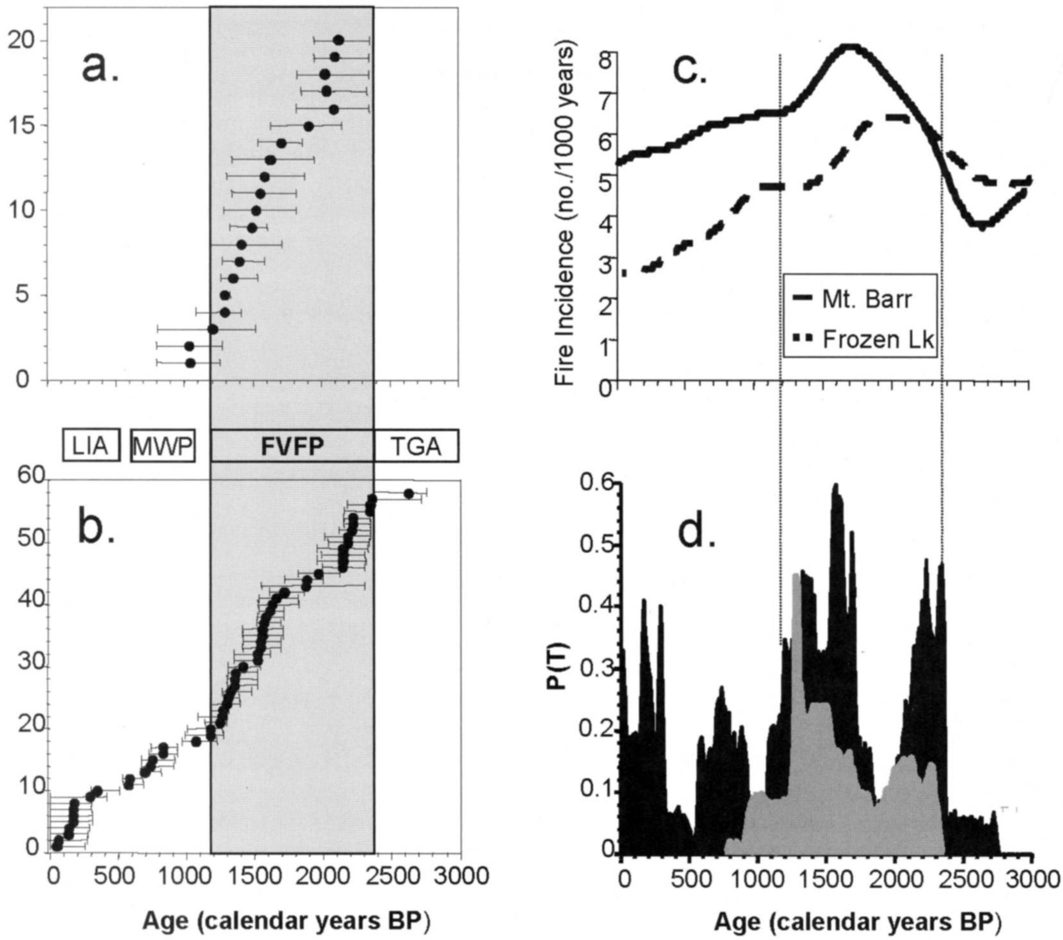


**Figure 2. Relationship between calibrated radiocarbon ages during the FVFP and the Marpole phase. (a) Middle intercept age and 2-sigma error bar range of confirmed Marpole sites (based on Clark 2000). (b) Middle intercept age and 2-sigma error bar range of soil charcoal ages from Frozen Lakes and Mt. Barr Cirque paleoecological sampling sites (from Hallett et al. 2003). LIA = Little Ice Age, MWP = Medieval Warm Period, FVFP = Fraser Valley Fire Period, and TGA = Tiedemann Glacial Advances. FVFP is highlighted bar connecting figures a and b. (c) Estimated fire incidence from Mt. Barr and Frozen Lakes based on lake sediment charcoal accumulation rates (Hallet et al. 2003). Note high fire incidence during the FVFP. (d) Summed probability (2-sigma range) plots of radiocarbon ages from confirmed Marpole sites superimposed over the paleoecological soil ages from Frozen Lakes and Mt. Barr Cirque. Dashed parallel lines joining figures c and d denote the FVFP. All dates have been calibrated using Calib 4.3 (Stuiver et al. 1998).**

the Gulf of Georgia as a whole there are 13 Biogeoclimatic variants, representing five Biogeoclimatic zones (of 14 zones in the Province as a whole).[1] Eleven of these variants occur on the mainland between the Fraser estuary and the mountain ridges of the eastern Fraser Valley, and eight are unique to this area within the region. Only two variants are found on the Gulf Islands and none are unique to that part of the Gulf of Georgia. On the coastal lowlands of eastern Vancouver Island, five variants occur and two occur there uniquely within the region (BC Ministry of Forests Map of BEC Units for Vancouver Region). Thus the lower Fraser Valley contains a broad sample of the total ecosystem diversity of the region as a whole, including significant elements of ecological variation that, within the region, are unique to the Fraser Valley. The Fraser Valley is more than twice as diverse as southeastern Vancouver Island, the next largest physiographic unit in the region.

At low elevations from the Southeast coast of Vancouver Island through the Gulf Islands, summer drought is prominent and ecosystems are similar to those to the south in Oregon and Washington, with fire or drought-tolerant species such as Douglas-fir, Garry oak, and arbutus being common (Meidinger and Pojar 1991). On the adjacent mainland, the Fraser River Delta and lower Fraser Valley represent an ecologically rich, fluvial landscape almost entirely dominated in the past by floodplain dynamics of the Fraser River. Marshes and sloughs are common and, in the past, substantial areas were flooded seasonally. These ecosystems provided the Coast Salish with a diverse range of important plant resources such as wapato, cattail, and bog cranberries.

The Fraser Valley is bordered by the Coast Mountains to the north and the Cascade Range to the south, with summits reaching over 2000 m. At low elevations, these mountains are dominated by Douglas-fir and other species of the seasonal rainforest (Pojar and MacKinnon 1994). Because of strong orographic precipitation gradients, mid- to high-elevation forests on these mountains exhibit the true-fir, cedar, and hemlock dominated rainforests characteristic of the cool, wet rainforests of the coast farther north. At higher elevations, closed canopy subalpine forest grades into a subalpine parkland with abundant berry-producing shrubs that were important as both wildlife habitat and food for ancient peoples (Lepofsky et al. 2005).

The Fraser is one of the largest river systems in North America, draining an area of roughly 250,000 $km^2$. This drainage basin occupies almost a quarter of the British Columbia landmass, and the Fraser Valley thus reflects the hydrological and ecological processes of a large portion of Northwestern North America. The Fraser is the most productive salmon river in the world, with all five species of Pacific salmon and many other species, such as sturgeon, utilizing it (Northcote and Larkin 1989). The Fraser Valley sees the passage of an enormous number of fish destined for spawning grounds dispersed through much of the interior of the province. For instance, of the 158 distinct stocks of sockeye salmon breeding in the Fraser System, only 14 spawn in tributaries arising in the Fraser Valley, while the remainder pass through the Fraser Valley on their way east and north (Schubert 1998). These stocks exhibit substantial variation in run timing, from spring to late fall, and thus in their susceptibility to seasonal fluctuations in water levels and temperatures (Hodgson and Quinn 2002). Historic run sizes were enormous: dominant sockeye runs prior to 1913 were estimated to be about 100 million fish, and still today, during peak season, up to 20 million salmon of various species are present in the Fraser estuary. Faunal diversity is not limited to fish; the Fraser estuary is also a globally significant wintering and staging area for waterfowl and shorebirds.

### *Cultural Context*

Historically, as today, the Halkomelem speakers of the Coast Salish of Vancouver Island, the Gulf Islands, and the Fraser River were linked through language, exchange, kinship, ritual, and mythology (Carlson 2003). For many, access to the abundant resources of the Fraser Valley, in particular the immense salmon runs and wapato tubers, was a fundamental component of the regional economic and social system (Barnett 1955; Carlson 2003; Duff 1952:25; Mitchell and Donald 2001; Suttles 1987a, 1987b, 1987c, 1990, 1998). Yearly, hundreds of people from Vancouver Island with familial connections to people in the Fraser Valley traveled to the valley to harvest the diverse resources there (Brown 1996; Carlson 2003). This upriver movement of people is reflected in the island dialect of Halkomelem, which is a mixture of the two Fraser Valley dialects (Carlson 2003).

