Wapato (*Sagittaria latifolia*) In Katzie Traditional Territory, Pitt Meadows, British Columbia

by

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Abstract

Wapato (*Sagittaria latifolia* Willdenow; Alismataceae - Water Plantain family), a tuberous starchy carbohydrate food-plant, is frequently mentioned in ethnographies, historic accounts and archaeological reports concerned with the Halkomelem speaking Katzie First Nation (KFN) located in the Fraser Valley region of southwestern British Columbia. However, none of the archaeological reports contain substantive archaeobotanical evidence for the prehistoric use of wapato. The reports rely completely on ethnographic and historic accounts for their speculations and conclusions about wapato. The need for critical and contextual review is also evident for the ethnographic and historic accounts upon which the prevalent archaeological view of wapato is based. Complicating this situation is the absence of information regarding the charring and identification of carbonized wapato remains and the lack of a model to predict where it might be found archaeologically.

To rectify the foregoing situation this research brings together an informative survey of the abundant botanical literature on the ecology of wapato in conjunction with a critical and contextual review of relevant environmental, archaeological, ethnographic, linguistic and historic information to set the stage for the construction of an archaeological model for wapato. Field work involved the location of wapato patches in traditional Katzie territory and recording environmental information, and leads to the conclusion that wapato is only found outside the modern dike system and no longer in many of the ethnographically documented locations inside the dike system.

A major contribution to the process is the conduct of a wapato charring experiment which clarifies the nature of charring for this tuber and provides the necessary details for identifying charred wapato remains emphasizing macroscopic features visible with the unaided eye, supplemented with low power and scanning electron microscopy for greater detail. With the results of the critical and contextual review in combination with the charring experiment results, a model for the archaeological recovery and identification of wapato is constructed for Katzie traditional territory. All or some of the elements of the analytical process followed and the archaeological model are applicable in other locales and should contribute significantly to our understanding of traditional wapato use.

Acknowledgments

Both a perilous and pleasant task at times, lest someone is overlooked or forgotten with the passage of time, acknowledgments present the opportunity to recognize the many contributions made by others that ultimately make a thesis such as this better than it ever could be without their input. The whole does indeed become greater than the sum of its parts because of such contributions! If you are overlooked, take satisfaction in knowing you made a contribution.

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Chapter 1 - Introduction

"Katzie territory was famous for these, and in the fall outsiders came from a number of other tribes to gather them."

Wayne Suttles, 1955:26
Katzie Ethnographic Notes

Background

Wapato (*Sagittaria latifolia* Willdenow; Alismataceae), a tuberous starchy carbohydrate food-plant, is frequently mentioned in ethnographies and archaeological reports concerned with the Katzie First Nation (KFN) of the Fraser Valley region of British Columbia. First mentioned in the "*Fort Langley Journals*" of 1827/30 (Maclachlan 1998) and subsequently in local ethnographies (Duff 1952; Jenness 1955; Suttles 1955, 1987a) and archaeological reports (Crowe-Swords 1974; Patenaude 1985; Peacock 1981), the archaeological and historic context of wapato has not been addressed critically, nor has its archaeological preservation potential been assessed, notwithstanding the frequent mentions it has and continues to receive. While it has been studied in detail by botanists (Brayshaw 1985; Clark and Clay 1985; DeLesalle and Blum 1994; Fassett 1966; Kaul 1985; Lieu 79; Marburger 1993; Pojar and Mackinnon 1994; Wooten 1971) and to a lesser extent by archaeologists (Darby 1996; Hather 1991, 1993; Kubiak-Martens 1996; Neumann *et al.* 1989) wapato in Katzie territory is not well understood. This thesis intends to rectify this knowledge shortcoming.

The need for research into wapato can be justified on several fronts. As a dietary source of starch wapato would have been a predictable and abundant complement to diets that were high in protein. Nutrition would account for its apparent popularity as a foodstuff and a trade item. *Sagittaria* species occur widely throughout the world and are abundant in the Pacific Northwest, especially along both the lower reaches of the Columbia and Fraser Rivers. In wetland areas it could have been the object of cultural manipulation, including water management activities, to increase its abundance and production. There is fleeting mention of such horticultural behaviour in one ethnographic account (Haeberlin and Gunther 1930:21). Much of what has been written in ethnographies and historical references is often taken out of context and a critical accounting of the sources appears infrequent. The frequent inclusion of wapato in local archaeological reports is an example where much is made of wapato via ethnographic analogy and the direct historic approach, but ultimately no identification of wapato remains from archaeological contexts is provided. Hence, there is a need to assess its potential to survive in archaeological contexts and to predict where it might be found.

In view of the importance of wapato to the KFN, especially as regards traditional use studies in the environmentally sensitive Pitt Lowland area, a better understanding of what has happened to wapato since the time of first contact with Europeans is warranted. A critical and contextual review of the extant data on wapato will help fulfill this need while at the same time contributing to the creation of a predictive model for the archaeological occurrence of wapato. The review includes a look at native language data relevant to wapato.

Research Objectives

To address the foregoing issues a variety of research activities is proposed. As wapato is a ubiquitous aquatic plant, well characterized and documented in modern botanical literature, the first step towards better understanding is to summarize this information. Then a critical review of the historic and ethnographic information is required to take the modern botanical information back into the past to set the stage for constructing a model for the potential archaeological presence of wapato. Last but not least, since it could prove fruitless to search for wapato in archaeological sites, the model needs to be supported by evidence that wapato remains can be identified in such contexts. To summarize, the research has the following objectives:

1. to present a detailed description of the ecology of wapato;

2. to critically review ethnographies and historical sources;

4. to char wapato tubers to evaluate the potential for detecting archaeological remains;

4. to construct a model for the archaeological presence of wapato.

Geographic Area of Research

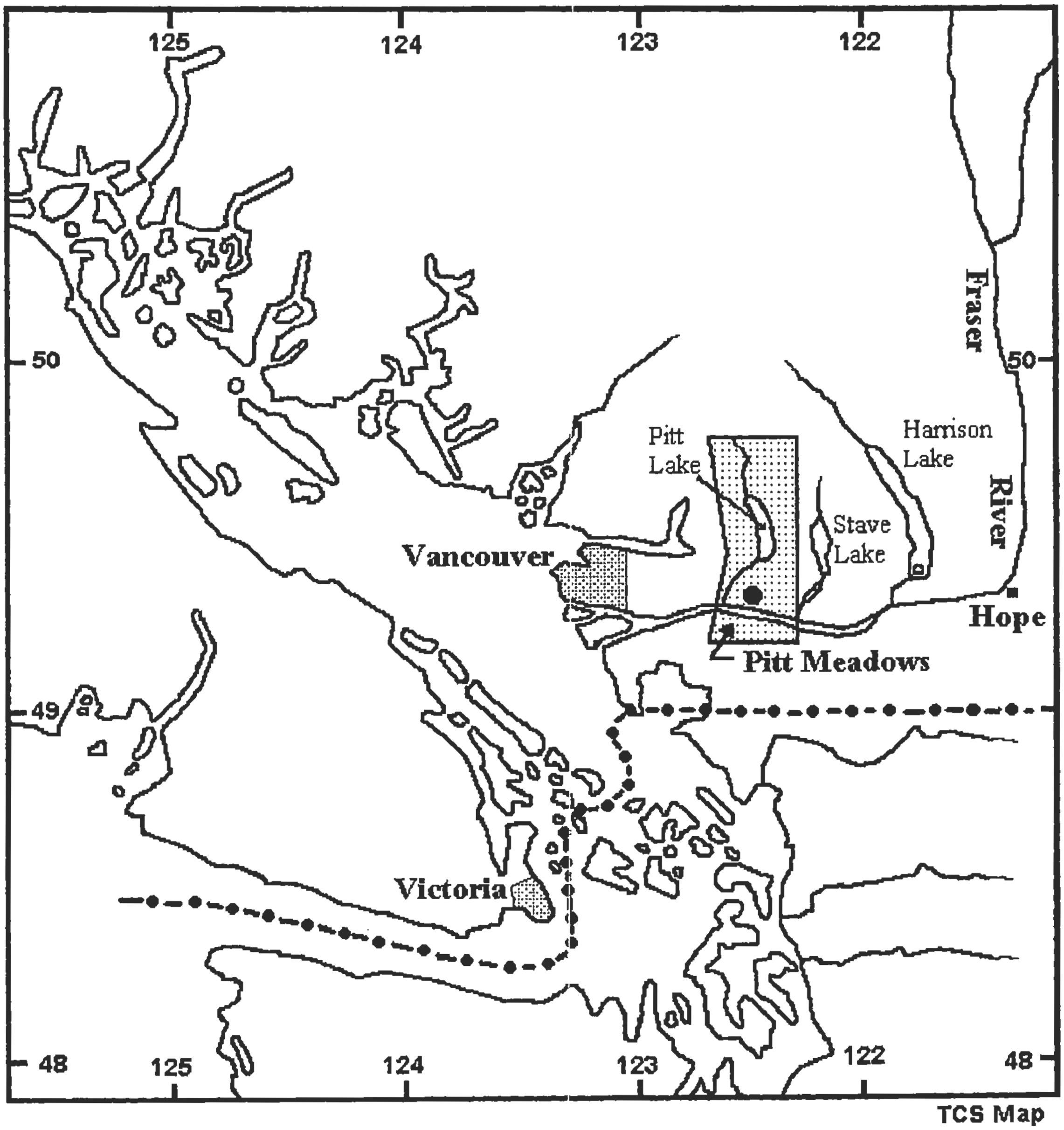
The geographic focus of this research is Katzie traditional territory (Figure 1) and the Pitt Polder/Lowland area (Figure 2). Within this larger area the wapato patches of the wet lowland areas of the Pitt River and Pitt Polder are of prime concern. A more detailed description of the area follows in Chapter 2. Furthermore, because the genus is widespread worldwide it is necessary to briefly consider other regions such as Europe, Southeast Asia and elsewhere in North America to gain greater insight into this tuberous food plant.

Potential Problems

To set the research stage it is necessary to recognize several potential problems that must be considered in addition to the aforementioned issues of critical ethnography, historical context and lack of archaeological evidence. These problems include: 1. the paucity of comparative paleobotanical materials; 2. the potential presence of research, informant and gender bias in ethnographies; 3. the

Figure 1

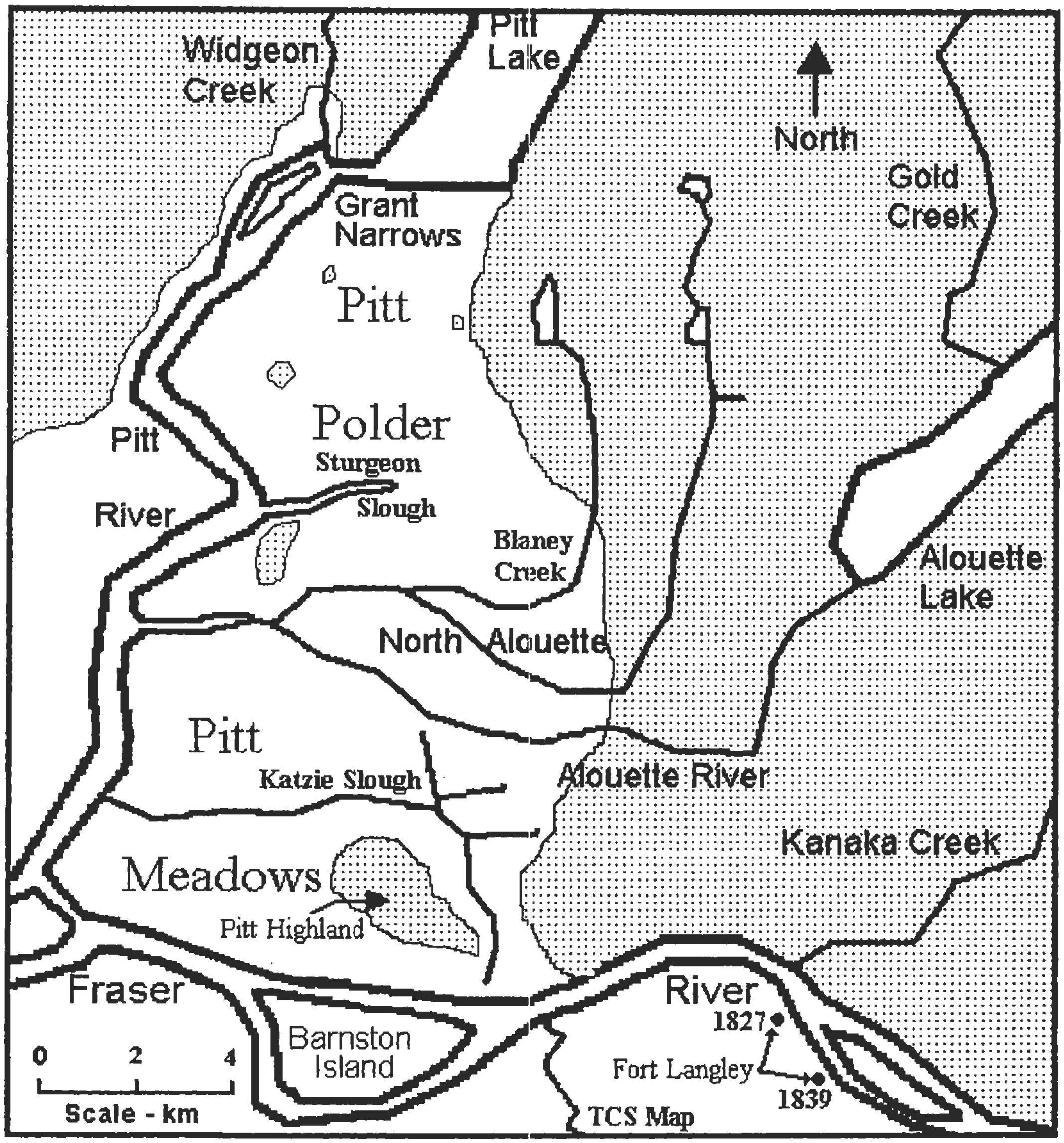
Katzie Traditional Territory



- Katzie traditional territory

Figure 2

Pitt Polder/Pitt Meadows Lowland



- Higher Ground

considerable passage of time from first contact to the recording of ethnographic data; 4. the relative lack of archaeological survey and excavation for the area of concern; 5. the potential for bias and misunderstanding of historical information pertaining to First Nations people; and 6.) the early diffusion of the potato (*Solanum tuberosum*) into the area (Brown 1868; Suttles 1987b) and the consequent potential for confusion. These issues will be addressed in the discussion which critically reviews ethnographic information and contextualizes historical data in Chapter 3.

Theory and Method

Critical archaeology serves to alert us to a number of issues pertinent to this wapato research. Archaeology in its quest for knowledge of past culture change has always borrowed theories and methods from the "hard sciences" such as physics, biology, natural science, mathematics and the "social sciences" of sociology, history, economics, political science, philosophy and ethnology. While largely unsuccessful in its own attempts to generate covering laws of a high order (Shanks and Tilley 1992:32; Trigger 1989:22), much of value has been borrowed and adapted from other disciplines for archaeological use. In this instance we focus upon Critical Theory which has been adopted from the recent social philosophers of continental Europe and ultimately applied as critical archaeology. Critical theory in its simplest form addresses the full range of issues raised by the impact of modernity on economic, political, social and cultural life (Kellner 1989:4) and also asks where social knowledge comes from and whose interests it serves (McGuire 1992:38). Critical theory thus represents a fertile field for harvesting by an archaeology that has experienced the impacts of modernity, post-modernity, the New Archaeology and the subsequent post-processual wanderings.

Critical theory presents archaeology with a framework for critique which recognizes that archaeology of the past is practised in the present by individuals who cannot claim a special objectivity just because they are "scientists" and whose knowledge is not immune from the social forces of the present. Bradley (1987:293) commenting on Leone *et al.* (1987) asks, "Is everyone a dupe for ideology except the academic?" Wylie (1985:134) refers to the situation as the "objectivist delusions" of positivist social science. As applied in archaeology two forms of critique emerge. The first is a critical reflection on the knowledge-producing enterprise itself. The second, where the reflection reveals a dominant ideology and social order mediated by the scientific production of knowledge, provides a basis for reflective understanding and criticism of the social context of research, taking the form of prospective social criticism and action (Wylie 1985:137).The resulting critique of archaeology, a development of post-processual archaeology in England and critical archaeology in the United States, rejects the pervasive positivism of processual archaeology, concerning itself with the political implications of the present on our interpretive study of the past, emphasizing the role of ideology in the past and the way modern ideology permeates museum exhibits and other public presentations of the past (McGuire 1992:79). Thus, we should ask critical questions about the sources of our knowledge of wapato use and what impacts the dominant social order engaged in the knowledge producing enterprise has had on the results.

The concept of time influences how the past/present dialectic is viewed by different groups. Modern western people tend to see time as a road or linear continuum where the future is ahead in the fog, the present is a short space of clarity and the past is the haze behind us (McGuire 1992:215).The western linear view of time creates separate time packages where the future is unknowable but predictable, the present is where we are and is observable but with bias, and the past while harder to observe can be seen more objectively, albeit more dimly but with less bias (McGuire 1992:215). This is where the notion of using the past to predict the future comes from and where because of their method and theory archaeologists claim a leading role as viewers of the past (McGuire 1992:215). Archaeology according to Shanks and Tilley (1992:245) is a critical contemporary discussion on the past (or the present) which has no logical end, where a unitary and monolithic past is an illusion.

There can be multiple accounts of the past based on the perceptions, interests, ethnicity, cultural, social and political views of the teller, and these may change as the concerns and realities of the present change (McGuire 1992:217; Shanks and Tilley 1992:245). If we accept that there are other views of time than the linear western view (for more on perceptions of geological time see Gould 1987), and such is the case for traditionalist native views of spiritual sources, ritual and oral tradition where the past exists in the present (McGuire 1992:240), then the linear view may unduly influence the way archaeologists go about the business of addressing the history of the peoples they study. Separating the past from the present, into two distinct parts with no direct linkage, is common in archaeology, the persistence of the notions of the "vanishing American" and the "savage primitives" being but two examples of this parting (McGuire 1992). In British Columbia archaeological interpretations frequently rely on ethnography and contemporary history, a situation which is ripe for critical review. The pervasiveness of the notion of the separation between past and present is illustrated by a comment on the dust-jacket of Heather Pringle's book (Pringle 1996) where Farley Mowat says "*In Search of Ancient North America* brings the distant past much closer and its inhabitants almost become neighbours to us once again." Well, the last time this researcher looked the descendants of some of them are still our neighbours.

Leone (1986:427) asks, "what are the pasts of those who have been denied a history: women, blacks, Third World workers ?" Elsewhere (Leone 1995:251), he adds immigrants, children, and free African-Americans to the list arguing that a critical approach leads to greater visibility of people or groups who have been suppressed or left out of capitalist dominated interpretations. Notably, this list seems to be inclusive of historical groups or classes, and this indeed seems to be the main focus of critical archaeology that is often concerned with interpretative situations which have some written or recorded history that can contribute to identifying the need for reflection and social criticism (see Leone 1995, 1986; Leone *et al.* 1987; McGuire 1992). McGuire (1992:213-45) critically addresses the relationships between indigenous Americans and the practice of archaeology, touching upon such topics as how each group regards the past/present, who controls the past, whether archaeologists should address the interests of Indian people, how the notions of heritage and nation influence interpretations, and how the dominant class has changed its view of the native American since the first arrival of Europeans to the present era of Indian activism. McGuire says archaeologists should initiate a process of dialogue with Indian peoples to fundamentally alter how archaeology is practised, our perceptions of the past, how we deal with living Native Americans, how we train students and how the results are presented to each other and the general public (McGuire 1992:241). On a more local note, a recent article by Holm and Pokotylo (1997:41) detailing a collaborative museum exhibit at the UBC Museum of Anthropology similarly states the need for archaeologists to reassess their role as sole experts with curatorial authority over the interpretation of archaeological collections.

In terms of involving native people at all levels in archaeology, Nicholas and Andrews (1997a) provide a stimulating collection of papers pertaining to what they refer to as "indigenous archaeology" (Nicholas and Andrews 1997b:1). The value of indigenous archaeology is explored in detail, addressing issues such as postmodern archaeology, who controls the past, differing world views, one past/many pasts/whose past, and ultimately, presentations of the past (Nicholas and Andrews 1997b). The value of indigenous involvement at all levels of archaeology is clearly indicated as a way to address many of the issues associated with critical archaeology.

Trigger (1996) presents alternative archaeologies in the form of Nationalist, Colonialist, Imperialist approaches which have influenced, guided and shaped a variety of archaeological endeavours around the world. He also discusses at length the variety of political and economic influences which have affected archaeological traditions in many different countries (Trigger 1989, 1996). Nationalistic archaeologies tend to be monolithic and expose a *party line*, where there actually can be a multitude of heritages in the history of a nation (McGuire 1992:225). As McGuire (1992:225) puts it, the key battle is whose heritage becomes dominant and thus isomorphic with national identity. Trigger (1996:620) considers colonialist archaeology as that which developed either in countries whose native population was wholly replaced or overwhelmed by European settlement or where Europeans remained politically or economically dominant for a considerable period. Wherever practised, colonial archaeology serves to denigrate native societies and peoples by trying to show they have been static in prehistoric times. Nations of the Commonwealth under British domination are good examples of colonial situations. The rise of critical theory in archaeology in the United States has concerned itself with dominant colonial influences (see Leone 1995; Leone *et al.* 1987; Wylie 1985). Imperialist or world oriented archaeology is associated with a small number of states that enjoy or have exerted political dominance over large areas of the world (Trigger 1996:623-7). The New Archaeology through its nomothetic or lawlike generalizations which reflect poorly on the prestige of historical studies can be seen as the archaeological expression of post-War American imperialism, having a major world impact in orienting many archaeologists around the world, and by criticizing nationalist traditions (Trigger 1992:625). The dominance of western capitalism has been a common theme of critical archaeology in much of the westernized world (Trigger 1992:626). While much of the critical archaeology carried out in North America has focused on historical archaeology in the United States it has not been absent in Canada. While lagging behind in some respects, there has been a consistent undertone that Canadian archaeology does not have to emulate American archaeology and has maintained stronger British and European ties (Kelley and Williamson 1996:10). In the 1960s and 70s Canadian archaeologists were doing work that Americans had done in the 1930s and 40s (Kelley and Williamson 1996:10), not unlike the situation Trigger (1989:223) notes when comparing certain aspects of Soviet archaeology of the 1930s to that of the Americas in 1960s. One consequence of the expansion of archaeology in Canada during the 1960s is that historical archaeology was quite under-represented in Canadian Universities, but was prominent in Cultural Resource Management (CRM) circles, unlike the dual institutional prominence of CRM in the United States (Kelley and Williamson 1996:10). Thus, given the focus of critical archaeology upon historical archaeology it is not surprising that it is only recently that much attention has been directed to critical archaeology in Canadian universities.