Several scholars have suggested that the strong social connections among historic Coast Salish groups were a means to level out disparities in regional resource availability (Carlson 2003; Miller 1989; Suttles 1987b, 1987c, 1987d, 1987e). These disparities were both ecologically and socially based. Ecologically, there were significant differences in temporal and spatial availability of resources, with some areas being consistently more reliable and abundant sources of foods (Carlson 2003; Suttles 1987d; see also above). Further, during the historic period, the most productive of the resource harvesting sites were owned and controlled by elite who managed the resources for families, settlements, or tribes (Carlson 2003; Suttles 1987c). People with blood or marriage relations to the owners of these resource sites were given preferential access to the resources within, while those without such familial connections were forced to acquire nonlocal foods through trade (Carlson 1997, 2003). In addition to redistributing unevenly distributed resources, the sharing of food both cemented family relations across the Gulf of Georgia region and increased the prestige of household heads who could produce enough food to meet these social obligations (Elmendorf 1971; Suttles 1987b).

Many researchers assert that various elements of the complex social and economic relations observed among the historic Coast Salish peoples, though present in isolated instances prior to this time, became fully developed during the Marpole phase (Burley 1980; Grier 2003; Matson and Coupland 1995; Mitchell 1971; cf. Carlson 1991). During the Marpole phase there is widespread evidence of status ascription in the burial record (Burley 1980, 1981; Burley and Knusel 1989; Matson and Coupland 1995; cf. Arcas 1999; Carlson 1991; Carlson and Hobler 1993; Curtin 1991) and specialization in items such as heavy-duty wood working tools, finely crafted baskets, and zoomorphic and anthropomorphic stone and antler sculptures (Bernick 1998; Duff 1956; Holm 1990). While the preceding Locarno Beach phase (3500–2400 B.P.) typically has little evidence of such developments, elaborate burials at two ca. 4,000 year-old Gulf of Georgia sites (Arcas 1999; Carlson and Hobler 1993; Curtin 1991) indicate that the widespread status differences and craft specialization present in Marpole had its roots in some older Gulf of Georgia communities. In the Late phase following Marpole (1200 B.P.–contact), there appears to be a decline in the number and kind of elaborate goods used as a yardstick to evaluate social complexity. This is likely due in part to shifts away from below-ground burials to above-ground interments, which are less likely to survive in the archaeological record. However, such a shift in burial practices (which occurs Coast-wide) also likely reflects a fundamental reorganization of the social system in the Late phase.

An important development associated with the Marpole phase is the appearance of the large, multifamily houses and multihouse settlements characteristic of the Coast Salish in the Historic era (Grier 2001, 2003). Though some of the oldest houses on the Northwest Coast are located in the Fraser Valley (Mason 1994; Schaepe 1998, 2003), houses and settlements remain relatively small until the Marpole phase. The appearance of large houses and villages during Marpole times indicates the reorganization of labor into larger social groups, possibly including slaves, and likely reflects shifts in the production and control of resources by those groups (Ames 1994, 1995; Grier 2003). The large houses may also mark concomitant changes in authority over household labor associated with the emergence of ranking (cf. Arnold 1993).

Regional similarities between artifact assemblages and the presence of traded goods and shared symbols indicate that the social and economic links between people of parts of southeast Vancouver Island, the Gulf Islands, and the lower Fraser River may have become solidified during Marpole times (Brown 1996; Burley 1981; Duff 1956; Grier 2003). Some stylistic expressions of these intra-regional linkages existed prior to Marpole. Most notable are the lip plugs (labrets) and other adornments for the face (fondly referred to as "whatzits" or "Gulf Island Complex," Dahm 1994), which were likely markers of social distinction. During Marpole, however, these regional connections became stronger and perhaps more circumscribed regionally. This regionalization is clearly reflected in the sophisticated Marpole art and basketry, which tends to be standardized across the region and contains many styles unique to the Marpole phase (Bernick 1998; Holm 1990). Some of these objects likely reflected the high status of the owner (Holm 1990) and served to integrate the elite in social, and perhaps political, regional networks (Brown 1996; Grier 2003). The strong regional integration of the Marpole phase is also indicated by the decline in the long-distance exchange of obsidian (Carlson 1994) and the concomitant increase in the lower-grade, but locally available Garibaldi obsidian (Carlson 1994; Reimer 2003). Grier (2003) posits that access to and control over Fraser River salmon by the elite, particularly of large households, is an important feature in the sociopolitical cohesion of Marpole times.

Many researchers (Burley 1980; Croes and Hackenberger 1988; Matson 1983, 1992; Mitchell 1971) have hypothesized the importance of salmon in Marpole phase economies. Unfortunately, there are few faunal studies that actually track shifts in animal resources through time (Cannon 1996:27). The available data do demonstrate the importance of salmon, as well as many other marine and terrestrial animal resources (Matson and Coupland 1995:223–224; Grier 2003; Burley 1980:55–57; cf. Driver 1993). A shift to thinner ground-slate knives during Marpole was thought to represent a

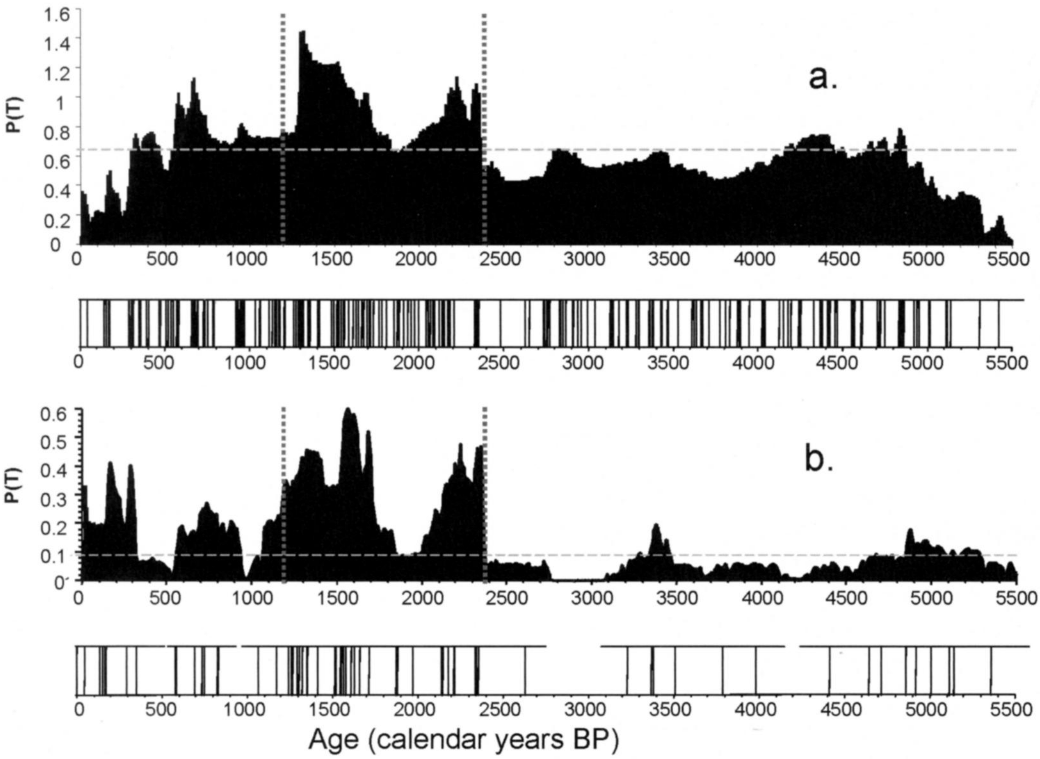


**Figure 3. Comparison of late Holocene soil charcoal dates from paleoecological sampling sites and dates archaeological sites in the Gulf of Georgia region where Marpole sites are found. Vertical grey lines in Figures a and b represent boundaries of the FVFP (see figure 2). (a) Calibrated radiocarbon dates of archaeological sites from the Canadian Archaeological Radiocarbon Database (CARD), compiled in 2001 (N = 345). Upper figure: Summed probability plots (2-sigma range). Bottom figure: midintercept ages (vertical bars) with their 2-sigma age range (horizontal bars). To avoid overrepresentation of sites with many radiocarbon determinations, only one radiocarbon date was used from each site per 200-year interval. In cases where a site had more than one determination from a single interval, we selected the determination with the smallest standard deviation. Although this figure includes all dated sites, not just those that have been definitively placed in the Marpole phase, the occupants of these sites were likely involved in the same social and economic networks. Note the similarity in shape of the curve of definitive Marpole sites (Figure 2d) and all sites in this figure. Dashed horizontal line on upper figure represents mean P(T). Note that during the FVFP, there are more dated sites than the mean. (b) Composite charcoal AMS ages showing fires in the Fraser Valley mountain hemlock sites (N=73). Upper figure: Summed probability plots (2-sigma range). Bottom figure: midintercept ages (vertical bars) with their 2-sigma age range (horizontal bars). Dashed horizontal line in upper figure represents mean P(T). Note that during the FVFP, there are more fires than the mean. All dates have been calibrated using Calib 4.3 (Stuiver et al. 1998).**

shift to more efficient processing of salmon (e.g., Mitchell 1971), but recent experiments demonstrate that there is no advantage over thicker knives (Morin 2004). Rather, the shift to thin knives may reflect the importance of finely crafting certain tools during the Marpole phase—especially those associated with economically and/or socially important resources, such as salmon. No data are available to assess the importance of plant resources (Lepofsky 2004), but based on the ethnographic literature (e.g., Barnett 1955; Suttles 1951), we expect a range of plant resources to have also been critical to the diet. In particular, carbohydrate-rich root foods, such as camas bulbs that grew prolifically on the Gulf Islands and eastern Vancouver Island, and wapato tubers that were abundant in freshwater marshy areas in the lower Fraser Valley, would have been essential components of the diet.

The distinctiveness of the Marpole phase may also be reflected in shifting settlement patterns. Our analysis of the number of dated sites in the Gulf of Georgia revealed a dramatic increase in the number of sites at the beginning of the Marpole phase (Figure 3a). These data may indicate an increase in population, and/or that people were more widely dispersed across the landscape. Several researchers have also suggested (after Mitchell 1971) that a supposed shift in the location of sites to the Fraser River during the Marpole phase reflects an increased importance in Fraser River salmon, but scrutiny of the current settlement data (as presented in Clark 2000 and Matson and Coupland 1995) does not indicate a shift in the location of sites. There may be a shift in the location of certain site types (e.g., short-term camps or villages), but the settlement data have not been analyzed in sufficient detail to evaluate this. More detailed analyses of the distribution of site types across the landscape, and changes in this distribution through time, are needed to fully evaluate these ideas.

Finally, Coast Salish oral traditions may provide additional details about the nature and development of social complexity among Marpole communities. A central element of Stó:lō (the Coast Salish of the Fraser Valley) transformation narratives are the "sky people" (*tel swayel*)—the people who came from above and are the first ancestors of permanent settlements and tribal territories. The appearance of the large settlements described in the transformer stories is one of the defining features of the Marpole phase. Among the Stó:lō, the status of male elites in each settlement was linked directly to the ability to trace ancestry to these First People (Carlson 2003). Also central to these oral traditions are "worthless people," who are born of the union between elite men and slave women (Carlson 2003). Thus, these narratives may provide insights into the origins of class and gender-based status differences in these early communities.[2]

## Previous Explanations for the Marpole Phase

Because of its archaeological distinctiveness, and its potential for helping understand the evolution of social complexity on the Northwest Coast, several researchers have attempted to explain the social and economic developments associated with the Marpole phase (Table 1). Space does not permit a detailed review of these models here (refer to Ames 1994; Clark 2000; Matson and Coupland 1995). Instead, we briefly review some commonalities among them.

In all models, the intensive exploitation of Fraser River salmon is considered one of the defining features of the Marpole phase (Table 1). The shift to intensive salmon exploitation, either to offset the decline of other resources (Croes and Hackenberger 1988; Mitchell 1971) or to compensate for declines in salmon species per se (Clark 2000), the labor organization required to harvest and process salmon (Burley 1980), the control over salmon surpluses (Grier 2003), and differential access to abundant stocks (Matson 1983, 1985), have all been cited as central to increased social and economic complexity during Marpole. Unfortunately, with the exception of the Hoko River site (Croes and Hackenberger 1988), the faunal data offer only weak support for the supposition that salmon were more central to people during the Marpole phase than during preceding times. Direct evidence in general is sparse but indicates that a wide range of resources was used during Marpole times, though salmon was undoubtedly critical among them (Cannon 1996). The fine ground slate knives discussed above are an example of indirect evidence for the importance of salmon.

All models but Matson's explicitly provide a reason for the timing of the development of the Marpole phase. Mitchell (1971) posits that a supposed shift to cooler climates was linked to socioeconomic changes during Marpole; however, recent paleoenvironmental data show no evidence of this cooling trend (see below). Clark (2000), on the other hand, hypothesizes the mega-thrust earthquake reported by Mathewes and Clague (1994) was responsible for the Marpole phase, but, the earthquake is not precisely dated, nor is it likely to have had a sufficiently widespread ecological impact (John Clague, personal communication 2002). Croes and Hackenberger (1988), on the other hand, based on a model of exponential rise in population throughout the Holocene, posit that population pressure prompted the intensification of salmon harvesting that in turn increased regional carrying capacity. While our proxy data of population in the Gulf of Georgia (Figure 3a) do not prove that population is a causal factor in Marpole socioeconomic systems, they are consistent with the idea that increasing population is correlated with other social processes during this time. Finally, Burley (1980) argues that it was the diffusion of technological knowledge to store salmon that spurred social changes on the coast. However, there is every reason to think that the knowledge to

Table 1. Summary of Explanations for the Marpole Phase.

| Reference | Summary of Model | Evaluation |
|---|---|---|
| Burley (1980) | Salmon storage technology developed inland and diffused to coast. Status ascription developed out of need for complex labor organization associated with mass harvest and storage of salmon. | Storage technology on coast likely ancient. Status elite not needed for salmon production. |
| Clark (2000) | Mega-thrust earthquake ca. 2000 B.P. (Mathewes and Clague 1994) caused a decline in Fraser River salmon. To compensate, people intensified salmon production and increased trade. Status differences resulted from differences in access to resources. | Evidence for intensification of salmon is weak. Mega-thrust earthquake not precisely dated nor likely to have had a widespread ecological impact (J. Clague, personal communication 2002). Marpole transition may be closer to 2200 B.P. |
| Croes and Hackenberger (1988) | Exponential rise in south coast populations beginning around 4000 B.P. High populations in Marpole, coupled with depletion of other resources, led to increasing harvests and storage of salmon to increase carrying capacity. | Faunal record shows increased use of salmon at Hoko River site, on which the model is based, but not at other Marpole sites. Increase in population at Marpole transition may be supported by proxy data. |
| Matson (1983, 1985), Matson and Coupland 1995) | Transition to Marpole hinges on the exploitation of salmon, as a predictable, reliable, dense resource Sedentism linked to resource control. Differential access to salmon spurred economic and social competition. | Evidence for intensification of salmon is weak. Other resources are ignored. No explanation for timing of Marpole. |
| Mitchell (1971) | Shift to cooler climate led to a reduction in oak and camas, which spurred an increased reliance on salmon. Concurrent was the development of prestige system where food is converted to wealth | No paleoecological evidence of cooler climate. Evidence for intensification of salmon is weak. |

process salmon through smoking and drying was commonplace on the coast from much earlier in prehistory (Ames 1994).