On a worldwide level we might regard Trigger's (1989) comprehensive "*A History of Archaeological Thought*" as critical archaeology although more specific Canadian examples exist. It is possible to regard "*Captured Heritage: The Scramble for Northwest Coast Artifacts*" by Douglas Cole (1985) and Arthur J. Rays' (1996) history *"I Have Lived Here Since The World Began"* as critical Canadian commentary. Alison Wylie (1985, 1993) is a leading proponent of critical archaeology in Canada, addressing both gender issues and the settling of the west by European invaders. Recently at SFU, Olga Klimko's (1994) Ph.D. dissertation presented a history and critical analysis of the archaeology of land based fur trade posts in western Canada. The focus on the fur trade and European colonization in Canada fall into Trigger's national and colonial categories of alternative approaches to archaeology. Klimko approaches her critical review of the fur trade by focusing on the recent political uses of archaeology, the history of the discipline of archaeology as it pertains to fur trade archaeology as practiced in recent decades, and upon the political and cultural contexts at the time the work was done. In part she concludes, the problems inherent in the results of Canadian fur trade archaeology relate to nationalist, ethnocentric and tourism oriented political demands of recent times which were part of government heritage programs and not directly associated with universities (Klimko 1994).

In spite of criticisms, critical theory and its archaeological offspring, first forged in the fiery furnaces of modernist Marxism and subsequently refined in the multiple crucibles of postmodernist thought, has been tempered and sharpened in post-processual archaeological debate to make a valuable contribution as a critique that enlightens us to the potential for ideological influences on how archaeologists perceive and do their work, alerts them to ideological forces that are at play in the past contexts they study, emancipates interpretively under-represented groups and individuals, and provides opportunities for alternative explanatory interpretations of past culture change. George Orwell (1949:204 in McGuire 1992:217) who wrote in his book *"1984"* "Who controls the past controls the future; who controls the present controls the past" provides a concise summation of what the critical theory driven critique in post-processual archaeology is all about.

Any critical review must also consider context. Hodder (1991:143) notes that each object exists in many relevant dimensions at once, the totality of the relevant dimensions of variation around the object of study is identified as its context. In its simplest form Hodder says the context of an archaeological attribute, artifact type, culture or whatever is ***the totality of the relevant environment.*** Trigger (1989:348) says "the contextual approach is based on the conviction that archaeologists need to examine all possible aspects of an archaeological culture in order to understand the significance of each part of it." Contextual data according to Hodder (1991:143) provides "a rich network of associations and contrasts that can be followed through in building up towards an interpretation of meaning." Hodder (1991:145) goes on to note an object out of context cannot be read, historical archaeology, with its rich network of data (ethnographic accounts, histories, etc.), is easier to interpret, but it is clear that a critical approach to the data is necessary to properly assess the relevance of each context. In the case of wapato, pertinent ethnographic and historical information has been recorded in contexts removed from the prehistoric occurrence and use of the plant. An intense use of wapato likely occurred prior to the introduction of the potato (***Solanum tuberosum***) but many historic and ethnographic records of its use, save for the Fort Langley Journals, were collected decades or generations removed from its most intense use. While cultural change in the study area has been accelerated since first contact with Europeans, the scale of change in the physical environment has been less spectacular but is nevertheless significant. The creation of Indian Reserves, land alienation, diking and agriculture have all affected the contexts of wapato use. Critical review and contextualizing of the ethnographic and historical data relating to wapato contribute significantly to clarifying our view of wapato use and by extension other species.

Summary

It will be argued here that aspects of gender, colonial, national and imperialistic biases (Trigger 1989) addressed by critical archaeology are present and must be accounted for in our pursuit to understand the use of wapato in northwest North America. The historical and ethnographic information pertaining to wapato has been derived from the process of communication between individuals and from written records, a process potentially fraught with the biases and contextual problems as addressed by critical theory and by extension critical archaeology. These same data have been gathered in the totality of changing contexts, necessitating a critical review of contexts. The notion that wapato is well understood archaeologically will be refuted by the review and the potential importance of this valuable food plant resource will be established, if not archaeologically, then at least for the post-contact period.

As a final contribution, a wapato tuber charring experiment has been carried out and a review of a variety of ethnographic and other information will be used to resolve issues related to the paucity of paleobotanical information pertaining to wapato to subsequently provide a model for the potential archaeological occurrence of wapato. The experiment will be used to answer questions about the potential for identifying preserved charred remains resulting from the heating of wapato tubers and will provide comparative examples against which archaeological remains can be assessed. A disclaimer is in order here to avoid any confusion - the charring experiment is not intended to directly address wapato cooking in pit-hearths or open fires. It is felt that before looking for wapato in archaeological contexts that it is important to establish whether or not identifiable charred tuber remains can be anticipated, what parts of the wapato plant can be expected and whether cooked tuber remains can be identified. The result of the critical and contextual review combined with the charring experiment should provide a solid, factual base upon which further archaeological knowledge of wapato can be pursued.

Chapter 2 - Wapato In Katzie Traditional Territory

"Camas, so important to the Interior Salish and to some of the salt-water tribes, was evidently rare in Katzie territory;..."

Wayne Suttles, 1955:27
Katzie Ethnographic Notes

"The 'wild potatoes' obtained from down-river may have indeed been the camas, but one wonders about the failure to mention the commonest type of 'wild potato' — the arrowhead, Sagittaria latifolia."

Wilson Duff, 1952:73
The Upper Stalo Indians

Introduction

Wapato (*Sagittaria latifolia)*, once an important food plant for the Katzie, has frequently been mentioned in ethnographic and archaeological literature but is not as well known or understood as these sources seem to imply. In Katzie traditional territory wapato has never been identified in archaeological contexts, nor have the ethnographic and historic information sources been critically reviewed to place the information pertaining to wapato into a more contextually accurate framework. Finally, there is potential to extract useful information about wapato from native language sources that can further archaeological and ethnographic research and to-date this has only been done in a preliminary manner.

Chapter 2 will attempt to clarify a variety of issues pertaining to the ethnography and archaeology of wapato. First, the botany, local history and cooking and nutrition of wapato will be addressed. Second, a brief introduction to the Katzie, their territory, ethnography and language will be provided. Third, factors affecting the potential to find wapato in archaeological contexts will be discussed.

Finally, from a variety of linguistic and ethnobotanical sources a native language word listing for *wapato* will be provided along with some analysis of the results. The intention is to clarify many issues which potentially affect the study of wapato in Katzie traditional territory and to provide an accurate information base from which further archaeological and linguistic research can be launched.

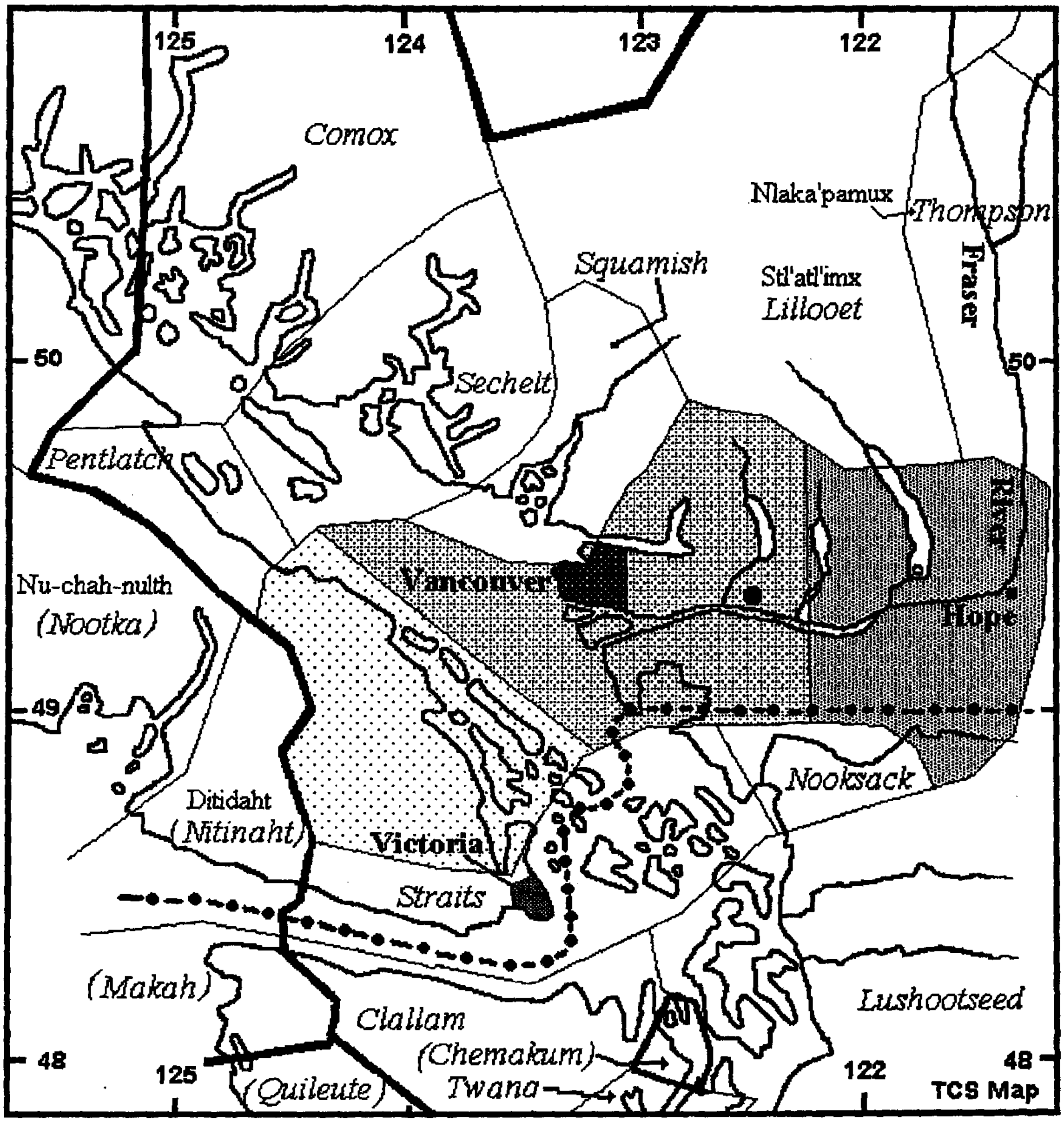
The Katzie

The area addressed in this study specifically focuses on the traditional territory of the Katzie First Nation. The Katzie, who are Halkomelem language speakers, are included in the lower Fraser River Stalo sub-group and are one of the Central Coast group of Coast Salish peoples (Suttles 1990:453). For linguistics purposes the area of study enlarges outwards from the Fraser Valley to include adjacent Coast Salish speaking neighbours shown in Figure 3. Katzie territory encompasses the easternmost portions of the municipalities of Port Coquitlam and Coquitlam west of the Pitt River, portions of Surrey and Langley south of and adjacent to the Fraser River, an area which includes Fort Langley. The area as shown in Figures 1 and 2 extends east through Maple Ridge to Websters Corner and north to the upper reaches of Pitt Lake and the Pitt River. Fort Langley, an early fur trade post, is specifically included because of its proximity, early post-contact economic importance and the fact that frequent mention is made of the Katzie and wapato in the *Fort Langley Journals, 1827-30* (Maclachlan 1998). Suttles (1998a) acknowledges the value of *The Fort Langley Journals* in providing a source of otherwise unavailable information about native activities of the time. The area addressed, based on Katzie traditional use, and ethnographic and historic references to Katzie activities, is not correlated with any legal territorial definitions. Here, only a brief overview is given of the landscape and the abundance of natural resources prehistorically available for exploitation.

Figure 3

Salishan Language

- Halkomelem Dialects -



After: Suttles 1990:454; Thompson & Kinkade 1990; Gerdts 1977.

Island Halkomelem

Downriver Halkomelem

Upriver Halkomelem

- Parentheses around name denotes a non-Salishan language.

Katzie traditional territory, approximately 50 km up the Fraser River from the ocean, is located within the Georgia Depression and the Coast Mountain physiographic regions. The lowland areas are just a few metres above sea level and prior to the advent of modern diking in 1892 (Collins 1975) were flooded annually by the Fraser River freshet. Today, low lying areas are still subject to seasonal and daily water level fluctuations. On a daily basis there are tides which ebb and flow in the regionally dominant drainages of the Fraser and Pitt Rivers, affecting the lower reaches of the Alouette River and Widgeon Creek drainages, and Pitt Lake. During the middle-Holocene, as the Fraser delta migrated southwestwards, the Pitt Polder area was part of a large estuary. Tidal Pitt Lake is located in a former fiord, long cut off from the ocean by sea level change (Ashley 1977). The daily tidal reversal continues to build a delta front that presently extends ca. 6 km into Pitt Lake (Ashley 1977). Alouette and Pitt Lakes are surrounded by mountains rising to elevations of 1,500 metres and more. Rising vertically, from lowland to highland elevations in successive order, the area is contained within the Coastal Douglas-fir, Coastal Western Hemlock and Subalpine Mountain Hemlock Biogeoclimatic Zones (Farley 1979). Driver (1998) provides a more detailed description of the geology, vegetation and wildlife. Figure 2 shows the lowland/highland distribution of terrain in Katzie traditional territory.

In the past the Katzie utilized the abundant natural resources of the region in an annual round of fishing, hunting and gathering. Because their traditional territory encompasses such a variety of natural settings the Katzie had ready access to fresh and saltwater fish, a wide variety of mammals and birds, and a plentiful supply of plant resources. The Fraser River supported predictable migrations of salmon which entered the local drainages, and other saltwater species such as eulachon and seals, in addition to resident sturgeon, were seasonally plentiful throughout the region. These species were all used by the Katzie (Driver and Spurgeon 1998; Suttles 1955; Woodcock 1996). For detailed accounts of Coast Salish ethnography refer to Barnett (1955) and Suttles (1987b and 1990).

Wapato

Wapato, also known as arrowhead, arrowleaf, Indian potato, swamp potato and duck-potato, produces starchy tubers which were an ethnographically known food source for native groups throughout much of North America. Although a few archaeological studies have been undertaken on *S. latifolia* (Darby 1996; Kubiak-Martens 1996; and Neuman *et al.* 1989), in southwestern British Columbia where it is documented as an important aboriginal food source there have been no archaeological studies. Wapato is mentioned in *The Fort Langley Journals* (Maclachlan 1998), and in the ethnographic work of Wayne Suttles (1955, 1987a and 1998a) and Wilson Duff (1952), both of whom studied the lifeways of the Salish people of the Fraser River region.

S. latifolia (Figure 4) is variously described as a marsh, semi-aquatic or aquatic herbaceous perennial with its above water foliage having leaves of a characteristic arrowhead shape (Borman *et al.* 1997; Brayshaw 1985; Pojar and MacKinnon 1994). There is consensus that wapato is often found in the margins of water bodies at depths less than 1 metre, commonly in depths of less than half a metre and pH readings of 5.9 - 8.8 (Marburger 1993:251). It is a member of the Alismataceae or Water Plantain family. Wapato is easily identified by its characteristic arrowhead shaped leaves, and white three petalled flowers (Figure 5). The plant produces ovoid tubers 1 to 3 cm in diameter in the substrate of shallow waters (Figure 6). The starchy tubers are storage organs produced from the plants' horizontally creeping underground stems or rhizomes. *S. latifolia* reproduces vegetatively from the

Figure 4

Wapato Plant Leaves

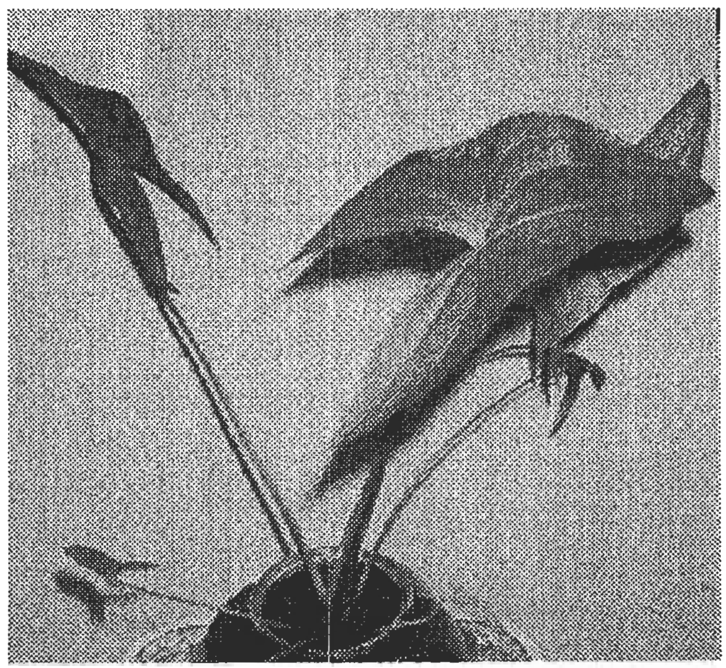


Figure 5

Wapato leaves and flowers

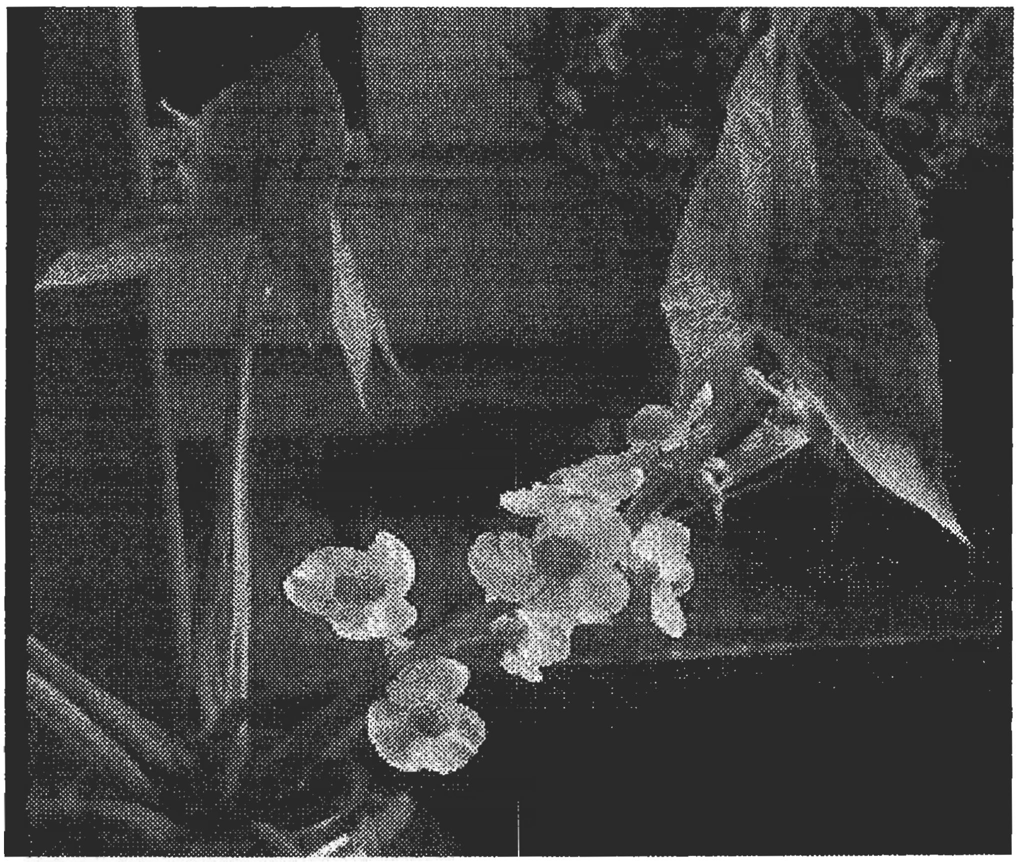
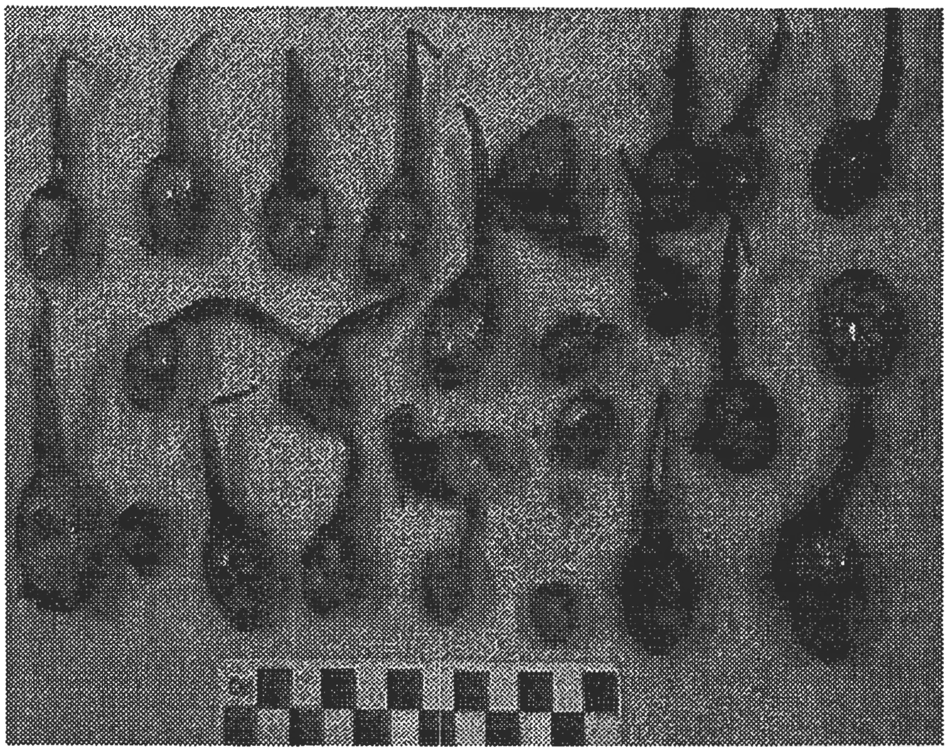


Figure 6

Wapato Tubers



- scale 1 cm

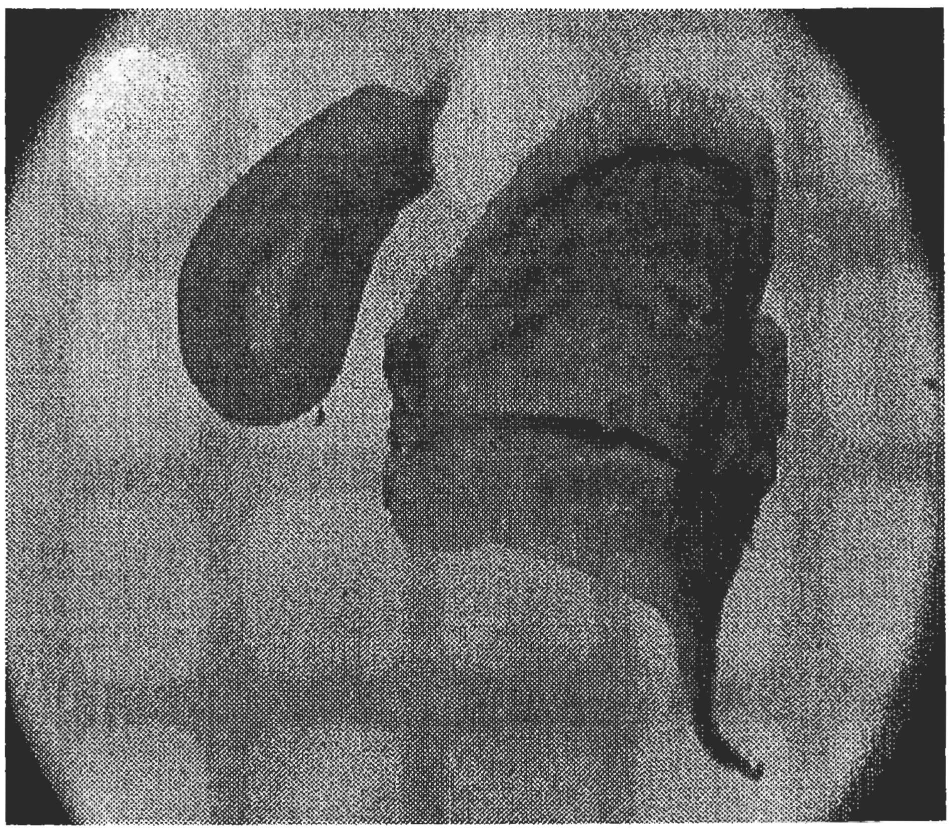
tubers and sexually from seeds. The fruits are flattened, beaked achenes (Figure 7). The production of tubers and achenes varies considerably with growing conditions (Marburger 1993). Widely used today for wetland enhancement, restoration and creation, this C_3 species tolerates and assimilates high levels of nutrients and heavy metals, and is eaten by insects, waterfowl, mammals and fish (Brayshaw 1985:45; Marburger 1993; Piper 1906). *Sagittaria cuneata* (Brayshaw 1985:45-46), another species of *Sagittaria* is widespread in British Columbia and elsewhere in North America but is not addressed further in this study. A more detailed morphological description and classification of roots and tubers which reproduce vegetatively can be found in Hather (1994). Hather's classification of roots and tubers addresses *S. sagittifolia,* the European and Asian species of arrowhead.