## The Fraser Valley Fire Period

In past work, we examined the history of fire in the high-elevation forests of the upper Fraser Valley as represented in the record of charcoal in forest and meadow soils and in the bottom sediments of small lakes at two study sites (Hallett 2001; Hallett et al. 2003; Lertzman et al. 2002). We reconstructed the incidence of fires for the past 12,000 years at one site and the past 7,500 years at the other (Figure 1). These reconstructions are based on 102 AMS soil charcoal dates from well-controlled stratigraphic contexts that include volcanic tephra markers as independent ages and well-dated lake sediment cores. The reconstructed incidence of fire varied substantially over this time in a manner largely consistent with known climate fluctuations (e.g., a period with high fire incidence in the early Holocene associated with the solar maximum, followed by several thousand years with lower fire incidence). The greatest evidence of synchronous fire across our sites, and the most recent peak in fire incidence, occurs between 2400–1200 cal B.P. (Figure 3). We called this the Fraser Valley Fire Period (FVFP). The FVFP corresponds to the Roman Warm Period (RWP) in Europe (Lamb 1995), a period of milder climate over Greenland (Mayewski et al. 2004), and a time of faster thermohaline circulation in the North Atlantic (Bianchi and McCave 1999). Many fire events during the FVFP correlate visually with solar maxima (or $\delta^{14}C$ minima; Stuiver and Braziunas 1993) and warm events in the GISP2 ($\delta^{18}O$ ice core data (Stuiver et al. 1997). Drought episodes during the FVFP have been documented from other regions in western North America (e.g., Gavin et al. 2003; Hallett et al. 2003; Meyer and Pierce 2003) and are likely linked to high solar activity during this time (Hallett 2001).

Synchronous periods of frequent fire across our study areas suggests a regional response to climate forcing. Fire incidence in this area is driven by mid-tropospheric anomalies that produce significant periods of sustained warm weather with abnormally low precipitation (Gedalof et al. 2005; Skinner et al. 1999). This is similar to the association of major blocking high-pressure ridges with fire weather in the southern Canadian Rockies (Johnson and Wowchuk 1993). Enhanced high-pressure circulation during the summer/fall fire season would have dried fuels and led to an increase in dry lightning storm tracks across the Pacific Northwest during the FVFP (Rorig and Ferguson 1999). Thus we can use the incidence of fire during the FVFP as an indicator of the climate conditions that lead to fire: the FVFP would have been a period with an increased frequency of years with persistent, long, dry summers that stretch into the fall, and probably periods of drought extending over several consecutive years (Gedalof et al. 2005).

## Spatial and Temporal Correspondence of Marpole Phase and FVFP

There is good spatial and temporal correspondence between our cultural and ecological data sets. Our paleoecological sampling sites located in the high-elevation zones of the upper Fraser Valley (Figure 1) are good proxies for regional climatic shifts, especially for those involving fire, for three reasons. First, these sites are near the upper limit of forest growth and, like high-elevation sites in other areas (Pellatt et al. 2000; Rochefort et al. 1994), are more sensitive ecologically to climatic fluctuations than nearby sites at lower elevations. Second, these are very wet forests, which in a typical year have persistent snowpack for 7–8 months of the year and substantial fog and rain the rest of the time: it takes a substantial, possibly multiyear drought to produce a high fire hazard there (Agee 1993; Gedalof et al. 2005). The climatic processes that produce strong fire weather indices in these forests result from regional- to sub-continental-scale processes that produce a blocking high-pressure ridge over much of the southwest coast of British Columbia (Skinner et al. 1999). Thus, the weather associated with fire years in the high-elevation forests is a good indicator of a warm dry summer and fall at a regional scale. Third, over the Holocene, forests at upper and lower elevations appear to respond together to major regional-scale climatic drivers (Brown and Hebda 2003).

There is striking similarity in the temporal distribution of Marpole aged sites and soil charcoal from the paleoecological sampling sites (Figures 2 and 3).[3] Sites with Marpole characteristics appear in the record almost coincident with onset of the FVFP after 2400 cal B.P. (Figure 2a and 2d), and at the same time there is a dramatic increase in all dated sites in the region (Figure 3a). Mid sequence, there is a dramatic drop in both soil charcoal dates and dated archaeological sites, though the number of sites and fire events are still at or above the mean (Figure 3). At the end of the sequences, there is also generally good correspondence, though the datasets are not completely overlapping. The FVFP ends ca. 1200 cal B.P., when fire frequency drops dramatically. While the vast majority of the Marpole sites date during the period we identify as the FVFP, two sites date more recently than its completion. This may represent a time lag in cultural response to changes in resource availability. We note also that this 200-year interval from 1200–1000 cal B.P. may have been a period of transition of both climate and culture, since renewed fire activity begins from 1000–600 cal B.P., coeval with the Medieval Warm Period in Europe (Figure 2, and Hallett et al. 2003).

While it is possible that some of the similarity in distribution of archaeological and soil charcoal dates is the result of confounding of anthropogenic charcoal and charcoal arising from wildfires, this source of error does not alone explain the correspondence in the two data sets. That is, we recognize that a few of the charcoal samples submitted from archaeological sites may represent natural fires rather than cultural events, since there were more natural fires occurring on the landscape during the FVFP. However, we cannot imagine that archaeologists submitted enough poor quality dates to skew the distribution of such a large data set (*N* = 345 samples). Further, the fact that the much smaller subset of data representing secure Marpole sites also displays the same pattern (Figure 2d), suggests that the distribution accurately represents the actual number of dated sites.

It is also possible that some of the charcoal dated in our paleoecological sampling sites resulted from a human-set fires rather than from lightning ignition. That is, since there may have been more people on the landscape during this time, and more people using the high-elevation zones (see below), there is a greater chance of forest fires resulting from human activity. In fact, elsewhere, we have predicted an increase in frequency during Marpole times of small, prescribed fires set by the Coast Salish in high-elevation areas to increase berry productivity (Lepofsky et al. 2005). If this is the case, it makes the relationship between climate, fire, and human activity somewhat more complex, but it does not change the nature or validity of our conclusions. Whether the source of the fire was lightning or people, in "normal" years, these high-elevation forests are just too wet for fires to propagate (Gedalof et al. 2005). Irrespective of the source of ignition, only during periods when years with substantial drought were frequent, such as during the FVFP, could fires have been frequent and large enough to leave the record of high fire incidence that characterizes the FVFP. [4]

## Ecological Consequences of the Fraser Valley Fire Period

In this section, we review the effects of the FVFP on a selection of resources that were traditionally important to the Coast Salish people (Table 2; Barnett 1955; Duff 1952; Suttles 1951). We consider fish resources, but also discuss a range of other resources because we believe, along with a growing number of researchers (e.g., Ames and Maschner 1999), that a variety of resources were important in the development of Northwest Coast societies and we expect this broad dependence to be especially important in times of changing climate and resource abundance. Our review focuses on food resources because the accumulation of food was inextricably tied to wealth and ultimately prestige among the historic Coast Salish of the region (Suttles 1987b). Further, the overall abundance and availability of most major non-food resources used by the Coast Salish (e.g., western redcedar; yellow-cedar, cattail) were unlikely to have changed significantly as a result of the climatic shifts associated with the FVFP. Our review of resources demonstrates that while some resources increased in abundance and availability during the FVFP, others declined or were less predictably abundant. In this dynamic ecological context, the Fraser Valley, with its rich and varied terrestrial and riverine ecosystems, emerged as a source of relatively more abundant, diverse, and predictable resources.

### *Terrestrial Resources*

The primary effects of increased fire incidence on terrestrial ecosystems, and the processes that would drive most of the other changes we discuss, are changes in the distribution of seral stages on the landscape and shifts in the nature of the forest mosaic. The distribution of stand ages on the landscape would shift from older stands toward more younger stands. At all elevations within the Gulf of Georgia region, fires would mostly be higher severity, stand replacing events when they occur (Agee 1993), and would largely initiate the development of new young stands. In addition to shifting the age distribution of stands on the landscape, more continuous tracts of old forest are likely to be fragmented by an increased frequency of disturbance, leading to an increase in the amount of edge between younger and older patches of forest and shorter distances between patches (e.g., Dorner et al. 2002).

We expect that many terrestrial resources likely increased in abundance and availability during the FVFP as a result of both the prolonged summers and the increased fire frequency. The increase in fires would have had a positive effect on resources that benefit from more open forests and a more fragmented forest mosaic. Deer and elk, as well as smaller animals, such as snowshoe hare, marmot, and grouse, are more likely to survive the winter and spring with the increase in forage associated with more open ecosystems and the greater juxtaposition of edges between mature and regenerating forests (Bitter and Rongstad 1982; Lee and Funderberg 1982; Mackie et al. 1982; Nyberg and Janz 1990; Shackleton 1999). In addition, berry-producing plants should increase in number and productivity during the FVFP (Lepofsky et al. 2005).

In addition to the direct benefits to humans, the increased productivity and availability of berries would have had a significant impact on bear populations. Both grizzly and black bears rely on late season berries for much needed winter fat stores, which in turn directly influence spring fecundity (Cowan and Guiguet 1956; Craighead and Mitchell 1982; Pelton 1982). Thus, more berries would result in healthier bear populations to be hunted, and, since an abundance of fall berries during warmer fall weather means that bear delay their return to their den (Pelton 1982), the hunting season for bears would have also been extended.

The extended warm fall weather associated with the FVFP would have broad effects on the accessi-

Table 2. Possible Consequences of FVFP on Major Food Resources of the Coast Salish.

| Food Resource | Consequence |
|---|---|
| Meadow resources (e.g., camas, Garry oak) | Increased fires → expansion of meadow ecosystems. |
| High elevation resources (e.g., mountain goat, blueberries, marmots) | Delayed snowfall → increased accessibility and extended harvest period. |
| High elevation berries | Delayed snowfall → ensure ripening. Increased fires → increase abundance and productivity. |
| Late season berries (e.g., blueberries, salal) | Extended period of maturing/ripening → increased harvests. |
| Mule deer, elk, snowshoe hare, marmot, grouse | Increase in fires results in more open forests and increased forage → increased population. |
| Black bears, grizzly bear | Increased temporal and spatial availability of berries → increased fecundity. Increased availability of berries → longer hunting season because delayed return to winter den. |
| Salmon- pink and sockeye | Decreased abundance at times of higher spring and summer SSTs, but no data to determine effects of FVFP on spring/summer SSTs. |
| Salmon – coho | Reduced abundance of fry in small streams due to low water. Decreased abundance at times of higher winter SSTs, but no data to determine effects of FVFP on winter SSTs. |
| All salmon | Delayed freshets result in delayed migration to natal streams, pushing many runs to the fall. Increased peak flows, erosion and sediment mobilization in burned watersheds decreases reproductive success. Increased temperatures and low water in natal streams increased predation and decreased survival. |
| Herring | Decreased abundance at times of higher spring SST, but no data to determine effects of FVFP on spring SSTs. |
| Pacific hake | Increase due to increased SSTs. |

bility and productivity of a variety of resources, especially those at high elevations. For many high-elevation resources, that is, those available in the mountains of the Fraser Valley (e.g., blue huckleberry and mountain goats), and late season low-elevation berries (e.g., salal), extended warm periods in late summer and early fall could have made the difference between a good harvest and none at all. In the case of berries that typically ripen in the fall, the extended warm period is critical for an abundant harvest. Further, the mild fall weather meant that people could successfully travel to high-elevation areas to pick berries or to hunt. In our experience, in years with delayed melting of spring snow pack and an early winter, berry productivity is considerably reduced in high-elevation meadows, and there is a surprisingly narrow window of time between when the snow melts and when it arrives again.

In the relatively drier and more open ecosystems of eastern Vancouver Island and the Gulf Islands, increased fire during the FVFP would have created more parkland and meadows. These ecosystems supported the highly valued camas bulbs and acorns, sources of much-valued carbohydrates. The relative increase in these important resources may have been one of the few positive ecological consequences of the FVFP in eastern Vancouver Island and the Gulf Islands.

### *Fish*

There are potentially two distinct lines of evidence to project changes in fish resources during the FVFP: (1) empirical records of actual trends in fish abundance during the FVFP, and (2) the effects of changes in oceanographic, climatic, and freshwater conditions on fish abundances during warm, dry periods today. Though the first line of evidence would be preferable, the few studies that examine past fish abundances in the Northeast Pacific are not appropriate proxies for the FVFP.[5]

Thus, in this study, we use current records of fish populations and their responses to environmental changes to predict the effects on abundance during the FVFP. It is well recognized among fisheries biologists and oceanographers that fish abundances today and historically are influenced by ocean and fresh water conditions that are in turn influenced by shifts in climate at varying temporal scales (e.g., Chavez et al. 2003; Downton and Miller 1998; Finney et al. 2000; Hare et al. 1999; Hoebday and Boehlert 2001; McFarlane et al. 2000; Mueter et al. 2002; Peterman et al. 1998). While we recognize that a complex mix of oceanographic and atmospheric processes drive physical and ecological responses, and it is uncertain how well the changes during the FVFP are modeled by these more recent and shorter-term phenomena (e.g., El Niño, Pacific Decadal Oscillation), at this point these recent interactions are our best proxy for developing hypotheses about abundances in the more distant past. This approach is similar to that taken by researchers wishing to predict the future sensitivity of fish populations to anthropogenic climate change. Like them, we also expect an association between increasing sea surface temperatures (SST) and periods of warmer atmospheric temperatures (e.g., Alheit and Hagen 2001; Mote et al. 2003).

Climatic variation associated with the FVFP would have influenced fish abundances at different stages in their life cycle: as juveniles in the ocean, as adults returning to their natal streams, and as eggs in these streams. In the ocean, fish survival, especially of juveniles, is linked to several environmental conditions. Most studies measure the effects of sea surface temperature on survival rates, though SST is probably an indirect measure of other variables that affect abundances (e.g., abundance of predators and prey; sea level height; Hoebday and Boehlert 2001; Meuter et al. 2002). There are numerous studies that track the effects of SST on fish abundance, but most do not separate out responses by individual species or from specific stocks (e.g., Mote et al. 2003), and thus are not useful for predicting the responses of fish in the Gulf of Georgia, specifically. The data that do exist for the Gulf of Georgia fish populations suggest that while there is no relationship between chum salmon survival and SSTs, herring and sockeye and pink salmon survival are inversely correlated with SSTs. That is, warm ocean temperatures, particularly during the period when juveniles are in Strait of Georgia (spring and summer), are strongly associated with decreased survival of these species (Hinch et al. 1995; Mueter et al. 2002; Schweigert 1995; Ware and McFarlane 1995; Zebdi and Collie 1995). Declines in coho salmon in the Gulf of Georgia are correlated with increases in winter ocean temperatures and sea-level height (Beamish et al. 1999; Cole 2000; Hare et al. 1999; Hoebday and Boehlert 2001; Mueter et al. 2002). However, since our understanding of the FVFP climate is limited to summer and fall, these data do not allow us to make predictions about coho abundance during the FVFP. There are no data for the relationship of chinook salmon in the Strait of Georgia to shifts in SSTs.

Late summer drought and increased temperatures associated with the FVFP should have also affected the timing and success of spawning. With reduced precipitation, the onset of fall freshets would be delayed. Salmon would be forced to mill around stream mouths, waiting for the necessary outflow of water to migrate up rivers. While this is potentially detrimental to upriver human populations relying on those salmon, it should have made salmon relatively more available at the mouth of streams along the main Fraser River channel, in the Fraser estuary, and in the lower Fraser in general. However, delays in spawning because of low water, or increased stream temperatures at the time of spawning can result in significantly reduced spawning success of salmon species through both direct effects and increased predation (Burgner 1991:21; Heard 1991:138, Peterson and Kitchell 2001) and in-stream temperatures during upriver migration have shaped the evolutionary patterns of migration timing among some salmon (Hodgson and Quinn 2002). We expect these freshwater impacts to have been most severe for species relying on relatively small streams and catchments with little hydrological buffering, such as coho salmon, and we expect temperature and radiation-related effects to be greatest in small streams in the drier portions of the region (e.g.; eastern Vancouver Island, the Gulf Islands, and the lower Fraser Valley; Walters and Ward 1998). Finally, increased siltation of streams (as a result of the increased incidence of fires; Legleiter et al. 2003; Moody and Martin 2001a, 2001b), further reduces the survival of salmonid eggs (Heard 1991:157).