S. latifolia is found in both monoecious (bisexual) and dioecious (unisexual) forms (Brayshaw 1985:45; Marburger 1993:249-50; Wooten 1971). Monoecious plants bear both male (staminate) and female (pistillate) flowers on an individual plant whereas dioecious plants have their male and female sex organs on separate individuals (Capon 1990:173). Marburger (1993:250) notes that "dioecious forms are more limited in their ability to reproduce sexually, since out-crossing is obligatory." No attempt was made during the field work associated with this thesis to differentiate between the presence or absence of dioecious or monoecious wapato populations in the Pitt Polder.

S. latifolia and *S. sagittifolia* are generally physically similar, the main distinction here being the "New World, Old World" distribution difference. Bailey (1964:130) indicates the beak on the achenes of the latter are four times longer than the achene body. *S. sagittifolia* is also referred to as *S. chinensis* and *S. japonica* in its Chinese and Japanese variants (Simoons 1991:110). Consistent with

Figure 7

<u>Sagittaria latifolia (wapato) Achene and Embryo</u>



- 1 mm grid

descriptions in Porterfield (1940 and 1951), I have observed that the tubers of *S. sagittifolia* are more globular than those of the North American native *S. latifolia* which are somewhat flattened equatorially when viewed with the nodal line horizontal. Imported *S. sagittifolia* is available annually from local Asian food markets, especially around the Chinese New Year. Anderson (1925:134) notes the early presence of arrowhead tubers in the Chinese markets of the Pacific Northwest. They are larger than the local wapato tubers, a characteristic that might be attributed to their cultivation in controlled conditions. The local tubers are growing wild and are usually found in a silty, hard-packed substrate that locally contains an abundance of wood detritus that appears to distort the tubers as they grow.

While important nutritionally as a foodstuff, it should be noted that *S. latifolia* and its Asian relative were also used medicinally. Arnason *et al.* (1981:2243) report *S. latifolia* being used by the Iroquois to treat night crying in babies, and by the Ojibwa to treat indigestion, the former as an infusion and the latter as roots steeped with coneflower. Moerman (1998:500) details many medicinal uses for *S. latifolia* by native groups throughout North America. Porterfield (1940:47 and 1951:18) notes a number of therapeutic uses for arrowhead: "Bruised leaves are applied to infected sores, snake and insect bites, and as a powder to itching diseases. The eating of raw tubers is said to be dangerous, producing fluxes and hemorrhoids and inducing premature birth." There is no mention of Katzie use of *S. latifolia* for medicinal purposes in Woodcock (1996).

Wapato: Cooking and Nutrition

Mainly a starchy tuber of high water content, wapato provides a ready source of dietary carbohydrate. Wansnider (1997:2) states three reasons for cooking foodstuffs: 1.) to "advance the digestion process, so that more energy and nutrients can be obtained from any one mouthful of food" 2.) to "reduce the chance of illness by killing food-borne bacteria and parasites and by eliminating toxins that occur or develop in some tissues" 3.) so "spoilage bacteria are eliminated and water, needed by bacteria to grow, is reduced, so that the storage life of food may be extended." Cooking is an important factor in wapato nutrition as starch is not readily digested in the human gut without such processing (Englyst and Hudson 1997:9; Galliard 1987:3). Galliard (1987:3) notes that "because uncooked starch is poorly digested in the human alimentary tract, the main function of the various methods of cooking starchy materials is to convert starch granules to a form that can be attacked readily by the amylolytic enzymes of the digestive system."

Once harvested wapato tubers could be stored fresh, raw and unwashed, for several months according to Kuhnlein and Turner (1991:71). Wapato is reported as being eaten raw (Turner 1981:2341), cooked in hearths or hot ashes and in pits (Fladmark 1986:106; Haeberlin and Gunther 1930:23). Barnett (1955:60) indicates direct heating, steaming and boiling as the main cooking methods used by the Coast Salish but does not specifically mention wapato. Haeberlin and Gunther (1930:23) state that for the Puget Sound Indians "the principal methods of cooking were boiling with stones, steaming in a pit and roasting by an open fire." They refer to various kinds of roots and tubers, but do not specifically indicate a cooking method for wapato, instead noting that potatoes were pit cooked covered with sand. Boiling is the cooking method for wapato according to Anderson

(1925:134). Turner (1995:3) and Batdorf (1990:67) report wapato tubers being cooked in hot ashes. Annie York, consultant and co-author with Nancy Turner *et al.* (1990:113), describes the pit cooking of large quantities of wapato tubers by placing the tubers in a heated, covered pit. The earth oven or pit oven, dug into the earth uses a preheated stone cooking element covered by earth and layers boughs, leaves and the root food and then another layer of boughs and finally earth to bake or steam the food (Turner *et al.* 1990:30). Kuhnlein and Turner (1991:71) state that wapato tubers were "prepared for eating by boiling, or baking in hot ashes, or in underground pits, after which they could be eaten immediately or dried for long-term storage or trading." Darby (1996:69) indicates roasting in ashes or boiling as the most frequently mentioned cooking methods for wapato. The Katzie cooked wapato tubers as needed by baking them in hot ashes according to Suttles (1955:27). The use of clay lined roasting pits for processing wapato is attributed to interior influences reaching the coast from the Plateau area by Fladmark (1986:106). An AD 1749 report indicates that *S. latifolia* roots were either boiled or roasted in hot ashes by the Indians of the Missouri River region (Gilmore 1991:13). Porterfield (1940:46) reports that in China the tubers were boiled much as they cooked taro, *Colocasia*. Also in China, Simoons (1991:111) reports wapato tubers being baked, boiled or steamed. It is likely that boiling, steaming and baking were the cooking methods variously used by native peoples of the Northwest Coast to prepare wapato for consumption.

Wapato, when eaten raw is reported as having an unpleasant or bitter taste (Gibbons 1962:22; Kallas 1996:11; Sweet 1976:6). There are many modern recipes available for a variety of wapato dishes (Garrett 1975; Gibbons 1962). When cooked it resembles potatoes in taste and texture according to Gibbons (1962:22). Darby (1996:69) reports it as having a flavour similar to corn when roasted, and

Batdorf (1990:67) says it resembles potato in texture with a sweeter taste. Darby (1996:69) reports that roasting is more effective than boiling in eliminating the bitter taste. In fact all of Wansnider's previously noted reasons for cooking were likely at play in the cooking of wapato.

Because the terms starch and carbohydrate are used frequently in discussions about wapato it is appropriate to define them in more detail, particularly in the context of cooking which prepares the tubers for human consumption and ultimately may lead to the fortuitous archaeological preservation of wapato remains.

Starch is a type of carbohydrate, defined by the *Oxford Dictionary of Botany* (1996) as: a polysaccharide consisting of various proportions of two glucose polymers, amylose and amylopectin. Starch is the principal food-reserve polysaccharide in the plant kingdom forming the major source of carbohydrates in the human diet (Kennedy *et al.* 1987:115). It occurs widely in plants, especially roots, tubers, seeds and fruits, as a carbohydrate energy store. Starch is therefore also a major energy source for animals. When digested it ultimately yields glucose. Starch granules are insoluble in cold water but disrupt if heated to form a gelatinous solution. Porterfield, Jr. (1951) indicates that *S. latifolia* is 19.69% starch by weight (Table 1).

Carbohydrate is defined by the *Oxford Dictionary of Biology* (1996) as: one of a group of organic compounds based on the general formula $C_x(H_20)_y$. The simplest carbohydrates are the sugars (saccharides), including glucose and sucrose. Polysaccharides are carbohydrates of much greater molecular weight and complexity; examples are starch, glycogen and cellulose. Sugars, notably

Table 1

Nutrient composition - *Sagittaria latifolia*

Reference	Species	Kjoules x10^3	Calories	Protein(g)	Carbohydrate(g)	Ash(g)	Lipid(g)	Calcium(mg)	Iron(mg)	Magnesium(mg)	Zinc(mg)
H.H. Norton	*S. latifolia*	15.06	3.60	0.16	0.80	0.06	0.00	0.35	0.41	0.63	0.03
et al. 1984	*S. tuberosum*	15.73	3.76	0.10	0.85	0.04	0.00	0.35	0.03	1.09	0.02

- per gram dry weight

Reference	Species	Water	Protein	Starch	Fat	Albuminoids
W.M. Porterfield	*S. latifolia*	66.8%	4.4%	19.6%	1.0%	3.9%
1940	*S. sinensis*	61.5%	7.0%	22.9%	1.0%	4.7%

- from : Blasdale, W.C. A description of some Chinese vegetable food materials. USDA O.E.S. Bulletin 68:8 1899.

Reference	Species	Calories	Water	Protein - total	Starch	Fat	Protein - Albuminoids	Protein - Amides
W.M. Porterfield Jr.	*S. latifolia*	94 per 100 gm	68.88%	4.44%	19.69%	0.76%	3.98%	0.46% (by difference)
1951	*S. sinensis*	94 per 100 gm	61.51%	7.00%	22.95%	0.24%	4.71%	2.29% (by difference)

- cont'd.

- cont'd.

Species	Cane sugar	Pentosans	Crude fiber	Ash	Undetermined
S. latifolia	2.49%	-	0.98%	2.04%	2.71%
S. sinensis	*2.26%	0.32%	0.72%	1.69%	3.31%

* sample had no reducing sugars

Table 1 cont'd.

Nutrient composition - *Sagittaria latifolia*

Reference	Species	Water (g)	Ash (g)	Protein (g)	Carbohydrate (g)	Fibre (g)	Fat (g)	Riboflavin (μg)
Thor Arnason *et al.* 1981	*S. latifolia*	62.6	2.0	4.4	24.9	1.0	8.0	102

- in 100 g of plant material

Reference	Species	Food energy (kcal)	Water (g)	Protein (g)	Carbohydrate (g)	Crude fiber (g)	Fat (g)	Ash (g)
Kuhnlein &Turner 1991	*S. latifolia*	103	68	4.7	20.0	0.8	0.2	1.5

- per 100g fresh weight

- cont'd.

- cont'd.

Species	Thiamine (mg)	Riboflavin (mg)	Niacin (mg)	Vitamin C (mg)	Calcium (mg)	Phosphorus (mg)	Sodium (mg)	Potassium (mg)	Magnesium (mg)	Zinc (mg)	Iron (mg)
S. latifolia	1.60	0.25	1.4	5.0	12	165	22	922	51.0	0.7	6.6

- per 100g fresh weight

Reference	Species	Food Energy	Water	Ash (mg)	Protein (g)	Fat (g)	Ca (mg)	P (mg)	Na (mg)	K (mg)	Fe (mg)	Riboflavin (mg)
Horton (1987)	*S. tuberosum*	76 (kcal)	80 %	0.9	2.1	0.1	7.0	53.0	3.0	407.0	0.6	0.04

- per hundred gram edible portion

glucose, and their derivatives are essential intermediates in the conversion of food to energy. Starch and other polysaccharides serve as energy stores in plants, particularly seeds, tubers, etc., which provide a major energy source for animals, including man. Norton *et al.* (1984) indicate that *S. latifolia* contains 0.80 g of carbohydrate per gram of dry weight and Arnason *et al.* (1981) state that there are 24.9 g of carbohydrate in 100 grams of plant material (Table 1).

Caramelization, one result of cooking, is defined as the browning of sugars in anhydrous conditions using heat (Lee 1983:289). Caramelization reactions, heating under non-oxidizing conditions, transform sugars and are important for flavour formation, browning reactions and may give rise to changes in nutrition effects (Colonna *et al.* 1987:106). Caramelization is evident in the charring experiment reported in Chapter 4. Caramelization is likely present when wapato is roasted rather than boiled or steamed.

Speth and Spielman (1983) point out the importance of carbohydrates in hunter-gatherer diets particularly during lean periods when meat lacks sufficient fat content. This lack leads to several nutritional problems, among them elevated metabolic rates with correspondingly higher caloric needs and deficiencies in essential fatty acids (Speth and Spielman 1983). They indicate that carbohydrates are seen as an excellent substitute for the missing fats, with hunter-gatherer groups resorting to trade and limited cultivation activities to acquire needed carbohydrates. Wapato is potentially one such source of carbohydrate and was traded and sought after by groups not having local supplies of the tuber. Nutritional values for wapato as reported by several researchers are shown in Table 1. The table also includes values for *S. sinensis* and *Solanum tuberosum*.

Katzie Wapato Use and Trade

Wapato has particularly been associated with the Katzie whose traditional territory includes the Pitt Meadows and Pitt Polder lowland areas where it once grew in abundance. Wapato may have provided a predictable carbohydrate balance to a largely protein diet based on salmon, another predictable food resource. The Katzie and their neighbors maintained relationships based on the growing and trade of wapato. Katzie wapato harvesting and the associated pre-clearing and tending of wapato patches raises the issue of horticultural behavior in complex hunter/gatherer societies. Indeed, limited cultivation is noted by Speth and Spielman (1983:20) as a buffering strategy by hunter-gatherers to address the lack of fat in protein diets during winter and spring. Both Fladmark (1986:106) and Hayden (1990:40) note the emergence of rudimentary horticulture or plant management on the Northwest Coast. Hayden (1990:40) particularly associates this behaviour with the desirability of carbohydrates in a protein rich environment.

The Katzie seasonal round had approximately 12 months divided into 10 counted and two supernumerary months, the first of which coincided approximately with the calendar month of June (Jenness 1955:7). A variety of hunting, fishing and gathering activities occurred throughout the year culminating in potlatch and dance ceremonies at main villages during January and February. During the rainy, cold winter period the people stayed close to the main village, engaging in local food procurement activities not requiring extensive travel. In October the wapato harvest began in Katzie territory and continued through November (Suttles 1955:27). Wapato patches, either owned by families or the tribe, were located on the west bank of the Pitt River around Siwash Island, on the flats north of Sturgeon slough, with a shared patch located near the head of Sturgeon Slough (Suttles

1955:27). Some reports describe wapato harvesters wading in water and dislodging the tubers with their toes, or using canoes and pulling the plants free from the substrate (Pojar and MacKinnon 1994:337; Suttles 1955:27; Kuhnlein and Turner 1991:71; Turner 1995:37). It is not too great a leap to speculate that specialized tools similar to camas (*Camas quamash)* digging sticks (Haeberlin and Gunther 1930:20; Kuhnlein and Turner 1991:86) could have been used to augment the foregoing methods, although such perishable tools are not likely to be preserved archaeologically. The cultivation of introduced potatoes eliminated the requirement to enter water during the cooler months of the year, a necessary requirement to harvest wapato and was likely made easier through the introduction of metal tools acquired in trade.

There are many cross-cultural examples for the use of digging sticks. One example is associated with the cultivation of taro (*Colocasia esculenta)* in Oceania (Sillitoe 1983; Oliver 1989). Taro, which grows up to metre high, produces a large starchy corm (up to 30 cm long and 15 cm in diameter, propagates vegetatively, comes in many varieties and grows in dryland and wetland/aquatic conditions (Sillitoe 1983:37-42; Oliver 1989:190). Oliver (1989:194) indicates that digging stick cultivation techniques associated with taro include the loosening and turning of soil, digging planting holes and uprooting of tubers, some users employing different size sticks for different jobs. The commonest type of digging stick was pointed with the working end fire-hardened, although some from the New Guinea Highlands and New Caledonia had spatulate or shovel-like ends (Oliver 1989:194). Golson and Steensberg (1985:347-384) discuss a wide variety of such digging stick implements used in all phases of taro cultivation in the New Guinea Highlands for several millennia

Whether the movement of wapato in the Fraser River region was associated solely with trade or also involved free access to wapato for some outsiders is unclear. Acquisition by coastal and interior peoples of wapato from the Fraser Valley and specifically the Katzie area was common (Suttles 1955:26; Turner *et al.* 1990:113; Turner and Loewen 1998:Table 1). The Straits and Halkomelem Salish people on Vancouver Island acquired wapato from the Katzie as did the Squamish (Kuhnlein and Turner 1991:70). Turner (1997:160) mentions the Lower Nlaka'pamux of the Spuzzum area acquiring wapato from the Halkomelem people of the Fraser Valley. Katzie territory is reported as having patches that were shared with annual fall visitors. In one instance a large number of people congregated for the harvest at the confluence of the Pitt and Fraser Rivers (Maclachlan 1998:40).

The *Fort Langley Journal: 1827-30* (Maclachlan 1998:40) records the passage up-river on 21 December 1828 of Cowichan canoes laden with camas from Vancouver Island to be left in cache with salmon from the fall to use as food over the winter. Camas was rare in Katzie territory according to Suttles (1955:27) so it is possible that camas was one item used in trade for wapato. That such trade took place could be demonstrated archaeologically by finding charred wapato in archaeological contexts on the Island and charred camas in sites of the Fraser Valley.

Deserving further attention, but not to be addressed in any detail here is that some trade-goods received in exchange for wapato should be possible to identify in archaeological contexts if the goods were non-perishables *i.e.*, exotic lithics such as obsidian, jasper, crystal quartz, nephrite and perhaps larger bone and antler pieces. Of course, there is little likelihood of linking such goods to wapato trade archaeologically. The existence of prehistoric trade routes in British Columbia is well established (Ames and Maschner 1999:170-76; Carlson 1994:307-50). Primarily based on lithic evidence, especially obsidian, there is no reason to suspect that perishables such as wapato were not involved prehistorically given the ethnographic evidence for trade in numerous other perishable items which are not normally seen in the archaeological record. Turner and Loewen (1998) have compiled an extensive array of evidence for the trade and exchange of botanical products for Northwestern North America, and include the exchange of plant knowledge as an important factor. As paleobotanical research continues to increase on the Northwest Coast it is possible that preserved organic remains may contribute valuable evidence for trade and exchange involving botanicals such as wapato and camas.

Linguistics Background

Halkomelem, the native language spoken by the Katzie, is a member of the Salishan Language Family. Thompson and Kinkade (1990:33) divide Salish into five major sub-groups which include Bella Coola (Nuxalk), Central Salish, Tsamosan, Tillamook and Interior Salish branches. Another approach to sub-dividing the Salish Language Family is to place the 23 member languages into Coast and Plateau groups (Buchholtzer 1992:xxxvi). There have been a variety of classification schemes put forth for the native languages of British Columbia and the Northwest Coast, including detailed statistical and computer analysis of relationships within Coast Salish languages and culture (see Buchholtzer 1992:xxv-lv; Kinkade 1990:105; Jorgenson 1969), but the simple view of Coast and Interior Salish language groups suffices for this discussion.

Halkomelem is a Central Salish sub-family language existing as a "long continuum of intergrading dialects showing considerable diversity, but with mutual intelligibility throughout" (Thompson and Kinkade 1990:37). There are three dialects, referred to as Chilliwack, Musqueam and Cowichan by Thompson and Kinkade (1990:35), and frequently as Upriver, Downriver and Island dialects (Gerdts 1977:17; Suttles 1990:453-454). The three dialect divisions are more or less in consonance with cultural and ethnographic divisions presented by a variety of researchers (see Duff 1952; Mitchell 1971 and 1990; Suttles 1990). Suttles (1998b) discusses the difficulties the different Halkomelem dialects presented the English speaking recorders of *The Fort Langley Journals* when they recorded native group names. Prominent among these is the substitution of the sound *l* in the Upriver dialect for the sound *n* in the Downriver and Island dialects (see Thompson and Kinkade 1990:37). Figure 3 shows the Salishan languages of the regions adjacent to the Fraser Valley study area, plus the three part dialect division of the Halkomelem language.

Wapato Words

Table 2 is a listing of words for *S. latifolia* and *Solanum tuberosum* in various Northwest Coast native languages. The Table included in Appendix 1 provides language family and geographic details of the languages listed in Table 2. Table 2 provides a preliminary glimpse at the potential value that linguistics study has to further archaeological research focused on wapato. In the following commentary the number(s) enclosed in square brackets [#] corresponds to the number given each word listed in Table 2.