Collectively, these arguments indicate that in the warm years associated with fires during the FVFP there would have been significant changes in the distribution and abundance of many important fish resources in the Gulf of Georgia region. However, the Fraser River would have stood out in contrast to this regional pattern of reduced abundance and accessibility of salmon. Though runs were likely reduced in size, the salmon runs in the Fraser River were so large in pre-industrial times (Kew 1992; Northcote and Larkin 1989) that this reduction in numbers may not have had significant impacts on the native fishery there—especially since so many runs of so many species were concentrated in their passage upriver. We expect that because so much of the salmon production in the Fraser originates in interior streams experiencing very different climatic conditions to the Gulf of Georgia region and dispersed over such a large geographic area, this would have provided a degree of buffering of stocks within the Fraser from local environmental conditions. This buffering against local environmental variability would have been enhanced by substantial variation in life histories among these stocks (Hilborn et al. 2003). Smaller streams and rivers elsewhere in the region, containing only their own local stocks, would have been much more sensitive to regional fluctuations in climatic conditions. Perhaps most importantly, we expect that for these reasons, fishers along the Fraser would have experienced less year-to-year uncertainty in their fish resources than anywhere else in the region. Thus, during the FVFP the Fraser River fishery would have clearly emerged as the most predictable and abundant fishery in the region. Combined with the shifts in terrestrial resources, the Fraser Valley overall would have been the most consistently abundant, diverse, and predictable place to harvest resources in the Gulf of Georgia.

## Cultural Consequences of the Fraser Valley Fire Period

We posit that increases in regional cohesion and socioeconomic complexity during the Marpole phase were linked to the regional differences in resource abundance and availability brought on by the FVFP. We suggest that the differential availability of resources was the impetus for creating and affirming social bonds that ensured access to these resources more broadly across the Gulf of Georgia region. In particular, we hypothesize that Fraser Valley communities, and especially the leaders of groups who controlled prime resource areas, had an economic advantage over others outside the Fraser system because they were more consistently able to supply their relations with abundant resources. In a system where food wealth was converted to prestige, these individuals turned their economic advantage into a social advantage.

### *Differential Availability of Resources*

During the FVFP, even if salmon stocks were reduced overall, the main Fraser River would have had continued to supply more salmon than could have been harvested using traditional methods (Kew 1992). In contrast, climatic warming would have had a much more noticeable impact on salmon abundance in the smaller tributaries of the lower Fraser and the small streams of the adjacent mainland and Vancouver Island. Each of these would typically contain only one run of each species, and often would not have all species represented. In particular, few had runs of sockeye. Further, the climatic variability of the FVFP meant that people could rely less on their ecological knowledge to predict where and when certain aquatic resources could be most profitably harvested. Then, as today, local knowledge of seasonal migration routes and timing, typical depths, and feeding patterns would have been the key to successful fishing efforts, yet all of these can change in response to climatic and oceanographic fluctuations. The effects of this would have been particularly felt by people relying on fish in the ocean, since there are more places where the fish can go and fish can be dispersed over enormous areas. For instance, in some years, some stocks that typically migrate south to the Fraser along the inner coast between Vancouver Island and the mainland instead move south along the west coast of Vancouver Island and enter the mouth of the Fraser from the Strait of Juan de Fuca, rather than the Strait of Georgia—and this shift in migration route can have a devastating effect on even modern recreational fishers in the Gulf of Georgia (Beamish et al. 1999). Once in the Fraser River, there would have been a substantially reduced risk of failure, since movement options for salmon are more restricted, access by fisherman is more controlled, and fish are more concentrated. Further, the lower water levels (associated with drought) in the Fraser River result in the exposure of more beaches and lead to more places along the Fraser River where salmon can be harvested.

At the same time as salmon harvests were becoming more unpredictable in the surrounding region, the people of the Fraser Valley would have been enjoying more productive and more accessible terrestrial plant and animal resources. The high-elevation resources available locally only in the Fraser Valley (e.g., blueberries and mountain goat) would have been of particular importance. In cold, wet years these would have been difficult to obtain, but during warm, dry years in the FVFP would have been not only more accessible, but more abundant. Historically, these resources were highly valued among the Coast Salish; they were used in feasts, rituals, as markers of social prestige, and were traded to Coast Salish groups who did not have direct access to them (Barnett 1955: 71; Lepofsky et al. 2005; Ostapkowicz et al. 2002; Reimer 2003; Suttles 1951:95).

Although the Georgia Strait communities in the Gulf Islands and eastern Vancouver Island likely exchanged resources that were unique to their drier ecosystems, there is little data to suggest the regional importance of these resources. Camas and acorns in particular, available in greater abundance on the islands than the Fraser Valley, were likely among these resources. Although there are no definitive ethnographic records of such exchange (Galloway 1982), the genetics of a population of Garry oaks in the upper Fraser Valley suggests the acorns originated from the northern Gulf Islands (Lepofsky 2004). For many Northwest Coast peoples, carbohydrate-rich foods, such as camas, were at a premium. However, people of the lower and central Fraser Valley also had an abundant supply of carbohydrate-rich wapato, which was traded by some Fraser Valley groups to the Coast Salish on Vancouver Island (Kuhnlein and Turner 1991).

### *Cultural Responses*

Our understanding of how people may have responded to these environmental shifts of the Marpole phase is strongly influenced by our knowledge of the social and economic processes of the historic Coast Salish of the Gulf of Georgia region. Sharing food to protect against shortages was an essential part of Coast Salish socioeconomics in the historic period (Carlson 2003; Miller 1989; Suttles 1987b, 1987c, 1987d, 1987e). Complex exchange networks across the region allowed groups to even out food abundances and shortages and thus be rooted in a particular place, yet connected to a broader cultural and ecological landscape. The ecological pull of the Fraser system, in particular, meant that hundreds of Coast Salish from Vancouver Island and the Gulf Islands who had familial connections in the Fraser Valley traveled across the Georgia Strait annually to harvest the resources of the Fraser system. Ethnographic evidence suggests that these regional bonds were made through the elite (males), who had access to the food resources needed to cement affinal relations (Carlson 2003).

We suggest that the social and economic networks of the historic period were solidified during Marpole times to offset the ecological challenges associated with the FVFP. The ecological pull to the Fraser Valley would have been even greater during the FVFP, when resources were relatively less predictable and abundant in the Georgia Strait. We predict that communities in the Georgia Strait at this time sought to strengthen social bonds with those who had direct access to the resources of the Fraser system. As a result, those individuals who had access to Fraser River valley resources, either through direct ownership, or through affinal relations, would have had the potential to increase their social prestige. Further, by participating in such region-wide socioeconomic networks, aspiring individuals could enhance their status within their own communities. Larger numbers of people would have been both attracted to these individuals because of their ability to ensure a more constant food supply, and needed by those individuals to intensify resource production to maintain social relations. The region-wide symbols of wealth and power that typify the Marpole phase, such as the finely crafted baskets, and stone and antler sculptures, are the material correlates of these social and economic bonds.

An ethos of prestige was an important element driving the regional system of food exchange among the historic Coast Salish (Suttles 1987e). We expect it was also a fundamental element of Marpole communities. For prestige to have played a dominant role during Marpole would have required the presence of both aspiring individuals and a community that allowed or supported prestige-seeking individuals. The scant pre-Marpole burial record indicates that such an ethos could have had its foundation in at least some pre-Marpole communities. However, the widespread appearance of large houses, regional art forms, and symbols of prestige ca. 2,400 years ago indicates social intensification at the inter- and intra-community levels during the Marpole phase (Ames and Maschner 1999; Brown 1996; Grier 2003). The importance of prestige during Marpole times is further illustrated in Coast Salish oral traditions. Large settlements— many of which were likely established during the Marpole phase—and class-based relations are inextricably linked. Importantly, many of these same oral traditions also recount times of severe food shortages (Carlson 2003), reflecting a real need for a system of food sharing in the past.

We suggest that the incentive to allow these increasingly complex social relations during Marpole arose from the dramatic regional differences in availability and predictability of resources brought on by the FVFP. For communities living outside of the Fraser Valley, relatively more was gained by forming and augmenting inter-community social alliances than previously. Individuals with access to Fraser Valley resources would have had increased opportunities to enhance their status, while resource-poor communities would have had more incentive to allow them to do so. For all communities, alliance formation and the support of elites that is linked to it was a peaceful and thus relatively low cost solution to the problem of differential access to resources. Archaeological evidence for extensively fortified villages at key salmon harvesting and processing areas in the Fraser Valley (Schaepe 2001a) and extensive documentation of historic raids (Carlson 2001) indicate that peaceful solutions to economic problems were not always sought. Disentangling how these various kinds of regional interactions change through time remains an important question for future research.

We further propose that climatic shifts associated with the FVFP would have been linked in other ways to increased intra-regional contact and ritualized activity during Marpole times. Climatic amelioration during this 1,200 year period would have also encouraged more intercommunity contact simply because it was more pleasant, feasible, and safer to travel. Overland routes, which often traversed high-elevation zones (Schaepe 2001b), would have been relatively more accessible to a wider segment of the population, and sea conditions may have been relatively more predictable (diurnal changes in fair weather wind patterns are more predictable than those associated with frontal movement).

Increased access to high-elevation areas specifically during the FVFP may have influenced other important social changes during Marpole times. Among the Coast Salish peoples, mountainous areas are often considered places of power, and the resources that come from them are spiritually significant (Reimer 2003; Schaepe 2002). Further, access to "high spots" allows people to cement cognitive maps of their own territories as well as that of their neighbors (Mierendorf 1999). Schaepe (2002) notes that access and control of upland resources, so important to the political economy of lowland villages, is in part legitimized by ancestral links to high-elevation areas. Only from these high spots could all the important locations of events in Stó:lō origin myths be viewed, and consequently people of all ages went to the mountains to learn these stories (Schaepe 2002). Today, the telling of such stories is critical in the formation of bonds both within and between communities (Schaepe 2002). In years with "normally" wet and cold fall weather, getting to high elevations and spending a significant amount of time there would be a challenge, as it is today. However, during periods of milder fall weather, such as we posit for the FVFP, many more community members would be more able to engage in these important identity-forming and subsistence activities in the high-elevation zones.

In sum, we propose that the social and environmental conditions after 2,400 years ago in the Gulf of Georgia converged to form the phenomenon archaeologists know as the Marpole phase. Differential availability of resources associated with the FVFP encouraged intercommunity interaction, particularly among elites—and there were significant enough benefits to both environmentally advantaged and disadvantaged communities to support the developing prestige of those elites. Importantly, environmental changes associated with the FVFP were both of significant magnitude and sufficient duration for people to change their behavior—and for those changes to leave signatures detectable in the archaeological record.

## Discussion

Though the data are not yet available to characterize precisely Marpole social, political, and economic organization, it is clear that significant changes in these arenas can be inferred from the physical record of the Marpole phase. These transformations are reflected in the elaboration of burials and increased occurrence of cranial deformation; the region-wide trade in status validating items; the appearance of larger and more complex domestic groups living together in large houses and the concurrent shifts over household labor; and the increase in resource specialization. This is consistent with intermediate societies elsewhere in the world where archaeologists have hypothesized a link between increasing complexity and aspiring individuals who manipulated resources and people at the local and regional scales to further their own gain (e.g., Arnold 1993, 1995, 2001; Clark and Blake 1994; Hayden 1995).

The Marpole archaeological record provides insights into ongoing discussions about the role of resource abundance and increasing complexity in such intermediate societies. Arnold (1993, 2001) has suggested that environmental stress creates a resource-population imbalance, which in turn provides the opportunity for aspiring individuals to increase power. Others (e.g., Clark and Blake 1994; Hayden 1995), however, argue that it is productive environments that provide increased opportunities for aspiring individuals to augment their prestige. The Marpole data suggest yet another scenario—during times of environmental change, local differences in the productivity and predictability of resources within a region (both positive *and* negative) provide the opportunities for people to augment their social positions and cement social linkages among communities. Collectively, these observations suggest that aspiring individuals will, given the freedom to do so, take advantage of any opportunities to augment their status, and that these opportunities can be presented by a diverse range of social and environmental conditions. During Marpole times, we believe the incentive to allow individuals to augment their social standing, and to invest in social relations ("social capital"), was a collective buffering of uncertainty in resource availability.

Kelly (1994) has posited a similar model for the rise of social inequality among hunter-gatherers more generally. Drawing largely from the Northwest Coast ethnographic record (e.g., Donald and Mitchell 1994), he argues that in regions with spatial heterogeneity of resources, resource-poor groups will seek social alliances with groups who have abundant resources. Because they are in need of social and economic connections, the poorer groups relax the egalitarian ethos and allow wealthier groups to gain prestige. Kelly suggests that these wealthier groups in turn opt to share food resources rather than only hoard them because the cost of sharing is ultimately lower than defending against raids. As the Gulf of Georgia archaeological record indicates, however, regional interactions may more commonly be some complex mix of peaceful and violent interactions.

Heterogeneity of resources across the landscape may not alone provide the necessary conditions needed to encourage alliance formation and food sharing. Earle (1994) concludes that archaeological evidence worldwide indicates the prohibitive costs of transportation of bulky foodstuffs limits the importance of food exchange in the development of most societies. However, on Northwest Coast, where long distances and large amounts of foodstuffs could be transported relatively easily via canoes, the costs of travel and transportation were greatly reduced (Ames 2002; Earle 1994). This would have been especially true for the Fraser River, which was navigable throughout the length of the Fraser Valley. Further, in the FVFP, if we are correct, overland travel would have been relatively easier than at other times.

Our analyses highlight a common problem for those interested in the relationships between social and environmental changes: the lack of comparability between archaeological and paleoecological datasets. The problem is one of both spatial and temporal scale. Paleoenvironmental data must be fine-grained enough to reconstruct local environmental changes that may have influenced human populations. This requires fine-scale sampling from small catchments, such as we have used in the research that identified the FVFP (e.g., Hallet et al. 2003). However, since the signal provided by small catchment studies can be very local, it may be more difficult to link the paleoecological site with ecological processes at extra-local archaeological sites and to build regional-scale syntheses. Ideally, these discrepancies will be resolved in many regions as archaeologists and paleoecologists work more closely together.

The magnitude and severity of environmental or cultural change clearly influences our ability to link social and ecological data. Since, even in cases of "cultural collapse," archaeologists may not agree about the role of environmental deterioration (e.g., Erickson 1999; Ortloff and Kolata 1993), the relationship of culture change and environmental change will be harder to tease out when the environmental shifts are not life-threatening and thus changes in behavior aren't requisite. It may be that the disjunction between our paleoecological and archaeological data at the end of the Marpole phase is due in part to this phenomenon.

While we argue for an environmental driver of social change during the Marpole phase, we do not support the extension that all social change has an environmental component or that all environmental shifts will produce a social response. During Marpole, there is an intensification of social processes, but these processes clearly have their roots in the social relations of the pre-Marpole peoples. Likewise, though there is a surprisingly close correspondence between the end of Marpole and the end FVFP, complex, regional social relations did not stop 1,200 years ago: historic and modern Coast Salish society manifest a variety of regional social patterns for which we can see origins during Marpole.

The ebb and flow of Coast Salish social relations is demonstrated clearly among the Coast Salish during the historic period. At certain times, intertribal relations were emphasized in response to changing social and economic contexts associated with European colonization (small pox, the establishment of trading forts and the Gold Rush; Carlson 2003; Miller and Boxberger 1994). At those times, elite men put more effort into forging intertribal connections that resulted in increased economic and social opportunities. At other times, local, tribal-scale relations were highlighted. We suggest that during Marpole times it was also advantageous to augment intertribal relations, but these social relations may have undergone some kind of reorganization during the subsequent Late phase. This reorganization is reflected in shifts in burial practices—the physical manifestation of the connection to the ancestors. Given that in Coast Salish society genealogical connections affirm the social position of elites, shifts in the burial record may reflect more fundamental changes in social structure.