Wapato [1] is the Chinook Jargon trade language word for potato. This Pidgin language was used along the coast from the California/Oregon border to the Alaskan Panhandle at least since the time

Table 2

WAPATO GLOSSES

1. wapato - Chinook Trade Jargon; also known as *Sagittaria latifolia*, Indian potato, arrowleaf, duck potato, swamp potato, wapatoo; also reported as wap'to (Le Jeune 1924).

2. x^{w}aq'^{w}o'l?s - a distinct word for *Sagittaria latifolia* used by Katzie (Suttles 1955:27).

3. sqɛ́wθ - what visiting tribes to Katzie area called wapato (Suttles 1955:27).

4. scous or skous - Halkomelem for wapatoes or *S. latifolia* as recorded by Duff (1952:73).

5. skä'us - northern Straits, Halkomelem, Nooksack, word for tuber (Suttles 1987a:142).

6. sqéws - Lummi (Suttles 1987a:144).

7. sqáwc - Samish, Klallam and Northern Puget Sound (Lushootseed) (Suttles 1987a:144).

8. ska'us or ska'wec - Southern Straits, Klallam and Samish (Suttles 1987a:143).

9. s-qawc - Squamish for potato (Kuipers 1970:65).

10. sqaûc - Squamish for potato; Cw. sqɛwθ wapato, kows, potato; CdA s-qigwc "wild potato" (Kuipers 1967:295).

11. s-qawc - Mainland Comox for spud, potato (Davis 1968:84).

12. spiəqo'l'c - Puget Sound Salish (Suttles 1987a:142) - * he notes likely an error.

13. spiəqol'c - potato in Puget Sound dialects to south, old word for *Sagittaria* (Suttles 1987a:143) - *probably in error.

14. skawi'səl'ɬ - derivative word for the whole *Sagittaria* plant (Suttles 1987a:143).

15. s.píq^{w}uc or s.páyq^{w}uc - Puget Salish for potato; arrowhead plant, wapato (Hess 1976:340).

- s.pí?q^{w}uc - s.pq^{w}úc - s.píq^{w}ulc - s.píq^{w}úc - informant variants (Hess 1976:xiv).

16. spɩqɔ'ɑc - Twana for arrowhead or wa'pətu (Elmendorf 1960).

17. q'^{w}a·/q'^{w}úl's or q'^{w}ə·/q'^{w}úl's - Thompson (Nlaka'pamux) Interior Salish for *S. latifolia* (Turner *et al.* 1990); also Secwepemc (Shuswap)(Turner pers. comm.2001). ckwa/kwalul's or xk^{w}alk^{w}al-ul's - "opaque eyeball" Secwepemc (Turner pers. comm. 2001).

18. s-qawc - Lillooet (van Eijk 1997:246).

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19. sqig^{w}c - Coeur d'Alene from qig^w "dig roots" reconstructed as s-qawc (Kuipers 1970:65).

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20. qa.wac - Nootka for potatoes (Sapir and Swadesh 1939:292).

21. ska'wəs - Nootka word for potato (Suttles 1987a:143 from Dr. Morris Swadesh) - in error.

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22. skow-shī t - Haida word for potato (Dawson 1880:113B in Suttles 1987a:143).

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23. čwa - Klamath for root (wild potato or *S. latifolia*) and potato (Barker 1963:80, 524-5).

24. ma'mptu - Tualatin branch of Kalapuyan word for *Sagittaria latifolia* (Zenk 1976:85 in Darby 1996:63).

25. ma'mpɒu - Tualatin or Wappato Lake dialect of Kalapuya for wild potato (Jacobs 1945).

26. páapa - Lake Miwok (Penutian) for potato (Callaghan 1965).

27. wáala - Lake Miwok (Penutian) for Indian Potato (*Sagittaria latifolia*)(Callaghan 1965).

28. wakxa't - Wishram word for wapato (Spier and Sapir 1930:183 in Darby 1996:66).

29. tuk-hát or tuk'-hut - Chinook for wappatoo root (Gibbs 1863).

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30. ká·wats - Quileute for potatoes (from Chinook Jargon), (Powell and Woodruff 1976).

31. t̓sí·xak̢ - Quileute for root (edible), (Powell and Woodruff 1976).

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32. k'ona.'ka - Salinan Miqueleño for - bulb, wild potato (Mason 1918).

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33. ari-wa-wa-kon - Iroquois for *Sagittaria latifolia* (Arnason *et al.* 1981:2204).

34. ra-o-non-wa-ro-e - Mohawk for *S. latifolia* (Arnason *et al.* 1981).

35. oo$^{n'}$wa'ho'no^n - Seneca for *S. latifolia* tubers boiled (Arnason *et al.* 1981).

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36. muj'ota'bûk - Ojibwa for *S. latifolia* tubers dried and boiled for winter (Arnason *et al.* 1981).

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35. K'UHM-us - Practical Phonetic System - Halkomelem for wild potato (Wells 1965:39).

of contact with Europeans. Chinook Jargon, which has vocabulary accretions from indigenous native languages of the area, as well as French and English, should not be confused with native American Chinookan languages (Thompson and Kinkade 1990:41). Wapato as a jargon word for potato has a similarity with the Spanish words "batata" or sweet potato and "patata" or potato. It is not always clear from the literature whether wapato refers specifically to *Sagittaria latifolia* or *Solanum tuberosum* - the domesticated Irish or white potato. Today, it is generally conceded to refer to both, the latter having more or less replaced the former after its early introduction to the region (Suttles 1987a). Brown (1868:379), referring to *wappattoo (S. sagittifolia)*, states " Since the introduction of the potato the use of the roots of the *Sagittaria* has much declined, and the name is now transferred to the potato." Suttles (1987a:138-9) suggests several possible early sources for *S. tuberosum* on the Northwest Coast, all attributable to the presence of Russian, English and Spanish maritime explorers prior the close of the 18th century and to fur-traders early in the 19th century. There are no reported accounts which discuss the possible influx of potatoes to the Coast Salish area through native trade prior to these early white contacts. This is in contrast with *S. latifolia* which was widely traded by native peoples living along the Fraser and Columbia Rivers.

The existence of distinctively separate words, xʷaq'ʷo'l?s and q'ʷa·/q'ʷúl's, q'ʷə·/q'ʷúl's or xkʷalkʷal-ul's [2 & 17] for wapato in the Thompson, Secwepemc and Katzie areas may be significant as indicators of areas where *S. latifolia* grew, was traded and as words that existed before the more common *scous* or *skous* [4] variants and *wapato* [1] terminologies arrived.

There are numerous words which appear similar to sqɛ´wθ [3] and include all of [4, 5, 6, 7, 8, 9, 10, 11, 18, 19, 20 & 21]. These encompass an area which includes Howe Sound, the Fraser Valley, Vancouver Island, Puget Sound and the Gulf Islands, Lillooet and Northern Idaho. Kuipers (1970:65) notes an etymological similarity for [9 & 19] which involves Squamish and Coeur D'Alene, both Salish languages separated by some distance. Hess (1979) has reported the wavelike nature of the distribution of native words for *deer* in much of the same territory in which *wapato* words based on sqɛ́wθ [3] variants indicate similar patterning. He suggests that Halkomelem, as a centrally located Central Coast Salish language, served as the originator for the spread of the different words for *deer* (Hess 1979:10). The role of Halkomelem speaking people of the lower Fraser in up and downriver trade has already been noted, and this is consistent with the middlemen role speculated upon by Hess (1979:16) when he suggests that Halkomelem may have been "quite widely known - perhaps as an incipient pidgin, parallel to the case of Chinook along the lower Columbia River." A similar development for *wapato* words should not be surprising for the Halkomelem dialects and those other languages in the Gulf of Georgia and Puget Sound areas immediately adjacent to the Halkomelem speaking region.

The use of the word *wapato* seems to be related to trade and was generally applied to both *Sagittaria latifolia* and *Solanum tuberosum*, particularly in more recent times. Given the nature of Chinook Trade Language, trade would have facilitated cross-language communication and the associated passage of native language variants between adjacent dialects and close language neighbours. The movement of wapato throughout the Halkomelem area down the Fraser River and across the Gulf of Georgia, up the Fraser River to Stl'atl'mix (Lillooet) and Nlaka'pamux (Thompson) country, and into Howe Sound to Squamish is evident in the word morphology similarities. For more distant language groups there is little word morphology similarity in evidence and this may be a function of Chinook Trade Jargon usage and limited contact due to distance from the Fraser Valley. There is no similarity in word morphology between the Fraser River associated languages and those of the Columbia River groups [24 & 25], the other well known *S. latifolia* growing and trade area. The lack of similarity suggests differing native language origins for *wapato* words for these distinct areas, a problem made more difficult to resolve with the advent of the Chinook Trade Jargon and the rapid spread and common use of the term "wapato."

Quileute [30] and NuuChahNulth (Nootka) [20 & 21] words for potato appear similar. Suttles (1987a) indicates the Nootka word [21] is in error, but the similarity of the Nootka word [20] to the Lushootseed word [7], the Southern Straits [8], Squamish [9] and Mainland Comox [11] words is apparent. All of these languages are immediately adjacent to Halkomelem, and in the case of Nootka perhaps provided the language link to Quileute via the Olympic Peninsula and the Makah, or alternatively the adjacency of Lushootseed and Straits may have influenced the Quileute usage.

That *Sagittaria latifolia* was present throughout much of North America and widely used by native peoples elsewhere is indicated by the variety of words [32, 33, 34, 35 & 36] attributed to other native languages well removed from the Northwest Coast region, albeit a somewhat limited listing at this juncture. These words also serve to demonstrate the rich variety and dissimilar nature of the many native languages spoken in North America.

What was intended by Wells (1965) for his variant for wild potato [35] is unclear. Perhaps, as is evident in the Preface and Introduction of his vocabulary booklet, the development of the Practical Phonetic System (PPS) used by Wells springs from a frustration with complicated phonetic systems only understood by scholars, and for his era (1965), which pre-dates the easy availability of the printers and varied computer fonts in use today, the lack of facility to easily reproduce phonetically standard listings. His word [35] shows little similarity with others listed for Halkomelem, a situation that may be more a result of my linguistically unpractised eye and ear, exactly the situation apparently frustrating Wells. This is a problem likely even more complicated for the journal recorders at Fort Langley in 1827-30. Notwithstanding, his list refers to wild potato which as discussed in the next chapter raises the potential for confusion with other plants and thus his word [35] may not refer to wapato at all.

There is more work to be done collecting native language words for *wapato* to complete the listing with entries from Northwest Coast languages not yet included, and for native languages elsewhere in North America. Language changes such as neologisms, loans and coinages which have impacted native languages since contact must be also be considered. The extinction of some languages, the great reduction in the number of speakers for others and the ever changing nature of these indigenous languages in adapting to new circumstances may inevitably have some bearing on the matter at hand Indeed, the terminology used by recorders and researchers in referring to wapato, potatoes and the scientific nomenclature have some relevance too.

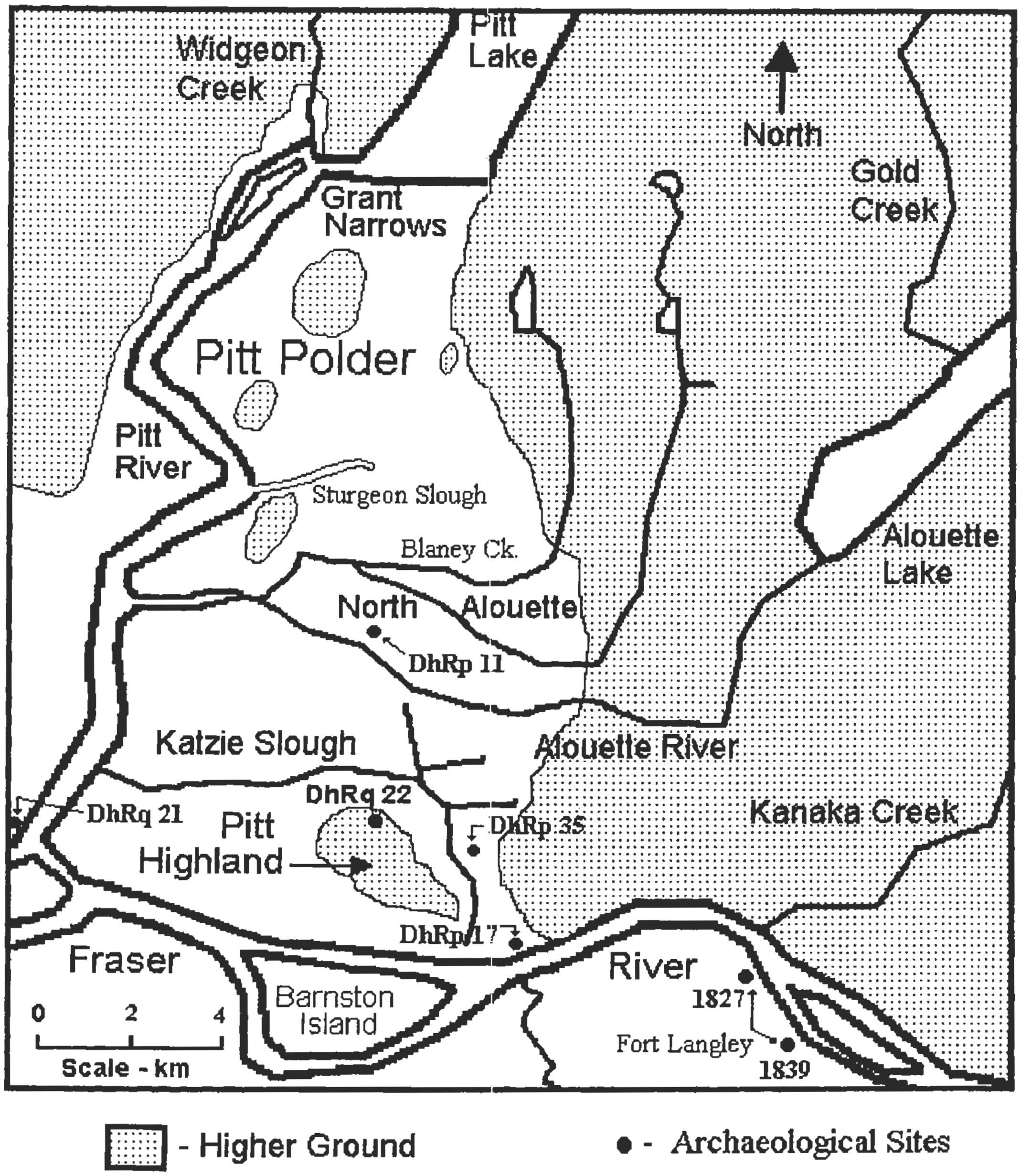
Archaeological Sites

The traditional territory of the KFN contains several excavated archaeological sites. There are numerous recorded but unexcavated sites in Katzie traditional territory. Potentially, there are numerous unrecorded sites in the area as surveys have not fully covered the area nor have they focused on all locales of high potential (Driver and Spurgeon 1998:92). The excavated sites are: Port Hammond (DhRp 17 - Smith 1903); Carruthers (DhRp 11 - Crowe-Swords 1974); Pitt River (DhRq 21 - Patenaude 1985); Telep (DhRq 35 - Peacock 1981) and Park Farm (DhRq 22 - Spurgeon 1984, 1994, 1996, 1998b). The locations of the archaeological sites are shown in Figure 8. As noted earlier site reports for the area mention wapato but none of them have demonstrated the archaeological presence of wapato remains. Paleobotanical remains were specifically looked for in the last three excavations listed. The potential to contain wapato remains for each of the five sites is discussed briefly here. The radiocarbon dates included are uncalibrated and as listed in the original reports. For a detailed analysis of these and all other radiocarbon dates for Katzie traditional territory see Spurgeon (1998c:Appendix B).

The Port Hammond site is a shell midden which has been mostly destroyed by development. There still may be some undisturbed deposits remaining to excavate using modern archaeological techniques unlike those used by Harlan I. Smith (1903) at the end of the 19th century. The site contains a variety of non-local lithic materials such as obsidian, crystalline quartz, red jasper, nephrite and chalcedony which may have arrived in the area as a result of trade. On the north shore of the Fraser the site was easily accessible to those travelling the river. Burley (1980:43) describes it as a Marpole occupation on the basis of artifacts illustrated by Smith. An AMS date of 1,995 +/- 80 radiocarbon years has been reported by McMillan and Nelson (1989:216) for a mammal bone club (presumed to be whalebone on the basis of size) purported to be from Hammond, indicating a Marpole Phase occupation.

Figure 8

ARCHAEOLOGICAL SITES



DhRq 22 - Park Farm (Spurgeon 1984,1994) DhRp 35 - Telep (Peacock 1982)

DhRp 17 - Port Hammond (Smith 1903) DhRp 11 - Carruthers (Crowe-Swords 1974)

DhRq 21 - Pitt River (Patenaude 1985)

Recently, as part of an Archaeological Alteration Permit monitoring project numerous artifacts were recovered from beneath a cedar dry kiln floor (Antiquus 2001). Five radiocarbon dates with conventional radiocarbon ages spanning the period 1530+/-60 BP to 1910+/-80 BP were reported (Antiquus 2001:Table 7). The radiocarbon dates and the artifacts confirm the Marpole Phase assignment for Hammond. The monitoring project also conducted some flotation to recover paleobotanical remains. The seed remains included Cyperaceae (Sedge family), Gramineae (Grass family), Caprifolaceae (Honeysuckle family), Chenopodiaceae, Polygonaceae (Buckwheat family), and Roseacea (strawberry) but no evidence for the presence of *S. latifolia* (Antiquus 2001:84-86).

The Carruthers Site is a series of mounds extending approximately 365 metres along a tributary slough, in the area of low, flat land between the North Alouette and South Alouette Rivers (Kidd 1968:225). Crowe-Swords (1974:159) who excavated the site interpreted it as a hunting and gathering base, and secondarily as a fishing camp. There are no radiocarbon dates, but the site was assigned to the period AD 400-800 on the basis of typological studies of the lithics. Crowe-Swords (1974:18) suggested the "specific location of the Carruthers site is likely due to the availability of a multiplicity of edible resources......in particular the Indian potato may be the specific locational factor." No archaeological information is provided to substantiate this conclusion. The site contains overlapped discontinuous lenses of charcoal, ash, burned soil, dark midden material, fire cracked rock and small pockets of clay hardened as if by heating (Crowe-Swords 1974:42). The clay-lined depression features reported have no rock, ash or charcoal associated, are surrounded by postholes suggestive of structures overhead and were not likely to have been used as firepits (Crowe-Swords

1974:53). There was no identification of botanical remains in the site sediments, nor is there any indication that paleoethnobotanical investigations were contemplated or conducted. The site is located in an area that once contained wapato patches and could have been a wapato processing site. The nearby Alouette River was a much larger river prior to the damming of the Alouette Lakes and the advent of diking which now restricts flooding (see Driver and Spurgeon 1998). This site was likely quite wet at periods throughout the year.

The Pitt River Site was interpreted by Patenaude (1985:289) as a late summer/fall camp for the harvesting and processing of salmon, wapato and berries. The artifact collection contains a wide variety of stone tools and detritus. Poor preservation of faunal and floral remains is reported. Pit features, rock lined hearths and many earth-ovens were excavated. The pit features were dug into "hardpan clay", some with cobbles pressed into the rim and postholes surrounding, but none with evidence of fire (Patenaude 1985:10 Vol. II). The layered earth-oven features are described as typical of those described in ethnographic reports for the region but lacking rock in association (Patenaude 1985:5 Vol. II). The site apparently includes components of the Charles, Locarno Beach and Marpole cultures, with possible later occupations. Radiocarbon dates span the period from 4,390 to 216 radiocarbon years BP (Patenaude 1985:15). Wapato was noted growing in the vicinity of the site (Patenaude 1985:31). The site is located at the mouth of the Pitt River where it enters the Fraser River, the location where *The Fort Langley Journals, 1827-30* (Maclachlan 1998) report large numbers of natives gathering to harvest wapato. The probability of wapato being processed at this site is high, although deerberry or wild lily-of-the-valley (*Maianthemum dilatatum*) seeds were the dominant plant remain recovered from earth-ovens using water screening of sediments, dry mesh screening and flotation (Patenaude 1985:163 and Appendix 1-4:358). It is likely that charred wapato remains could have been recovered using these methods, but it is unclear whether such remains could have been identified at that time. Archaeological remains of wapato were not identified in the site.

The Telep site was excavated and reported by Peacock (1981) who describes it as a late autumn salmon and duck hunting camp (Peacock 1981:225). The site is near the north-westward flowing Katzie Slough drainage which runs from Port Hammond to the Pitt River as noted by Smith (1903:136) and Suttles (1955:11). It is assigned to the Locarno Beach culture type and was radiocarbon dated to circa 3,000 radiocarbon years BP (Peacock 1981:9). Critical comment on the usefulness of the Telep Site radiocarbon dates is contained in Driver and Spurgeon (1998:Appendix B). Chipped stone lithics dominate the artifact assemblage with poor preservation of faunal and floral remains reported. A preliminary flotation test was done on three sediment samples from a hearth feature with only wood charcoal fragments being recovered (Peacock 1981:152). Hearths were noted with fragments of duck, fish and mammal bone present (Peacock 1981:168). No features associated with plant processing were present, but some artifacts had plant residues present in the form of starch (Peacock 1981:208; Broderick 1981:Appendix 2 in Peacock 1981). The starch remains were not attributed to specific plants.

The Park Farm site is located on the northern edge of the Pitt Meadows highland which rises several metres above the surrounding lowland. The site is a palimpsest of occupations radiocarbon dated from ca. 4,200 years ago to ca. 300 years ago. Charles, Locarno, Marpole and Developed Coast Salish Phase components are present. Stone tools dominate but there are fragmentary faunal remains and some floral remains. The lithics include a wide variety of materials including obsidian from Three Sisters, Oregon. There are numerous hearths, pit-ovens and clay lined cooking features (see Spurgeon 1998b for details), the latter having produced floral remains when floated. The recovered plant remains have not been analyzed in detail. There are many concentrations of charcoal associated with the features. The site is thought to be a three season resource procurement and processing site with no winter occupation yet identified. The more exotic lithics present are indicative of trade and exchange, while pit-ovens and clay lined cooking features indicate the processing of food resources. The site is a good candidate for the identification of preserved wapato remains.

Summary

The Katzie are Halkomelem speakers whose traditional territory provided an abundance of subsistence resources. One of these, wapato, was particularly associated with the Katzie. Wapato, an aquatic plant that produces starchy tubers, provides a predictable source of carbohydrate to complement the variety of protein rich resources available. Elsewhere, today wapato is used to absorb heavy metals from polluted wetlands (Marburger 1993). Its distribution is widespread in North America and there is an old world species that is cultivated and eaten in Asia and imported and sold in Chinese groceries of North America.