Assessing our hypothesis about the role of the FVFP in social change during the Marpole phase will require collecting detailed archaeological and paleoecological data to evaluate predictions of the model we propose (Table 3). For instance, a fundamental prediction of our model is that the shifts in abundance of upland and lowland terrestrial and riverine resources should be reflected in their relative abundance in the archaeological record. Currently, our sample of plant and animal remains from Marpole sites is not sufficiently fine grained to evaluate such shifts. However, more rigorous sampling schemes, combined with new methods of identification (Yang et al. 2004), will go a long way toward understanding the role of different resources during the Marpole phase.

Similarly, we expect that shifts in resource abundance will be reflected in data on Marpole settlement patterns. That is, since it was relatively easier to access high-elevation ecosystems, we expect more sites in the subalpine zones. We also expect a shift in the distribution of lowland sites toward the Fraser River core of the region. While this idea of shifting settlement pattern during Marpole has been in the literature for some time, data and analyses are currently insufficient to evaluate it critically. Detailed settlement studies in both the uplands and lowlands are needed.

We also expect that changes in demography were associated with socioeconomic shifts in the Marpole phase. Indeed, it is almost an anthropological truism that demographic shifts will be linked to shifts in social complexity (e.g., Keeley 1988; Kelly 1994; Kirch 1984). During the historic era in the Gulf of Georgia, declines in population associated with the small pox epidemics were a major catalyst in social change (Carlson 2003). At different times during the Marpole phase, there appears to be some kind of reorganization of people (either more people or more sites) coincident with changes in climate. However, we are not yet in a position to hypothesize about the specific role of population since we do not know if these changes represent shifts in population dispersion (more small sites) or population increase (more sites of all kinds). Our ongoing research, which focuses on tracking temporal and spatial changes in the num-

Table 3. Evaluation of FVFP- Marpole Model.

| Cultural or Ecological Consequence | Possible Evaluation |
|---|---|
| Easier access to high elevation zones | • More archaeological sites in high elevation zones<br>• More high elevation resources in archaeological sites (e.g., blueberries, mountain goats) |
| Increased focus on Fraser system | • Concentration of sites along the main Fraser Valley corridor relative to elsewhere in the Gulf of Georgia region |
| Drying up of small streams → decline in coho, especially | • Relatively less coho in archaeological sites |
| Increased regional exchange of resources | • Fraser River salmon, wapato, blueberries, mountain goats in other Gulf of Georgia sites; Gulf Island camas in Fraser Valley sites |
| Decline in salmon, especially in Gulf Islands and Vancouver Island stocks; increase in ungulates | • Relative decline in salmon, and increase in deer in some sites outside the Fraser Valley |
| Increase in early seral state vegetation and fire-tolerant species | • At low elevations, increase in alder and Douglas-fir pollen |

ber and kind of sites, will go a long way toward understanding the role of population numbers in changing Coast Salish relations.

Another approach to evaluating our model is to examine the cultural changes in other regions we expect to be affected by the climatic shifts associated with the FVFP. The FVFP is likely a regional manifestation of a more widespread climatic shift in western Canada (Hallett 2001) and, if our model is correct, we may find contemporaneous, similar cultural responses in similar ecological settings. It is intriguing to note that cultural sequences from regions surrounding the Gulf of Georgia also highlight the period after 2400 cal B.P. as an important time of cultural change. For instance, on both the West Coast of Vancouver Island, and Queen Charlotte Strait, shifts in artifact assemblages have prompted archaeologists to posit the replacement of Salishan speakers by Wakashan-speakers (McMillan 2003; Mitchell 1989, 1990). An alternative model to "cultural replacement" is that these shifts in artifacts may represent increased regionalization of social and economic networks, such as is evident in the Gulf of Georgia region. Evaluating this hypothesis will require a detailed examination of the cultural and environment context of each region ca. 2400–1200 B.P., and the formulation of predictions about how these changes may be manifest in the archaeological record of those regions.

*Acknowledgments.* Financial support for the climatic reconstructions came from a Forest Renewal British Columbia grant (awarded to DL, KL, and RM), a Natural Sciences and Engineering Research Council of Canada research grant (awarded to RM), graduate fellowships for DH from Simon Fraser University, and Global Forest. Many thanks to Bruce Finney, Randall Peterman, Sean Cox, David Patterson, Carrie Holt, and Ann-Marie Huang for help understanding the effects of climatic change on fish populations, to Alton Harestad for advice on interactions between climate, fire and wildlife, and to Doug Brown for discussions about Northwest Coast archaeology. Conversations with Keith Carlson about Coast Salish oral traditions and interactions helped breath some life into the archaeological and ecological model. Michael Blake, Roy Carlson, Iain McKechnie, R. G. Matson, Colin Grier, Bill Prentiss, and four anonymous reviewers, provided very useful comments on an earlier draft of this paper. Our thanks to Andres Valle-Domenech and Marcela Olguin-Algarez for the Spanish translation of the abstract.

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## Notes

1. Biogeoclimatic Ecosystem Classification is the system with which ecosystems are classified in British Columbia; variants are a relatively fine scale within the system of classifying subregional and landscape variation in plant communities and climatic conditions (Meidinger and Pojar 1991).

2. To date, extensive archaeological excavations of villages linked with such transformation narratives is limited to the Scowlitz site, in the central Fraser Valley. At Scowlitz, Sumqeameltq fell from the sky and taught people how to fish for salmon (Hill-Tout 1978:148–150). Though the Scowlitz site was occupied 3–600 years before the onset of the Marpole phase, the large village occupation dates to the Marpole phase (Lepofsky et al. 2000). Our current research in the Fraser Valley is particularly targeted at village sites connected to oral traditions. The results of this project will help us to continue to refine our understanding of the connection between oral traditions, village formation, and the development of ancient Stó:lō social systems.

3. It is particularly notable that the strong temporal correspondence holds despite the fact the FVFP is based on AMS dates and the archaeological sites are largely conventional dates, sometimes with large standard deviations (Figure 2). Many of the archaeological dates listed have not been corrected for isotopic fractionation, but these errors are small for wood charcoal in the late Holocene.

4. An analysis of the relative importance of climatic and human controls on fire in the tropical rainforests of Chiapas, Mexico provides a good model for the interaction of humans, fire, and climate we might envision during the FVFP (Román-Cuesta et al. 2003). Most fires are ignited by the indigenous people (some through negligence but many as a part of traditional resource management practices), but during wetter, non-ENSO years (El Niño Southern Oscillation), fire spread and area burned is determined primarily by vegetation parameters—essentially, wet fuels constrain fire behavior. In contrast, during the droughts associated with ENSO years, the prime determinant of fire was the presence of ignition sources, since when a fire started, all fuels were dry enough to burn. During dry years, the number and extent of fires were directly correlated with the number of people in the forests.

5. Finney (and others 2000, 2002; Finney personal communication 2003) found a reduction in the number of sockeye salmon in Alaska and Northern British Columbia during the period covered by the FVFP, but given the dominance of local and regional-scale processes on fish survival rates (Mueter et al. 2002; Peterman et al. 1998; Pyper et al. 2001, 2002), we cannot extrapolate these data to southern British Columbia. A deep-sea sediment core, extracted from the Saanich Inlet, within the Gulf of Georgia region off of southeastern Vancouver Island, showed that a mix of salmonid prey and predators, Pacific herring, Pacific hake, dogfish, and skate, collectively were more abundant between roughly 2000–1000 B.P. (extrapolated dates; Finney et al. 2002;

Tunnicliffe et al. 2001). However, the number of recovered remains is so small that we cannot confidently distinguish meaningful trends in the relative abundance of these different taxa—and distinguishing the trends of predators relative to prey would be necessary to inferring impact on salmonids. Finally, Chatters et al. (1995) model the past abundance of salmon in the Columbia River based on various lines of evidence, but they have no data for the period included in the FVFP.

*Received June 1, 2004; December 6, 2004; Accepted December 8, 2004.*