Wapato tubers were harvested by women in the fall and winter months and cooked in earth-ovens or the ashes of hearths. Once cooked they could be stored for several months. Ethnographies report a variety of harvesting methods including pulling the whole plant, including tubers, from the substrate by its above ground foliage, the use of feet and toes to dislodge the tubers from the substrate for gathering as they float to the surface and finally the use of digging sticks to dislodge tubers (Darby 1996; Suttles 1955). Wapato patches were owned and tended by families or available for use by the community at large. The tubers were much sought after by neighbouring Salish speaking people from Vancouver Island, the adjacent interior region and the Squamish area. Wapato was aquired by outsiders as part of the annual salmon fishing gatherings on the Fraser River.

While the linguistic information presented in Table 2 is preliminary in nature it does suggest there is more to learn about *wapato* through further linguistic study. Patterns of trade may be linked to dialect and language commonality and with additional work collecting *wapato* words, the patterns might be traced more accurately. Perhaps it may be possible to identify in a similar manner the way wapato terminology has spread with attention to adjacent dialects in the Halkomelem language area and the implications for trade from further afield. Addressing native language terminology for landscape features and places (see Suttles 1955:16) might also prove informative. Additional study of words associated with other plant and animal species, especially where word root forms are expanded upon in a variety of applications, in concert with landscape words, might cast additional light upon dimly perceived prehistoric behaviours that can often only be interpreted on the basis of lifeless artifacts and the use of ethnographic data. Clearly more linguistics research is warranted to construct a more comprehensive picture from the puzzle pieces provided by a variety of related disciplines. The inescapable conclusion is that archaeological research, at least that focused on more recent prehistory, can benefit from linguistics data as is evident in this preliminary work.

There are several well known archaeological sites in traditional Katzie territory but none have produced direct, unequivocal evidence for the processing of wapato. Tantalizing glimpses of cooking features that might contain wapato remains are evident. The inclusion of paleobotanical considerations in future research designs aimed at positively identifying wapato in archaeological contexts in KFN traditional territory and elsewhere is needed.

Chapter 3 - Critical Review of the History, Ethnography and Linguistics of Wapato

"We hear that a mass of Indians are now collected there, and that their women are busied in gathering Wappatoes (wapatos) a root of which they are particularly fond, and which is found under the water in Pools and Marshes. The Indians here call it Skous, tho' I have given it the name by which it is known on the Columbia.

George Barnston
The Fort Langley Journals 1827-3
(Maclachlan 1998:40)

Introduction

In this chapter a critical review is conducted of the data pertaining to wapato presented in Chapter 2 in order to provide a more understandable framework in which to study traditional Katzie use of wapato and ultimately to set the stage for dealing with wapato in possible archaeological contexts. The need for this type of analysis should be self-evident given the modern emergence of critical archaeology whose main tenets were derived from ethnography and history by archaeologists. Additionally, the frequent and uncritical use of ethnographic analysis and the direct historical approach to augment or initiate archaeological interpretations demands that greater attention be paid to critical review of original sources to avoid perpetuating misleading interpretations.

Searching For Bias

Recognition of bias is an important consideration in the process of critically reviewing the information available. Hammersley and Gomm (1997:1.1) conclude that accusations of bias are a recurrent event in the social sciences. They make the point that in response to such accusations of bias there is often a counter-charge that it is not the original research that is at fault, it is the evaluation of the research that is biased. Bias exists in three main forms in their view: the first is "the adoption of a particular perspective from which some things become salient and others merge into the background"; and secondly in reference to systematic error, or "deviation from a true score as a valid measurement of some phenomenon or to accurate estimation of some population parameter"; and lastly in a more specific form denoting a particular form of systematic error: "that deriving from an unconscious or conscious tendency on the part of the researcher to produce data, and/or to interpret them, in a way that inclines towards erroneous conclusions which are in line with his or her commitments" (Hammersley and Gomm 1997:1.1).

Communication in the form of verbal accounts, written records and observed behaviour provide the basis upon which the historic and ethnographic information researchers use was recorded. Communication implies something in the way of information being transmitted from the source and the reception of this information by the recorder. For the former the expectations of the enquirer may not always be fully understood and for the latter understanding of the information being transmitted may not always be clear. Subsequently, users of the recorded information also bring their biases and potential for misunderstanding into the process, often at great distances in time and space. Obviously the process is fraught with potential problems that must be addressed to ensure the veracity of the final record and subsequent interpretations. Assuming the process at least includes an informant and a recorder, for now leaving out the ultimate user, some of the problems are:

- recorder qualifications - writing ability, language understanding
- recorder and informant comprehension - what is really meant?
- informant knowledge and biases - gender, width of view (family, community) and validity
- informant distance in time from the activity being recorded

- distance in time the recording takes place from the activity being recorded
- translation problems - is a potato a potato?
- do informants intentionally mislead or are they misinformed?
- do recorders inject their biases and is the research itself biased?

Glavin (2000:7) puts the need to consider these numerous ramifications quite succinctly when he states "Sorting out the history of the North Pacific involves the business of considering questions not only about the observed but also about the observer and the observer's own culture and ideology." Such questions pertaining to Katzie traditional territory are initially examined in Driver and Spurgeon (1998) and are further pursued in the following examination.

Analysis of the quotation at the start of this chapter serves to illustrate the potential problems attendant upon uncritically accepting information at face value from quotations taken from a variety of historic and ethnographic sources. Taken as a whole such sources offer something of value when studying wapato, but nearly all can be misleading. There are potential problems with subject, intent, context, recorder and informant bias and many other issues. An excellent example is how the Barnston quote appears in different sources. The transcription by MacIntosh (1963:26) of the original archival copy reads:

> "*We hear that a mass of Indians are now collected there, but that most of them intend soon to clear out entirely for their lands, not to return again until next summer. It appears that they procure, where they are at present, a great number of Wappatoes a root found under water in pools and marshes, and held by them in great estimation as an article of food. The name they give it here is Scous or rather Skous. On the Columbia it is known by the one first mentioned.*"

The MacIntosh (1963) version does not attribute the entry to Barnston, implying that it is a journal entry by James MacMillan. Duff (1952:73) has essentially the same information, although he names the location as the "Forks" (of Pitt and Fraser Rivers) whereas the MacIntosh transcription of Barnston refers to the location as "the forks below." It is the recent work of MacLachlan (1998:40) that attributes the entry to George Barnston and introduces the notion that women did the digging, although there is no mention of women doing the digging in the other versions. Several references to this passage refer to 5,000 Indians assembled at the confluence to dig skous on return from salmon fishing up-river (Suttles 1987a:142 footnote 12; McKelvie 1947:33, 1991:39) although no such figure exists in the original journal. It appears this number originates from an 1829 estimate in a separate report by a Hudson's Bay Chief Factor (Duff 1952:26; Murphy 1929:19). Overall, there is evidence here of bias, error and interpretation, all added at later dates well removed from the original to enhance the quotation, notwithstanding that events may well have transpired each year as indicated. There is a hint here that one should take care in regards to the absolute veracity of such sources.

An important role of archaeology in addition to understanding the past is in providing historical perspective for understanding ethnographic data (Trigger 1989:336). Trigger indicates that anthropologists are coming to believe that "ethnologists and social anthropologists, whether studying social structure or change, are investigating the results of acculturation because their data are derived from small-scale societies that are either being destroyed or integrated ever more completely into the modern world system." He further notes that it is clear that no society can be properly understood or classified structurally unless its relationships with other societies is taken into account (Trigger 1989:336). This is an idea in consonance with Hodder's overarching view of context noted earlier.

On the Northwest Coast bias at a high level is quite evident in several forms. There is a bias in archaeological artifact preservation, where lithics dominate and faunal and floral remains are less successful in surviving the vagaries of taphonomic processes. The bias in artifact recovery results in the dominance of lithics analysis in reports, while faunal and especially floral analysis are less evident. Faunal analysis is more prevalent than botanical analysis which is only emerging in the last decade as a major focus in research design, recovery and interpretation (Lepofsky 2002). The traditional categorizing of hunter-gatherer bands and sedentary agricultural societies into separate entities is somewhat problematic on the Northwest Coast as sedentary collectors have more in common demographically, socially and politically with agriculturalists than they do with most hunter-gatherers (Trigger 1989:399). Archaeology can lead to re-interpretation of misleading or erroneous information in historic and ethnological information, this being evident in the emergence of paleoethnobotany as a major force on the Northwest Coast (Lepofsky 2002; Lepofsky *et al.* nd.; Loewen 1998; Lyons 2000). The following quote best sums up the present situation regarding typical Northwest Coast ethnography:

> *"When field notes were worked up into books, an academic datum plane was created: traditional Northwest Coast culture. If ethnographers asked their questions at the end of the nineteenth or early in the twentieth century, as many of them did, their informants remembered and described early- to mid-nineteenth-century societies. This was the slice of time that ethnography transformed into timeless traditional culture."*
>
> Harris (1997:28)

The remainder of this chapter takes a critical look at local ethnography, history, linguistics, context and bias to set the stage for understanding wapato in its modern and prehistoric environments.

Historic and Ethnographic Impacts Affecting the Study of Wapato

The potential entry of myriad biases into the historic and ethnographic record regarding wapato must be accounted for. All of the possible entry points for misleading information or bias as noted in the introduction are potentially at play when studying wapato in Katzie territory.

To properly conduct archaeological interpretations of wapato it is appropriate to use accepted archaeological methods to arrive at interpretations. Also, it is necessary to more fully pursue our understanding of the roots of our modern knowledge of wapato. The archaeological methods of paleoethnobotany should be directed at the matter. In conjunction, it is useful to address the numerous historic changes since contact that have influenced our present knowledge of wapato use and affect the potential to confidently use the direct historical approach or ethnographic analogy as methods to infer prehistoric practices. Table 3 presents post-contact influences which have regionally affected our modern understanding of this plant resource. The table presents the major influences in more or less chronological order from the present to early contact times and includes brief comments on each of the impacts listed. Accompanying these influences, especially since dyking commenced, is a continuous disturbance to or loss of archaeological sites. Represented in the table is an almost continuous series of impacts with both one-time and cumulative effects such that any speculation about wapato must be tempered with at least one or more of these factors. For many traditional uses the local native population was precluded from accessing significant portions of the landscape by land alienation which, while distributing land first to speculators (Collins 1975) and later to settlers, excluded native land ownership.

TABLE 3

Factors affecting wapato use in Katzie traditional territory:

Major Influence	Associated Impact(s)
* Urbanization and development	Since 1860 - ever increasing access restrictions to traditional use areas.
* Hydroelectric development	Since dam construction in 1925 - reduced water flow in Alouette River, changes to Alouette Lake(s).
* Forestry	Since late 19th century, ending by 1930. Mainly second growth left, large forest fires burned remainder ending logging. Access roads and hydrology disruptions.
* Agriculture	Mainly since dyking - reduced access, increased biotic disruptions, crops and pastures replace native plants.
* Dyking	Started in 1892 - diversions, ditches, dredging, continuing maintenance, major biotic disruptions.
* Botanical nomenclature	Old world/New world plant naming conventions.
* Land alienation/Indian Reserves	Since 1860 - reduced or prohibited access to traditional use areas, ghetto like treatment of native population; land surveying started.
* Colony status granted	1858 - new government, spurs settlement, irrevocably sustains new economy.
* Language change	Constant erosion/change to native languages.
* Fur Trade/Fort Langley	1827 - a new economy introduced - furs, money, jobs, trade goods, demand for consumer items such as food products.
* Simon Fraser	Spring 1808 - Fraser river in freshet, notes expanses of water in Fraser Valley area, natives with firearms at mouth.
* Potato (*Solanum tuberosum*) introduced	May signal end of large scale wapato harvest.
* First contacts/ Disease	Pre- AD 1800 - native population reduction begins, trade goods introduced.

The continuous depredations of disease, estimated to have reduced pre-contact native population levels by up to ninety percent, would have limited traditional uses. This factor coupled with the relatively late or, depending on viewpoint, recent gathering of ethnographic data (cf. Jenness 1955; Suttles 1955) raises questions about the accuracy of male dominated information about female activities and the nature of what was being reported and its closeness to pre-contact practices. Suttles (1987a:16 footnote 2) notes that personal recollections of the oldest informants did not date back earlier than the 1870s and 80s, a situation that raises questions then about the potential archaeological significance of some ethnographic reconstructions. It has been pointed out to me by Katzie band members that the knowledge of one family group about wapato as reported in Suttles (1955) might not necessarily reflect that of another family group.

An exception to closeness in time would be *The Fort Langley Journals: 1827-30* (Maclachlan 1998) which record activities during the AD 1827-30 period but have their own problems relating to the recorder's old world colonial and cultural biases and their difficulties in understanding and writing native languages (Suttles 1998b). The accompanying new economic climate where paid jobs, trade goods and changed markets dominated, would have affected wapato use through the introduction of potato (*S. tuberosum)* growing by natives for their own consumption and to serve local white markets. Suttles (1987a:145) suggests that in addition to meeting their own food needs the natives also grew potatoes because they had cash value at nearby trading posts. In contrast, the Fort Langley Journals (Maclachlan 1998:112) note potatoes (*S. tuberosum*) from the Fort being used as payment to native labourers in May 1829. Brown (1868:380) notes that native grown potatoes (*S. tuberosum*) commanded higher prices, even from whitemen, than any other potatoes. More discussion of the impacts can be found in Spurgeon (1998a).

Recently, landscape studies in archaeology have become popular in addressing people's interaction with their environment; indeed such studies are a fundamental part of studying prehistoric cultures. Contextualizing the landscape of the time and documenting the changes which have occurred e.g., diking, land alienation, are important in the understanding of wapato. Wapato is initially difficult to find in the absence of context and detailed study of relevant modern botanical information.

Botanists, ethnographers and historians variously refer to wapato as *Sagittaria sagittifolia* or *Sagittaria latifolia* depending on the date of the record. Early records compiled by European researchers will likely refer to wapato as *Sagittaria sagittifolia*, for the species nomenclature with which they were familiar in the Old World. Later recorders eventually adopted the plant classification *Sagittaria latifolia* to conform to the more modern convention for the New World species of the plant. Coupled with the variable native language words and meanings when referring to wapato and potatoes, the issue is further complicated. A factor complicating our knowledge of wapato is the rapid influx of the common potato (*Solanum tuberosum)* following first contact with Europeans as documented by Suttles (1987a). The rapid influx may in part have contributed to the decline in wapato consumption (Brown 1868:379; Rivera 1949:21). A comparison of the nutrient composition of *S. tuberosum* and *S. latifolia* as reported by Norton *et al.* (1984) and Horton (1987:94) in Table 1 shows them to be quite similar. The major difference between the two species is in their growing and harvesting conditions. Wapato is grown and harvested in water whereas *S. tuberosum* is grown and harvested on dry land.

Pitt Polder Climate

As noted, wapato was generally harvested between October and March. Periods of colder temperatures may have had energy gain and loss implications related to harvesting activity and success. This is particularly so where tuber recovery required harvesters to enter the water as noted in ethnographic accounts. In order to better understand the present day climate of the Pitt Polder area, especially for the colder months, a regular weekly set of qualitative and quantitative measurements was recorded by myself at six locations for the 69 week period between December 11, 1997 and April 04, 1999. Climate records for the Polder have not been kept in the past, making comparisons difficult, but the weather during the monitoring period did not appear to be appreciably different than that experienced in the last decade. An additional set of limited readings was made at Grant Narrows. Data was collected from the following:

- Blaney Creek: (TMP 1) - the full period
- Sturgeon Slough: (TMP 2) - the full period
- Homilk'um Marsh: (TMP 3) - 11 Dec. 97 to 06 Feb. 98 then no access (see TMP 6)
- Dike Site: (TMP 4) - the full period
- Park Gate: (TMP 5) - the full period
- Ditch Site: (TMP 6) - 21 Feb. 98 to end, replaces TMP 3 when access no longer possible
- Grant Narrows Wharf: 16 Aug. 98, 13 Sept. 98, then 26 Sept. 98 to 04 Apr. 99.

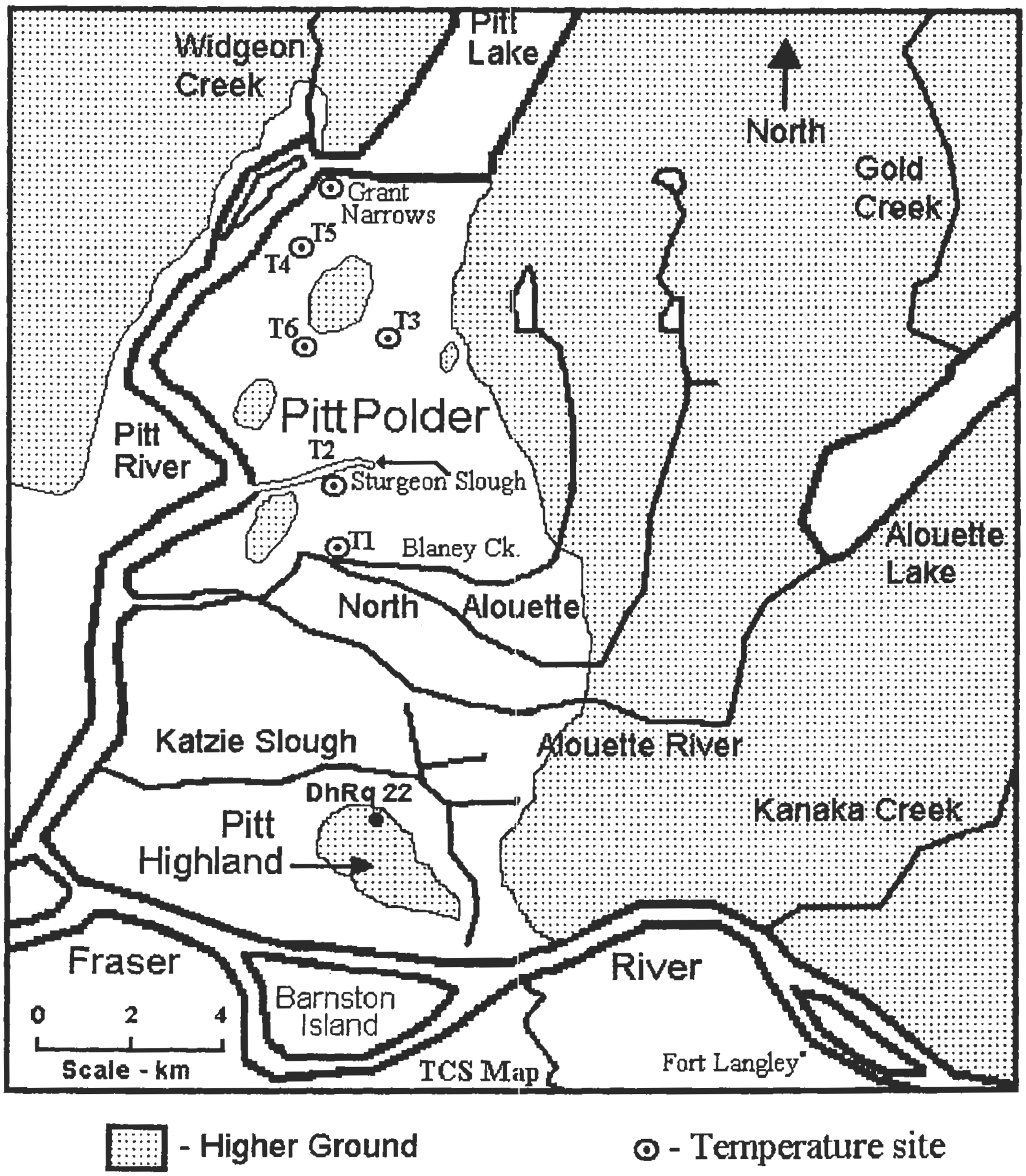
The information recorded includes: date, time (local), water temperature, air temperature, general sky condition, precipitation, wind, water level fluctuations (to record seasonal, tidal or dyking/pumping influences) and for flowing water locations *i.e.*, Blaney Creek, the current direction. Due to water level fluctuations the thermometer was allowed to lay on the bottom during all readings. During the period monitoring the old wooden bridge (it burned earlier due to arson) across Sturgeon Slough on Rannie Road was being rebuilt as an earth/culvert bridge so a detour was in place giving access to Homilk'um Marsh (TMP 3). When the new road opened access to Homilk'um Marsh was no longer available, hence the change in recording sites from TMP 3 to TMP 6 Ditch Site. Only later in the process was the Grant Narrows wharf used as a temperature recording site. Site locations are shown in Figure 9.

Water and air temperatures were recorded to the nearest half degree centigrade using laboratory quality glass mercury thermometers (FISHER brand 76mm IMM model 14-995-5B or equivalent). The thermometer, on a tether, was thrown into the water at the same location whenever possible (water depths were variable) and allowed to sink to the bottom, remaining at rest for at least a minute and then after quick retrieval the reading taken. Then the thermometer was dried and the outside air temperature was recorded. Subjective water level, current, weather and other information was then recorded.

The following climate tables and figures only include data for the listed full-period sites and Grant Narrows in Table 4, and for the selected sites at Blaney Creek (TMP 1), the Dike Site (TMP 4) and Grant Narrows for Table 5, and Blaney Creek and the Dike Site for Figure 10. Blaney Creek is a flowing water site, subject to daily tidal influences, located outside the polder dyking system. There is wapato present at the Blaney site. The Dike Site is a stillwater site located wholly within the polder dike/pumping system and is thus subject to longer term water fluctuations. There is no wapato at this

Figure 9

TEMPERATURE SITES



-- Pitt Highland/Lowland --

Table 4

Selected Water/Air Temperature Ranges

October thru March - Degrees C

	Blaney Creek		Sturgeon		Dike		Gate		Grant Narrows	
Month	Water	Air	Water	Air	Water	Air	Water	Air	Water	Air
October - Low	10.0	9.5	11.0	9.0	10.5	9.0	10.0	9.0	12.0	9.5
High	12.0	13.0	15.0	13.0	12.0	13.0	12.0	13.0	14.0	13.0
November - Low	7.0	6.0	7.5	6.0	6.0	6.0	6.0	6.0	7.5	6.0
High	10.0	11.5	10.5	11.0	10.0	11.0	9.5	10.5	11.0	10.5
December - Low	-0.5	-5.5	0.5	-6.5	-0.5	-8.0	-1.0	-7.0	2.5	-7.0
High	6.0	5.5	7.0	5.5	5.5	5.0	5.5	5.5	7.0	5.5
January - Low	0.0	-1.0	1.0	-1.0	0.0	-2.0	1.0	-1.0	4.0	0.0
High	5.0	7.0	6.0	7.0	5.5	6.0	5.0	6.5	5.5	5.0
February - Low	4.0	3.5	4.0	3.0	4.0	3.0	4.0	3.0	4.5	3.0
High	6.5	9.0	6.0	10.0	7.0	9.5	5.5	9.0	5.0	6.0
March - Low	5.0	5.0	5.0	5.0	5.0	5.0	4.5	4.5	4.5	6.0
High	9.0	12.0	10.5	12.0	10.0	12.0	9.5	11.0	6.0	7.5

Table 5

Monthly Average Water/Air Temperatures - °C

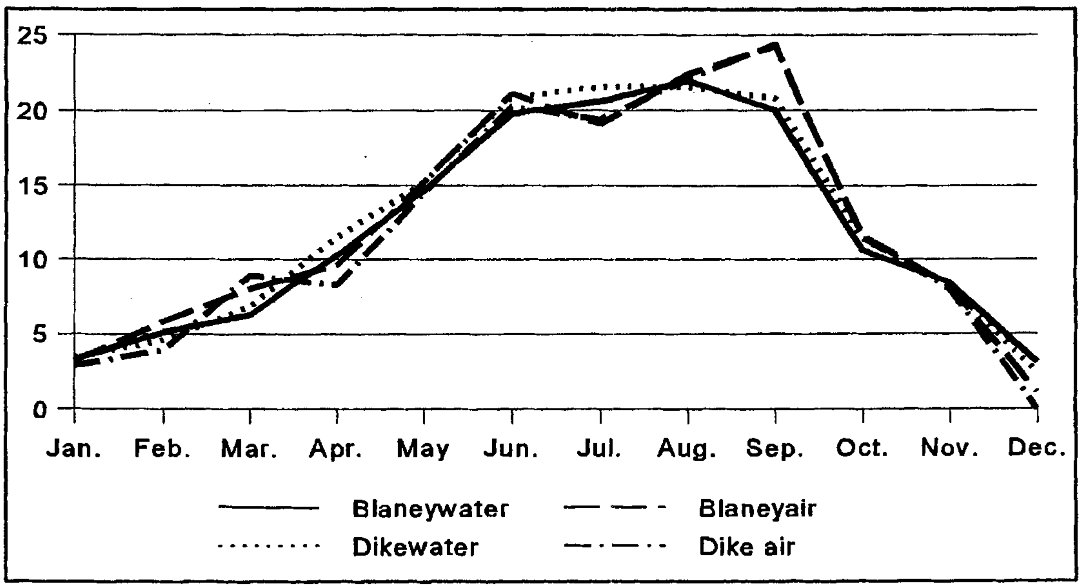
Observation period from 1 Apr. 98 to 31 Mar. 99 - 52 weeks

		Blaney Creek		Dike Site		Grant Narrows	
Month	n=	Water temp.	Air temp.	Water temp.	Air temp.	Water temp.	Air temp.
January	5	3.3	3.2	3.5	2.9	4.8	3.1
February	4	5.1	5.8	4.6	3.9	4.8	4.4
March	4	6.3	8.0	6.8	8.9	5.4	7.1
April	4	10.3	9.6	11.5	8.3	-	-
May	5	14.7	15.2	15.2	14.5	-	-
June	4	19.8	21.1	20.9	20.3	-	-
July	4	20.6	19.1	21.6	19.4	-	-
August	4	22.0	22.4	21.6	22.1	-	-
September	5	20.0	24.3	20.8	24.4	17.5	22.0
October	4	10.6	11.6	11.4	11.5	12.9	11.6
November	5	8.4	8.2	8.2	8.0	9.3	8.0
December	4	3.1	1.1	2.4	0.0	4.8	0.75

Figure 10

Average Monthly Water/Air Temperatures

Degrees C



site today. The Grant Narrows Site, completely outside the dike system and subject to daily tidal influences, is located at the boat wharf on the Pitt River where the river flows out of Pitt Lake opposite IR4. There is wapato growing in and around this site.

The recording sites are all located in the Pitt Polder, north of the North Alouette River. The sites were selected judgementally after a lengthy period of familiarization and observation based upon access, maximizing coverage of the Polder area and providing a mix of inside/outside the dike system sites. The distance from the more southerly - Blaney Creek, to the northernmost - Grant Narrows is only 8.9 kilometres. The other sites are more or less evenly spaced between the two. Despite the relative proximity of the recording sites there were noticeable minor climate variations amongst them as can be seen in Tables 4 and 5. The further north the site, the cooler the air temperatures. The Grant Narrows air temperatures are frequently cooler. The Grant Narrows water temperatures do not follow the general pattern, a situation I attribute to Pitt Lake acting as a huge heat-sink which reduces the magnitude of water temperature fluctuations.

Of major relevance are the water and air temperatures, especially for the cooler winter months from October to March. There were a total of 42 observations taken during this period over parts of three years, the resulting water and air temperature ranges being shown in Table 4. During the 42 observations moderate to strong winds were experienced just over a third of the time, with strong outflow winds present on several occasions. The net result was water and air temperatures that I felt did not encourage wading in the water. Several instances of ice-covered water were also noted.

Table 5 and Figure 10 present averaged monthly water and air temperature values over one contiguous year (52 weekly observations from 1 April 98 to 31 March 99). The general pattern of warm summers and cooler winters is evident. During the 52 observations, precipitation in the form of rain or snow for the winter period (October to March) was approximately six times more frequent than for the summer (April to September) period. This is consistent with the expected wetter winter period. The cooler temperatures of the wapato harvest period from October to March lend credence to the use of digging sticks for wapato recovery in place of wading which is widely reported as the tuber recovery method. It may be a modern bias but on those occasions when I harvested tubers using a shovel or trowel during the cold period hands rapidly stiffened and tolerable exposure times were very short.

Study Area Wapato Distribution

During 1998 I recorded wapato patches on the banks of the Fraser and Pitt Rivers, the lower reaches of Blaney Creek, the North and South Alouette and the Alouette River main channel below the forks. Wapato is also present on the Pitt River fronting IR4, in Widgeon Creek and slough and on Siwash Island. Field reconnaissance was split approximately evenly between inside and outside dike locales. The search involved walking along dikes observing water on both sides and included canoeing in the Pitt River, Pitt Lake, Widgeon Creek and Slough, and the Pitt Marsh where foot access is impossible. An estimated total in excess of 50 kms was surveyed by foot and canoe. Ongoing reconnaissance continues to reveal new wapato patches.

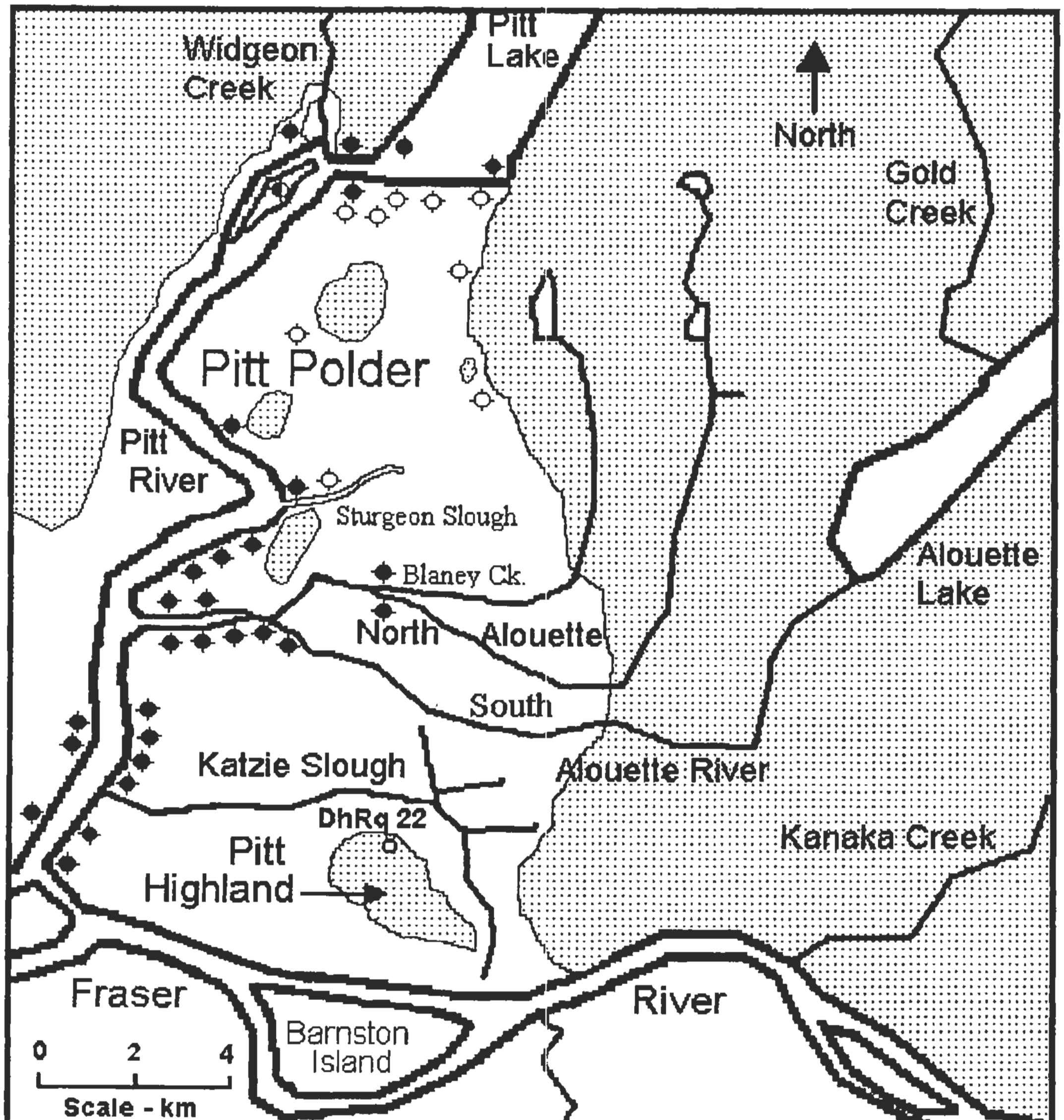
In all instances to-date the patches have been located in water bodies where there is daily flow, albeit subject to short term water fluctuations (*i.e.,*tides, flood stages), and with bottom sediments comprised of silty/clayey muds. As yet, no wapato has been observed growing in non-flowing waters or those subject to long term fluctuations in water level or where the bottom sediments are largely peat with mixed silt/clay, conditions typical of those behind dikes. Marburger (1993:250) indicates wapato grows in inland and coastal freshwater marshes, around the margins of lakes and ponds, and along rivers and streams. Turner (1995:36) notes the habitat for wapato as wholly or partly submerged in the water at the edges of lakes, ponds and streams, or in wet mud. Brayshaw (1985:45) has wapato growing in marshes and sheltered shallow water. Marburger (1993:250-52) discusses a variety of conditions affecting the sexual and asexual reproduction and growth of wapato, among them achene production being higher in water bodies with stable levels versus fluctuating levels, low water and dry conditions resulting in reduced flower and achene production, and plants growing in soft organic silts producing 14-15 times as many achenes as those growing in hard-packed clays. She further notes that above and below ground plant biomass is higher in sandy loam sites than in silty clay sites along the Mississippi River.

The initial association of wapato with flowing, muddy-bottomed waters subject to short term level fluctuations, in contrast to its apparent absence in non-flowing waters with peaty clay/silt bottoms and longer term water level fluctuations, leads to the conclusion that modern diking, which has interrupted the water flow in the extensively channeled pre-diked lowland, has resulted in conditions where wapato no longer thrives. Also contributing to the negative impact of dyking on wapato and archaeological site preservation is the regular maintenance of the dike system and the frequent dredging of channels, ditches and slough systems in the dike enclosed areas. Figure 11 shows ethnographically reported wapato sites from Suttles (1955: Table 1 and Map II) and those wapato patches observed by Spurgeon during summer 1998. In all instances the observed modern wapato was located outside the dike system, whereas many of the named ethnographic sites (Suttles 1955: Table 1 and Map II) were at locations now inside the dike system where there is no longer any wapato. Notwithstanding the frequent mentions of wapato in Suttles (1955), it should be noted that in his later compilation of plants for Chapter 3 in Woodcock (1996) Suttles notes that during his peregrination with Simon Pierre in August 1955 *Sagittaria latifolia* was not gathered for subsequent identification at UBC (Suttles 1996; also see footnote pp. 27 in Suttles 1955). This is an indication that wapato is not always easy to find, having been impacted by a variety of disruptive forces.

Based on my observations the notion subscribed to by some that wapato remains hidden below ground if not extensively cultivated is not correct. The false view is likely the result of several factors that, once understood, render wapato easy to find. These include the aforementioned diking impacts, water level fluctuations, wildlife predation and a narrow growing season. The distinctive arrowhead shaped foliage is best sought in the months of July and August. It is also seen in June and September depending upon annual growing conditions. At other times of the year the roots and tubers remain hidden below ground level making it important to have knowledge of the patch locations to effect the fall/winter tuber harvest, a season when foliage is no longer visible. Daily tidal fluctuations may also obscure the emergent foliage early in the growing season making searching during low tides a good practice. High tides seemed to protect young plants from predation but during a protracted period of low tides - common in the summer - plants are exposed to predation. While in the field I observed

Figure 11

WAPATO LOCATIONS



TCS Chart

Wapato sites - **ethnographic report** ⌖ - all inside dike system

observed 1998 ◆ - all outside dike system

both ◆ - outside dike system

▒ - Higher ground

Pitt Highland/Lowland

numerous instances of Canada geese feeding on the foliage whereby a large patch visible one day would be undetectable the next. Anderson (1925:134) mentions seeing flocks of swans "heads under the water, and tails in the air" feeding on wapato in the Columbia River. On the Columbia River predation by introduced European carp is blamed on the near extermination of this once abundant plant (Piper 1906:101). I observed that patches in the vicinity of frequent human activity *i.e.*,, boat launching ramps and hiking paths, were less impacted by animal predation and seemingly ignored by people.

While these are only preliminary conclusions based on several seasons of fieldwork it is not unreasonable to speculate a bit on the Katzie traditional use of this once important plant. The notion of the seasonal round that included some summer intervention to tend patches, ultimately leading to a tuber harvest, oversimplifies the realities of the activities associated with wapato. Considerable effort would have been required to initially locate patches, eradicate competing plants, ensure a continuous supply of fresh water and to protect immature foliage from predation. Once found the patches would likely be used repeatedly. Familiarity with the location of patches is necessary to facilitate fall/winter tuber harvesting, a time when the distinctive foliage would no longer be in evidence. Planning around high and low tides is another complication that required attention as the lowest tides are not always conveniently present in daylight hours or during the season of interest. To not properly plan these activities would potentially lead to a poor energy return for the time invested, a particularly serious matter given that air temperatures in the area during the harvest period (October to March) generally fall between minus 8° to plus 13° centigrade and water temperatures fall between minus 1.0° to plus 15.0° centigrade (see Figure 8), a rather cool mix for wading. I have harvested wapato into the month of April. While dyking appears to have had a negative impact on wapato growing inside dike enclosed areas, wapato remains in abundance outside the dike system. One could speculate perhaps that the many conditions and impacts attendant upon successful cultivation and harvest of wapato rendered the popularity of the introduced common potato (*Solanum tuberosum)* inevitable.

A final word on harvesting methods is in order. In the compacted silt/clay substrates in which the modern tubers grow it is almost impossible to dislodge tubers with toes pushed into the mud. This difficulty is further complicated by the natural detritus contained in the substrate. It simply may be that the substrates in pre-dyking times were less compacted and were not so fouled with modern detritus easing the effort required to dig with toes. Furthermore, several attempts have been made to pull tubers from the substrate using the above ground foliage for gripping. In all instances the foliage has been torn away with no movement of the buried tubers evident. Again the nature of the modern substrate may preclude success with this method. It is possible that some form of digging stick suitably shaped at the end for dislodging tubers and breaking up the substrate and root mat was used for harvest. Darby (1996:68-9) notes several accounts of digging for wapato tubers but digging sticks are not mentioned. Unfortunately, while such root digging tools are widely reported ethnographically associated with other root species (Brown 1868:379; Duff 1952:73; Haeberlin and Gunther 1930:20; Suttles 1987a:137 in reference to *S. tuberosum*; Turner 1979:33), there is little likelihood of such tools surviving in archaeological contexts unless waterlogged conditions exist.

Language, Trade and Taxonomy

The look at the linguistic evidence for *wapato* words in Northwest coast native languages in the previous chapter provides an informative perspective which suggests a need to carefully evaluate ethnographic information before accepting it at face value. The linguistic information reinforces the argument presented here that care must be taken to avoid confusion when using ethnographic and historic accounts of native people using wapato and potatoes.

Complicating the language picture, and not strictly a linguistics problem, is the fact that in addition to the potential for confusion between *Sagittaria latifolia* and *Solanum tuberosum*, there are several other edible "root" species in the Pacific Northwest that are frequently referred to as Indian and swamp potato. Ethnographies and botanical guides frequently contain references to Spring Beauty (*Claytonia lanceolata*) as "Indian potato" (Turner *et al.* 1980:113), Mariposa Lily (*Calochortus macrocarpus*) as "Wild potato" (Turner 1997:64), the Yellow Avalanche Lily (*Erythronium grandiflorum*) as "Indian potato" (Turner *et al.* 1990:121), all three being Interior species, and Broad-Leaved Starflower (*Trientalis latifolia*) as "Indian potato" (Pojar and MacKinnon 1994:322). Camas (*Camassia quamash*), mentioned in the previous chapter, while not present in Katzie territory could arrive there via trade and could easily be confused with wapato. The potential for confusion amongst edible "root" foods is obvious where proper botanical nomenclature is not used in conjunction with common names. Linguists and ethnographers could have frequently confused these species with wapato. Table 6 lists these species with the native language word for each. Fortunately, the native language words for these species are distinct from those related to wapato. Hopefully, ethnographers and others accurately documented native language words precluding such confusion.

Table 6

Native Language Names for Selected Species of Foodplants

- sometimes referred to as "potato"-

Common Name	Botanical Name	Native Language Word	Source
Spring Beauty	*Claytonia lanceolata*	skwehkwíhem Nlaka'pamux (Okanagan-Colville)	Turner *et al.* 1980:113
Mariposa Lily	*Calochortus macrocarpus*	/məqʔ=ú[·ʔ]peʔ Nlaka'pamux (Thompson)	Turner *et al.* 1990:119
Broad-Leaved Starflower	*Trientalis latifolia*	/ciq^{w}·=ó[·q^{w}]peʔ Nlaka'pamux (Thompson)	Turner *et al.* 1990:245
Yellow Avalanche Lily	*Erythronium grandiflorum*	s/k̇ém̓ec Nlaka'pamux (Thompson)	Turner *et al.* 1990:121
Camas	*Camassia quamash*	/ʔítx^{w}e ʔ Nlaka'pamux (Thompson) k^{w}a·dis Ditidaht k'a'məs Sto:lo	Turner *et al.* 1990:120 Turner *et al.* 1983:83 Duff 1952:73

A comparison of the Columbia and Fraser Rivers is illuminating as pertains to wapato distribution, language and the potential wapato provides as an item for trade. The comparison is also relevant given the linguistic origins for the Chinook Trade Jargon term *wapato,* and the word's subsequent spread throughout the Northwest Coast area. The major river drainages of the Northwest Coast have long been regarded as significant corridors for prehistoric human interaction between Interior and Coastal peoples. They support significant migrations of anadromous salmon (Schalk 1981) and serve as major transportation corridors. The Wappatoo Valley (Portland Basin) of the Columbia River and the Fraser Valley section of the Fraser River systems both supported extensive areas of wapato. In the case of the Columbia River there appears to have been trade involving wapato both up and downriver (Boyd 1996:149; Ray 1938:120; Ruby and Brown 1976:99). Darby's (1996) wapato research is centered on this region. A similar upriver/downriver movement of wapato is reported for the Fraser River, especially focused on the wapato patches in Katzie territory.

Summary

The need to critically review historic and ethnological data is evident. For wapato the modern records provide much of value but the inherent biases must be identified and accounted for. The historical context of the times, when changes were occurring in the use of wapato during the 19th century, is vital to its understanding. Critical review and contextual analysis reveal much about wapato and alert the modern researcher to the many sources of bias present in past records and to the potential for bias to enter into the research undertaken here.

A look at the modern Pitt Polder climate in conjunction with contextual analysis of the historic changes which have affected the Polder since European contact provides an illuminating view of wapato and the impacts affecting its continuing exploitation by native people. The climate conditions during the wapato harvest period in conjunction with indirect ethnographic evidence and cross cultural data support the argument that digging sticks were likely used to dig the tubers. A major influence has been diking which appears to have affected wapato distribution such that it is no longer present in many ethnographically reported locations. Wapato is present today only in waters outside the dike system.

Wapato is not the only species to have been impacted by modern influences. Locally, the Katzie were placed onto reserves and this act in conjunction with land alienation effectively removed them from the Pitt Polder lowland area. Traditional uses of the landscape were truncated or ended altogether. The depredations of disease further reduced the number of native people able to eke out traditional subsistence. The introduction of new economic influences in combination with the other major changes effectively brought about an end to the majority of traditional land uses in the area.

Analysis of native language words for wapato provides a tantalizing look at the use of wapato and possible trade implications. Native wapato trade was eventually ended through the introduction of the potato (*Solanum tuberosum*), a factor that has many implications involving wapato use. The introduced potato had economic, trade and horticultural implications. Taxonomic nomenclature can at the same time confuse and clarify the wapato picture. Ultimately, the widespread use of the terms "wapato" and "potato" to refer to a variety of edible root species requires researchers to be alert to potential confusion in historic and ethnographic data sources.

Chapter 4 - Wapato (*Sagittaria latifolia*) Tuber Charring Experiment

"I visited with the Indians, a place on the south branch of the Lillooet River (in Section 25.T 40) about 2 miles above the last mentioned fishery, but the Indians afterwards said they did not want it.....The lower place, the Indians said, would answer their purpose. Note This place could not be reached, owing to high water, when the commission was there. It is desired by the Pitt Lake branch of these Indians, who already have potato patches at the place."

Instructions to Surveyors
I.R.C. Surveys Katzie Indians, 19 May 1880
Indian Reserve Commission May 1880

Introduction

It is widely reported in archaeobotanical literature that charred tuber remains are difficult to identify in archaeological contexts (Hather 1991), and that tubers as food may "leave little waste and are rarely burned" (Ford 1979:300). In part, Hather (1991) attributes this situation to the lack of a developed identification methodology. Pearsall (1989:165) notes that in spite of their prehistoric subsistence importance, macroremains of underground storage organs are sparse. She attributes this to problems of preservation and identification difficulties. There appears to be a lack of agreement regarding the archaeological presence of tubers. Although wapato is touched upon in several Fraser Valley archaeological reports (Crowe-Swords 1974, Patenaude 1985) these should be questioned for both their uncritical use of ethnographic information and absence of actual archaeobotanical analysis dealing with wapato. We have seen in previous chapters it is also important to critically review local ethnographies to properly contextualize the information pertaining to wapato use. Notwithstanding, perhaps in the absence of an identification methodology we should not be too critical of the local reports which leave the impression that a lot is known about wapato in archaeological contexts. Elsewhere, Darby (1996) provides a detailed review of wapato use along the Columbia River but regional archaeological occurrences are only touched upon in passing. Stenholm (1987:13-10) identified a category of archeobotanical remain as PET (possible edible tissue) which might include wapato in her botanical analysis at Duwamish. A single old world example of wapato from a Polish archaeological site has been reported (Kubiak-Martens 1996). Hather (1993) provides an example of wapato tuber charring aimed at the identification of parenchymous tissues, although he used *S. sagittifolia* not *S. latifolia*. Parenchymous plant tissues are composed of roughly spherical, relatively undifferentiated plant cells frequently with air spaces between them (Oxford Dictionary of Biology 1996). Hather's study is not specifically concerned with the production of charred remains but rather is a guide to identifying charred parenchymous tissues. In his study of Near Eastern grass seeds, Nesbitt (1997:181) notes three reasons for the importance of charring studies in archeobotany. First, he indicates that some seed characters (for example: color, appendages, relief) may no longer be visible on charred remains. Second, he states that some seed characters may remain visible but become distorted. Finally, some seeds are less likely to survive and will thus be under-represented in the archaeological record. Pearsall (1989:440) attributes difficulties identifying charred remains to the species level to charring often destroying delicate structures and distorting specimen size and shape. Nevertheless, she (Pearsall 1989:173) states that "by studying the overall form of root or tuber material, external characteristics, anatomical structure, or a combination of these , it is often possible to identify archaeological material."

Based on the foregoing it seems prudent to establish a preliminary model of potential wapato remains and contexts prior to conducting fieldwork focused on searching for wapato in archaeological contexts. The experiment reported in this chapter is concerned with charring wapato tubers in a variety of heat and temporal regimes to ascertain if any remains might be expected archaeologically and the form such remains might take. While reference is made to charring experiments using other plant species, it is hoped that the results of this wapato charring experiment combined with the model building in the next chapter will contribute to a better understanding of potential archaeological contexts for culturally utilised wapato, at least for Katzie traditional territory.

Objectives and Assumptions

Before stating objectives and assumptions for the experiment some brief comments are in order on how charred food-plant remains come to be deposited in archaeological contexts. It is generally thought that such deposits are the result of accidents which occur as part of food preparation, consumption and disposal (Ford 1979:300). We are only concerned here with the deposition of charred plant remains that are produced in combustion conditions that char but do not reduce the plant tissues to ash. Such charring produces remains that have potential for long term preservation and subsequent archaeological recovery. The type and condition of original plant tissue, the duration of heating, the temperatures achieved and the surrounding fire conditions are all factors that influence charring potential. It is generally agreed that the best potential for the production of charred plant remains is at the base of fires in the ashes where temperatures are somewhat lower and the surrounding conditions are oxygen reduced (Hather 1993:viii; Hillman 1981:139). Plant tissues that fall through the upper levels of a fire into these basal conditions have an improved chance of surviving. Once deposited, such charred remains must survive the vagaries of taphonomic processes and the biases of recovery to have any potential of becoming the subject of subsequent archaeological research.

For this wapato tuber charring experiment there are several objectives which take the form of seeking answers to the following questions:

- Can charred remains be expected?
- What temperature and time parameters produce useful charred remains?
- What are the morphological characteristics of the charred remains?
- Are the morphological characteristics of the remains suitable for consistent identification using low power microscopy *i.e.*, powers less than 40X magnification?
- how does Scanning Electron Microscopy imagery of the remains compare with those depicted in Hather (1993), Kubiak-Martens (1996) and Stenholm (1987)?

Several assumptions are made regarding the tubers and the charring regime used. First, that wapato was charred in hearths or roasting pits prehistorically and did leave identifiable remains. The ethnographic information indicates this was the case but unequivocal archaeological results for the study area do not exist. There are several reports of *Sagittaria* sp. identified archaeologically elsewhere *i.e.*, in Colorado by Neumann *et al.* (1989) based on charred plant material recovered from human coprolites, in Poland by Kubiak-Martens (1996) based on internal vegetative parenchymous tissue structure of small pieces of tuber, and from the Columbia River area (Melissa Darby pers. comm.) but information is still sparse. Second, the tubers to be used come from harvesting at several locations in Katzie traditional territory and are assumed to be similar to those which would potentially have been charred prehistorically. There is a distinct possibility that prehistoric tubers were larger, the result of regular harvest and better substrate conditions than the compact, detritus laden silty clay of modern riverbanks. Third, it is assumed for this experiment that tuber remains are the only part of *S. latifolia* to occur in archaeological contexts of the study area. Thus, seeds and above ground stalks and leafy tissues are not being charred even though they are reported as being used medicinally elsewhere (Arnason *et al.* 1981:2243; Moerman 1998:500; Porterfield 1951:18) and do have the potential to occur in archaeological contexts. Fourth, it is assumed that the modern enclosed, electrically heated laboratory furnace provides a reasonable model for prehistoric heating conditions, at least in a manner permitting future replication of results.

Methodology

A survey of the more recent charring experiment literature reveals that charring experiments have not focused upon wapato or other tuberous plants but on seeds/fruits. While not strictly a charring experiment Hather (1993) did char *S. sagittifolia* tubers in pursuit of the identification of parenchymous tissues. The charring experiments reported generally take into consideration the following parameters:

- the variables of charring temperature, time and atmosphere.
- tuber condition and morphology: pretreatment, size, weight, moisture content.
- charring conditions such as medium, containment and matrix.

The following discusses each of the above parameters in more detail.

<u>Time, temperature and atmosphere:</u>

The main variables associated with charring are time or duration of heating, the temperature achieved and whether the charring atmosphere is oxygen rich or reduced. In addition to duration, final temperature and oxygen available, Smart and Hoffman (1988:172) indicate that for wood (they include a variety of plant tissues in the wood category) size, moisture content and tissue chemical composition are all factors in the outcome. Prolonged heating at higher temperatures produces only ash, while too short a period of heating will not result in charred remains that have the potential to be preserved in archaeological features. Temperatures ranging from 150°C to 250°C are reported as the region of onset for morphological changes in ancient and modern cereal grains based on comparative Electron Spin Resonance spectroscopy studies (Hillman *et al.* 1985:57). Smart and Hoffman (1988:172) indicate that charring can occur at temperatures below 200°C given enough time. In the range ca. 200-280°C they note "thermal decomposition produces primarily noncombustible gases and char." At temperatures above these thermal decomposition produces flammable gases, tars that burn when enough oxygen is present resulting in less char and more ash (Smart and Hoffman 1988:172). There is a linkage noted between temperature and charring period according to Hather (1993:viii).

A possible confounding factor related to the cooking environment is whether the charring atmosphere is oxygen rich or reduced - a rich atmosphere produces complete burning of combustible plant remains, whereas oxygen reduced conditions at the base of a fire prevents complete combustion. This experiment accounts for atmospheric variation by heating tubers in both ambient and reduced furnace conditions to determine the regime(s) likely to produce useful charred remains. To test reduced regimes several researchers have simply covered the subject crucible or placed the specimen in sand or wood-ash (Boardman and Jones 1990:3; Goette *et al.* 1994:12; Hather 1993:ix). Fine washed dry sand is used as the reducing agent in this experiment.

A combination of low temperature and long duration or high temperature and short duration may have similar results (Hather 1993:viii). At some point the only product is ash. Table 7 shows the temperature, time ranges and conditions used by other researchers to produce usable non-tuberous charred plant remains. From this it can be determined that a temperature range of 250°C to 500°C and a time of range of between 6 to 300 minutes is appropriate for such experiments. In this instance tuber pairs were subjected to temperature regimes of 200, 250, 300 and 350°C. The durations for each of the four temperature regimes were runs of 30, 60, 90 and 120 minutes. Thus, there were a total of sixteen runs with each run heating a sand covered and an uncovered tuber. Hather (1993:3) indicates that there are morphological variations seen in charred parenchymous tissues depending on whether the tuber was dried or moist prior to charring. Due to the proximity of the tubers to the user and the potential for tuber harvesting throughout the winter months it was decided to char only moist tubers in this experiment.

Tubers:

Tuber specimens for charring experiments normally have their morphology recorded and are often subjected to pretreatment. The tubers selected for the experiment were weighed, measured for diameter and their general condition recorded. The selection of tubers for each pair was done randomly to eliminate size selection bias and to facilitate subsequent analysis. The date of harvest was recorded and the duration of storage noted. Ethnographies suggest tubers were often cooked shortly after digging and thus they would normally be cooked in a moist condition. Other reports indicate they were not immediately processed, so as time passed (duration not known) they would become drier, eventually with possible tissue degradation occurring. The tubers to be used were kept cool and moist in a refrigerator prior to use. The tubers were not dried or modified in any way so their tissues must be considered moist at the time of charring.

TABLE 7

Charring experiment parameters for various plant tissues

Researcher(s)*	Temperature Range	Time Range	Plant Material	Method
Hather (1993)	250°C	2.5 to 4 hrs.	Parenchymous organs	Furnace, wood ash, reducing
Goette, Williams, Johannesson & Hastorf (1994)	180°C to 190°C	1.5 hrs. repeated	Maize kernels & cupules	Bunsen burner, sand, reducing
Srinivasan & Jakes (1997)	250°C and 350°C	30 min.	Hemp fibres	Furnace, ambient & vacuum
Boardman & Jones (1990)	250°C to 550°C in 50°C steps	30 min. to 5 hrs. to ash	Cereals	Furnace, ambient & reduced
Smith & Jones (1990)	250°C to 450°C	6 - 60 mins. closed 6 - 45 mins. oxidizing	Cultivated grape seeds, fresh & dry	Furnace, open & closed aluminum containers
Hillman *et al.* (1985)	100°c to 500°C	16 hours	Modern Emmer wheat	Open and closed crucibles and in sand

* See the Reference listing.

Charring conditions - medium, containment and matrix:

The charring was conducted using a Thermolyne Type 30400 Furnace, rated at 5500 watts employing a single temperature set point controller with a temperature range of 204°C - 982°C. The furnace has a chamber measuring 35 x 35 x 37 cm and has a removable, mid-chamber, fire-tile specimen shelf.

Each tuber was placed in separate aluminum foil crucibles, one tuber exposed to ambient conditions and the other resting upon a layer of sand and completely covered with sand. This arrangement provides both ambient oxygen and reduced charring conditions. Sand was used to prevent burning of the tuber where it otherwise would be in contact with the crucible and also as a covering or oxygen reducing medium. Because sand is used there was an extra step after charring to separate the final tuber remains from the sand. To facilitate handling, a fine-grain washed sand was used. Prior to placement in the oven each crucible with tuber and sand was weighed.

Identifying Wapato Tubers

In order to identify wapato tuber remains, whether charred or not, it is necessary to have some identification guidelines to follow. The first two parameters of importance noted by Nesbitt (1997:181) and the techniques identified by Pearsall (1989:173) and Hather (1993) were used for guidance. As there are other tubers, bulbs and corms that have the potential to be confused with wapato they must be eliminated from consideration. Among them are the species listed in Table 6 plus the bulbs of camas (*Camassia quamash*), also known as Blue Camas, Edible Camas, Sweet Camas and Common Camas (Turner 1995:42). Some species may be eliminated on the basis of their not occurring in area of study, others on the basis of their generalized shape. Pearsall (1989:148) however, indicates eliminating a taxa because they don't occur in the study area can be problematic if climate and vegetation are different than in the past and the possibility for trade is not taken into consideration.

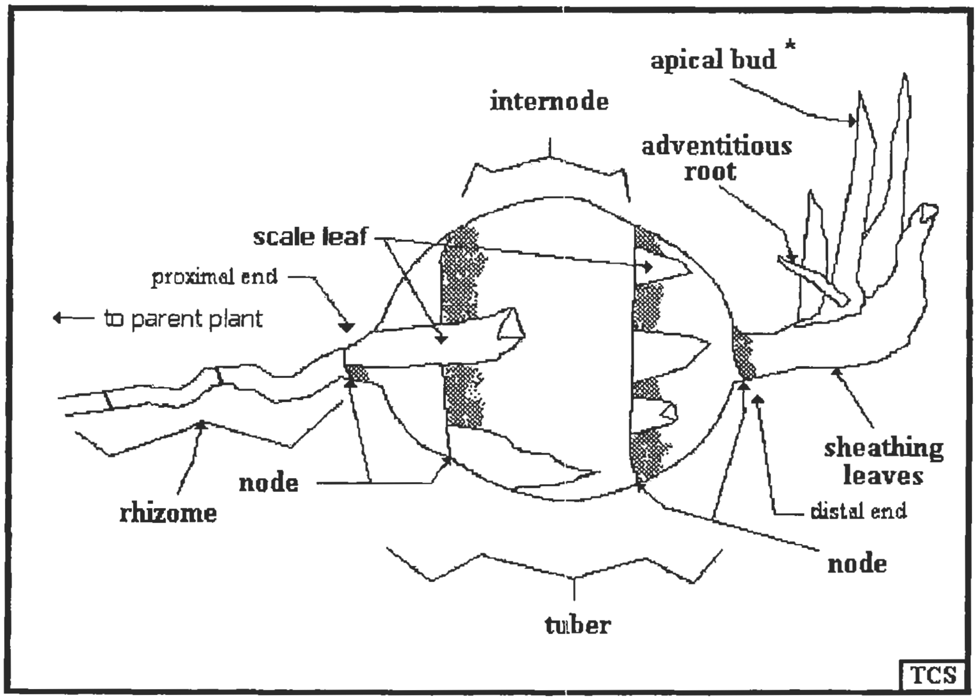
Differentiating between species based on the general shape of the tuber, bulb or corm eliminates other species such as camas, spring beauty and yellow avalanche lily from consideration. Archaeological macro-remains of roots and tubers can be identified based on external characteristics, anatomical structure or a combination of both (Pearsall 1989:173). If the shape of macroremains is not distorted by charring, and not all seeds and fruits are distorted badly, then differentiation based upon shape should still be possible (Pearsall 1989:440). Some features of gross morphology may be preserved to aid in identification. Features such as "nodes, scars left by the detachment of rhizomes, stolons, roots, scale leaves, buds, petioles and other aerial parts" may be of use for macroscopic identification (Hather 1993:5). Other identification criteria used by Hather (1993:4-8) for charred tissues include character of the parenchyma, charcoal colour, lustre and hardness, surface characteristics and cavity patterning.

Morphological characteristics such as distinctive surface markings of patterning, nodal lines, internal structural alignments and tissue lustre were observed under magnification, plus overall shape was considered during the analysis of the charred remains from this experiment. Figure 12, a drawing of a wapato tuber is included to show the nomenclature used to identify a variety of tuber parts.

Figure 12

Wapato Tuber

- Sagittaria latifolia -



* - younger tubers do not have fully developed apical buds with roots

After: Brayshaw 1985:47; Sculthorpe1967:344; Turner 1995:37

Analytical Methods

A variety of data was recorded before and after the tuber charring. All data recorded for each run are listed in Appendix 2. After charring the resulting remains were assessed for charring extent and survivorship of identifiable features using a subjective scale for each. Charring extent is scored as 1 for incomplete (not completely turned to charcoal) , 2 for complete (completely turned to charcoal), 3 for some tissue ashing or destruction (some charcoal turned to ash) , and 4 for complete ashing (all ash, no charcoal, very fragile). Usefulness of surviving features remaining for identification use was rated as 1 for good potential, 2 for potentially usable, and 3 for unusable remains. Survivorship was strictly a naked-eye assessment. Each crucible with its contents was weighed after cooling. This result subtracted from the pre-heating weight gives an indication of tissue and moisture loss. Remains permitting, details of their general morphology such as fragmentation or tissue loss were recorded for each tuber.

Low power microscopy *i.e.*, 40 power or less, was used to examine the specimens considered potentially useful for identification purposes. For comparison purposes uncharred tuber remains were also examined. SEM examination of selected remains was conducted to obtain a more detailed record of distinctive macroremain characteristics. SEM also permits comparison of results with Hather (1993), Kubiak-Martens (1996) and Stenholm (1987) and in conjunction with the low power microscopy provides useful tools for identifying wapato remains in archaeological contexts.

While almost all of the data gathered in the experiment are qualitative, some statistical analysis was possible. The subjective nature of the "amount of charring" (Char score) assessment and the "survivorship potential" (ID score) of the resulting remains provides ordinal scale data which are characterized by ranking (data indicating a scale of greater or lesser value) but as having no magnitude value. The variables measured in both instances are discrete in nature in that they have finite, pre-determined scales of value. Such data "measurements" are unsuitable for normal or logical arithmetic manipulation - they cannot logically be added or subtracted. They are however, amenable to some non-parametric statistical analysis and do require different graphing or presentation techniques than those of the continuous variables of weight, temperature and time which are also fundamental to this experiment. The random selection of the tubers facilitates subsequent quantitative analysis by eliminating any size bias, a necessary procedure as tuber size may well have an impact on the results.

Experiment Results

Table 8 shows before/after charring qualitative and quantitative data. The data for the variables Char Score and percent weight loss are plotted graphically in Figure 13. Although it is not common in archaeobotany it was deemed appropriate to record Munsell colours for the charred remains to establish some semblance of colour consistency. The Munsell results are shown in Table 9. A complete record of the experimental data is included in the data sheets in Appendix 2 which also contains a descriptive statistics summary.

Of note, while preparing the charred remains for SEM and photo-micrography it was found that the completely charred tubers were quite robust. To have an uncrushed or relatively undamaged surface to photograph it is necessary to snap the whole tubers in half. Cutting them would crush or otherwise

Table 8

Wapato Tuber Charring Results

A - ambient; B - reduced; * indicates SEM imagery

Tuber #	Temperature degrees C	Run Time minutes	Weight before -gm	Weight after - gm	Weight loss - gm	% weight loss	Char score**	I D score**
10A	200	30	7.4	3.2	4.2	56.8	1	3/2
10B	200	30	5.3	2.3	3.0	56.6	1	3
11A*	200	60	7.4	1.1	6.3	85.1	2	1
11B*	200	60	4.8	1.0	3.8	79.2	1 / 2	2 / 1
12A*	200	90	4.4	0.4	4.0	90.9	2	1
12B*	200	90	9.9	1.8	8.1	81.8	1 / 2	1 / 2
13A	200	120	5.4	0.5	4.9	90.7	2	1
13B	200	120	4.5	0.5	4.0	88.9	2	1
14A*	250	30	4.5	1.4	3.1	68.9	2	1
14B*	250	30	5.0	2.1	2.9	58.0	1	3
4A	250	60	5.7	0.8	4.9	86.0	2	1
4B	250	60	5.1	0.8	4.3	84.3	2	1
5A	250	90	3.6	0.4	3.2	88.8	2	1
5B	250	90	4.2	0.7	3.5	83.3	2	1
6A*	250	120	6.3	0.7	5.6	88.9	2	1
6B*	250	120	7.4	0.8	6.6	89.2	2	1

Char score: a subjective assessment of charring rated as: -
1 incomplete charring
2 complete charring
3 some tissue ashing or destruction
4 nearly complete ashing

ID score: a subjective measure of feature survivorship rated as: -
1 good potential
2 potentially usable
3 unusable

** double entry Char & ID scores indicate incomplete charring and are entered as inner value/outer value.

Table 8 cont'd.

Wapato Tuber Charring Results

A - ambient; B - reduced; * indicates SEM imagery

Tuber #	Temperature degrees C	Run Time minutes	Weight before -gm	Weight after - gm	Weight loss - gm	% weight loss	Char score**	I D score**
1A	300	30	3.5	0.6	2.9	82.9	2	1
1B	300	30	6.9	1.8	5.1	73.9	2	1
2A *	300	60	6.2	0.7	5.5	88.7	3	1
2B	300	60	3.3	0.5	2.8	84.9	2	1
3A	300	90	5.3	0.5	4.8	90.6	3	1
3B	300	90	5.1	0.7	4.4	86.3	2	1
16A	300	120	7.2	0.2	7.0	97.2	4	3
16B	300	120	5.0	0.15	4.85	97.0	4	3
7A *	350	30	4.4	0.5	3.9	88.6	3	2
7B	350	30	6.7	1.6	5.1	76.1	2	1
8A	350	60	5.4	0.4	5.0	92.6	3	2
8B *	350	60	2.5	0.3	2.2	88.0	3	2
9A	350	90	5.3	0.1	5.2	98.1	4	3
9B	350	90	3.0	0.35	2.65	88.3	4	3
15A	350	120	12.2	0.2	12.0	98.4	4	3
15B*	350	120	10.6	0.75	9.85	92.9	3	2

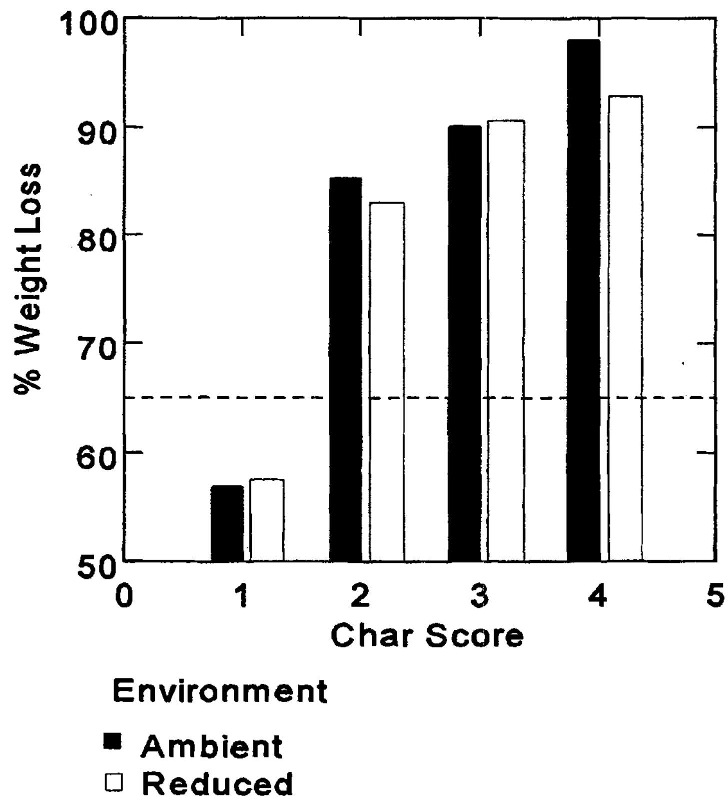
Char score: a subjective assessment of charring rated as: -
1 incomplete charring
2 complete charring
3 some tissue ashing or destruction
4 nearly complete ashing

ID score: a subjective measure of feature survivorship rated as: -
1 good potential
2 potentially usable
3 unusable

** double entry Char & ID scores indicate incomplete charring and are entered as inner value/outer value.

Figure 13

Wapato Tuber Charring - Percent Weight Loss/Char Score



-------------- % water content of wapato tuber

Char Score: - 1 incomplete charring
2 complete charring
3 some tissue ashing or destruction
4 nearly complete ashing

TABLE 9

Charred Wapato Munsell Colours

Specimen	Temp./time	Munsell Colour	Char Score	Specimen Description
10A skin	200/30	10YR 2/2	1	smooth/hard slightly charred skin
10A inner	200/30	2.5Y 8/6	1	centre soft more cooked than 10B
10B skin	200/30	2.5Y 4/4	1	wrinkled skin not charred
10B inner	200/30	2.5Y 8/6	1	centre soft less cooked than 10A
11A	200/60	Chart 1 Gley 2.5/N	2	skin bubbled, tuber charred to core
11B outer	200/60	10R 2.5/1	2	smooth skin, all charred
11B inner	200/60	7.5YR 7/6	1	centre hard, not charred thru
12A	200/90	Chart 1 Gley 2.5/N	2	skin bubbled, charred to centre
12B outer	200/90	10R 2.5/1	2	skin bubbled but all charred
12B inner	200/90	7.5YR 6/8	1	not charred to centre, more than 11B
14B skin	250/30	10YR 2/1	1	soft wrinkled skin not charred
14B inner	250/30	5Y 8/6	1	soft tissue, carmel/molasses odour
4A	250/60	Chart 1 Gley 2.5/N	2	from skin to centre
6A	250/120	Chart 1 Gley 2.5/N	2	from skin to centre
2A	300/60	Chart 1 Gley 2.4/N	3	from skin to centre
3A inner	300/90	Chart 1 Gley 2.5/N	3	tissue becoming softer
8A skin	350/60	10YR 5/2	3	flakey/soft surface
9A skin	350/90	10YR5/3	4	very fragile/flakey
9A inner	350/90	5Y 2.5/1	4	very fragile/flakey
15A skin	350/120	10YR 8/1	4	ashy/flakey skin
15A inner	350/120	Chart 1 Gley 2.5/N	4	soft flakey inner
15B skin	350/120	10YR 7/2	3	ashy/flakey skin
15B inner	350/120	Chart 1 Gley 2.5/N	3	centre hard

damage the surface. In the event, whole tubers grasped in fingers and snapped were found to be not all that easy to break. This may give some small measure of the tuber's potential to survive in the archaeological record. Attempts to snap whole tubers even a year after they were charred produced a similar result. Of course the partially or completely ashed tubers were much more fragile.

Perusal of the data reveals that the charring results using wapato tubers are generally consistent with the time/temperature/results as described by Smart and Hoffman (1988) and those depicted in Table 7 showing the results involving other plant tissues. Lower temperatures and times produced incomplete charring while the higher temperatures and longer times resulted in complete charring and at the higher extremes ashing or destruction. For specimens that were not completely ashed or consumed it was found that the tubers retained their general shape with some shrinkage.

At the shortest time/lowest temperature end of the scale tubers were caramelized but not charred and a characteristic caramel/molasses smell was noted. It is possible the caramelized or partially ashed remains would survive in archaeological deposits, although the more fragile ashed parts or the partly cooked inner tissues would probably not last for long periods. The heat hardened outer portions of some of the caramelized tubers would likely have the best survival potential. The tubers that were completely ashed were very fragile and deemed unlikely to leave any preserved macroscopic remains archaeologically. Due to their fragility it was difficult to record some parameters.

This investigation did not take any specific steps to identify starch grains or phytoliths. There were several reasons for this. First, it is already known that wapato tubers contain starch, and this study was focused on macroremains. Second, it is not evident from the literature that *S. latifolia* tubers even contain phytoliths. Pearsall (1989:312) indicates that phytoliths occur in stems, leaves and inflorescences of plants and in this research these plant parts were not studied in detail. Pearsall (1998) in her online database indicates that phytoliths were not present in *Sagittaria* sp. from Ecuador. Finally, although the analysis involved low power microscopy and SEM, the former is unlikely to detect phytoliths which requires high power microscopy, and the latter was applied for the purpose of increasing the resolution of macroremain features. In the event, SEM images did indicate the presence of starch grains. A concern to be addressed in pursuing phytolith identifications in similar tuber charring experiments relates to contamination from the fine sand used to provide a reduced atmosphere. The silicate sand might leave small bits that could be confused with phtoliths. In any event, a cleaning method which addresses specimen fragility would be required, or another method of achieving a reduced atmosphere could be used.

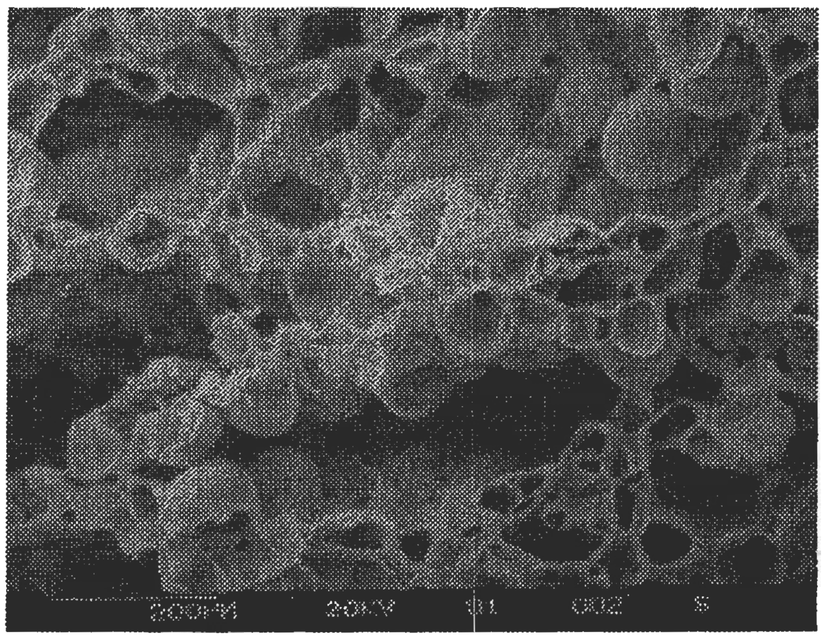
Results tend to validate the notion that the best potential for preserved remains might be at the base of fires where temperatures are lower and oxygen reduced as claimed by Hather (1993:viii) and Hillman (1981:139). A comparison of ambient versus reduced atmosphere tubers reveals that the reduced tubers did not cook or char as fast as their ambient partners. The reduced atmosphere tubers generally required a longer period of heating at the same temperature to achieve the same weight loss as the ambient tubers. It is fairly clear that charred tuber remains with the best potential for being identified in archaeological deposits were those falling in the time/temperature range of 200°C/60 minutes and 300°C/90 minutes with some variation at the higher end where 350°C at 30 and 60 minutes left usable charred remains. At temperatures of 300°C and a duration of 120 minutes there was complete ashing of the tuber. Similarly, at 350°C and durations exceeding 30 minutes the tubers were completely ashed. In fact, a tuber Char Score of 5, indicative of total combustion where no remains would be left, could be added for times and temperatures above those used in the experiment. It was noticeable that reduced atmosphere sand-covered tubers took a long time to cool after removal from the oven. The sand was very hot after heating so charring was likely to continue for at least the initial part of the cooling-off period which was around 30 minutes.

When tubers were heated the weight loss ranged from 56.8% to 98.4% for the ambient atmosphere tubers and 56.6% to 97.0% for the reduced atmosphere tubers. It is assumed that the largest proportion of the weight loss is the result of moisture loss, although it is apparent that more than moisture was lost. Exact weight loss data for all runs, and each temperature and time regime are shown in Table 8. The weight loss data for this experiment compare favourably with the data contained in Table 1 which shows nutritional values for wapato as recorded by a variety of researchers. Several of these (Arnason *et al.* 1981, Porterfield 1951) indicate water content for wapato tubers of 62.6% and 68.88%. The greater loss of weight in this experiment is attributed to the longer heating times and higher temperatures necessary to bring about charring as opposed to those required for cooking. The loss of weight over that accounted for by moisture would involve tissue loss and the combustion of nutrients shown in Table 1.

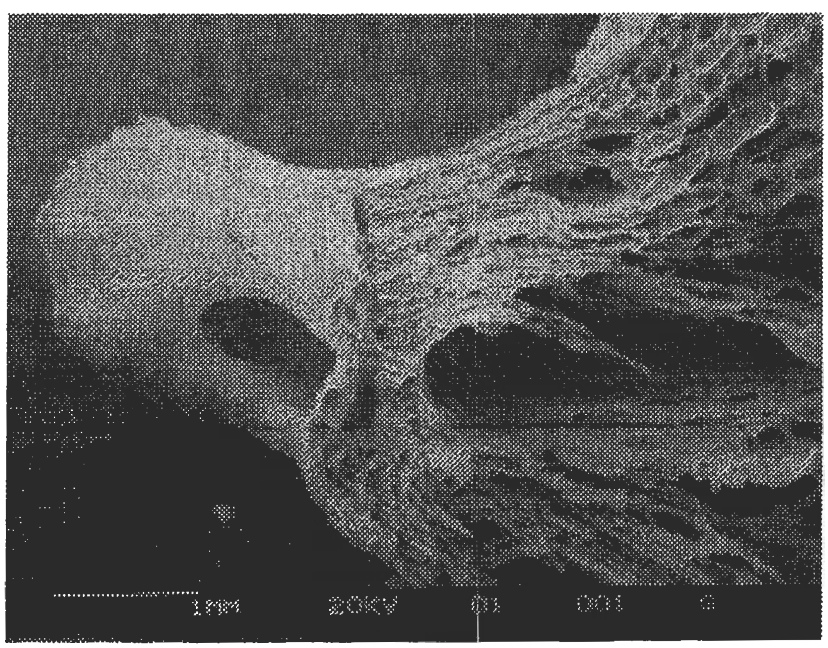
Figures 14, 15 and 16 are SEM images of the charred remains and Figures 17 and 18 are low power microscope images of charred tuber remains. Figure 19 is an SEM image showing epidermal patterning and a photograph of three charred tubers. Figure 14a shows the internal cellular structure

Figure 14

SEM Photomicrograph of Wapato



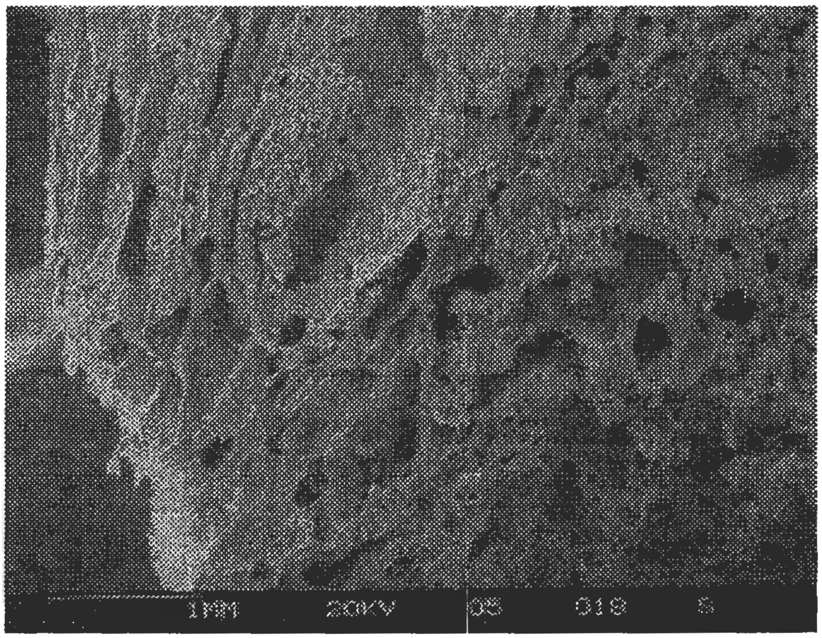
A.



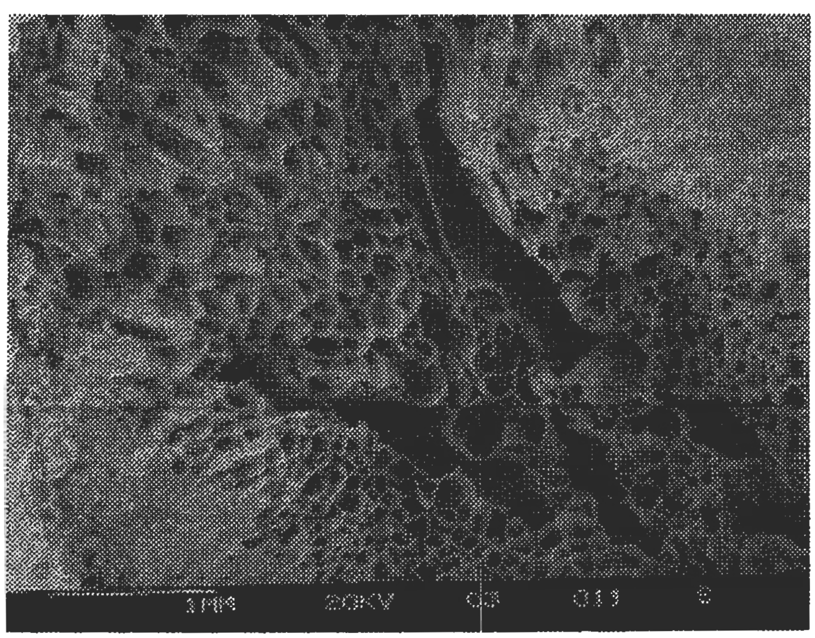
B.

Figure 15

SEM Photomicrograph of Wapato



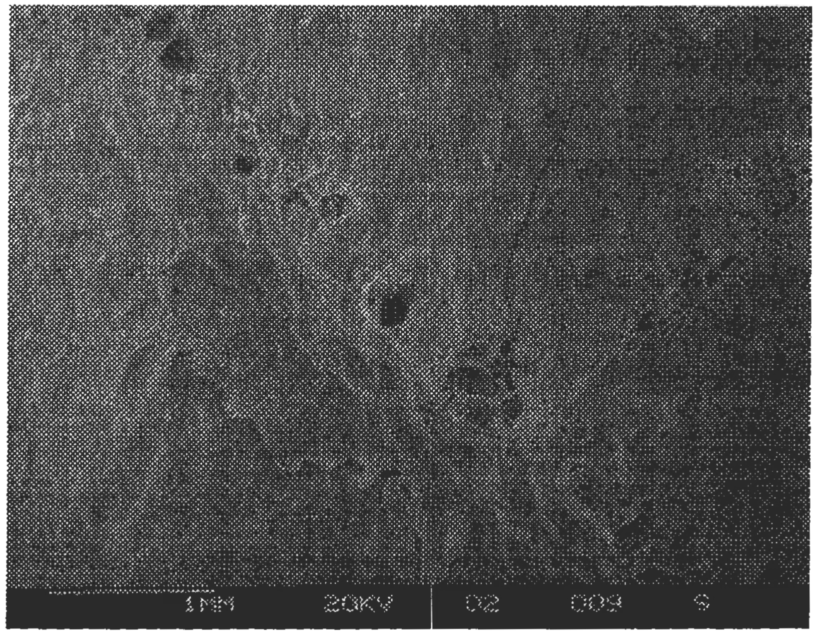
A.



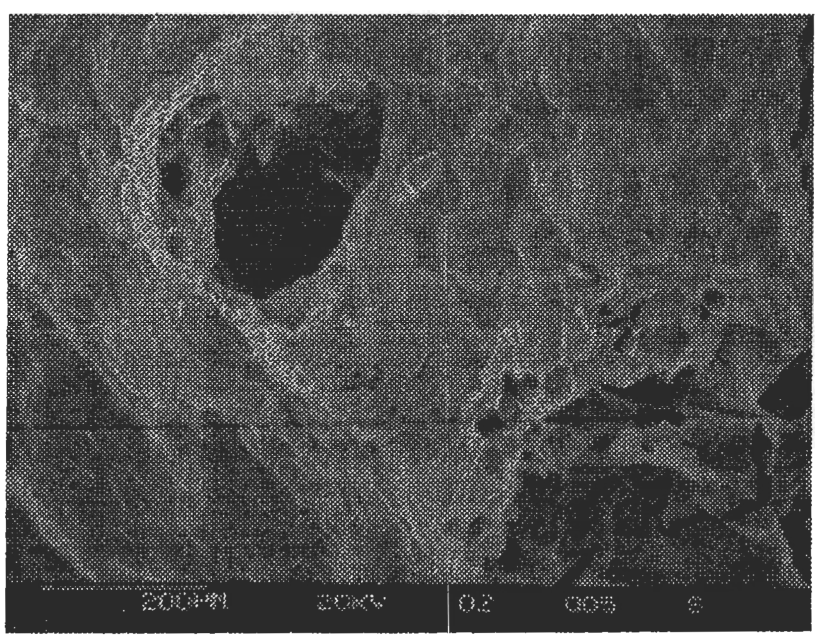
B.

Figure 16

SEM Photomicrograph of Charred Wapato Tuber



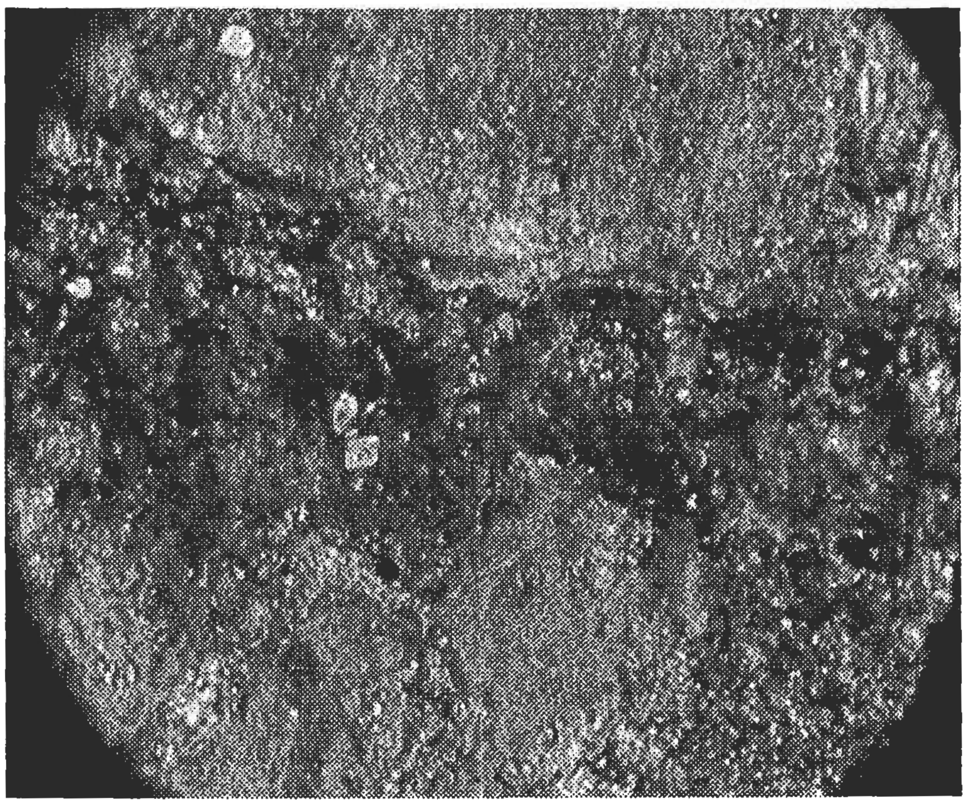
A.



B.

Figure 17

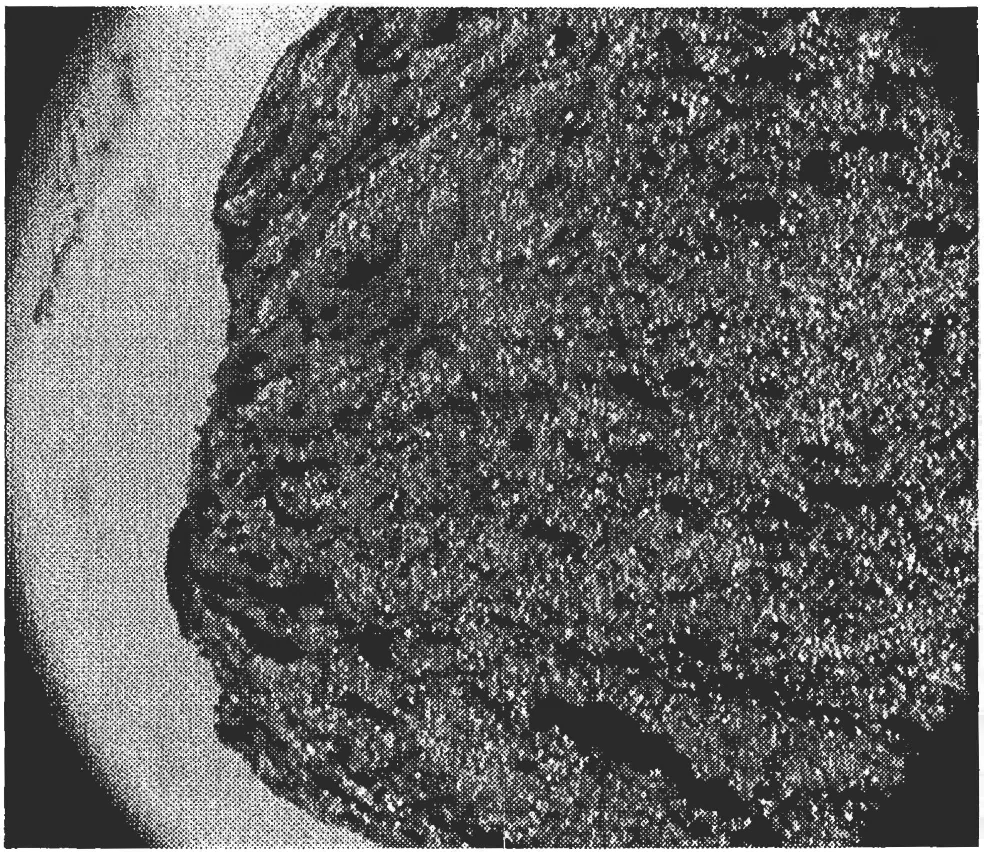
Low Power Microscope Image of Charred Wapato Tuber



- nodal line at 20x

Figure 18

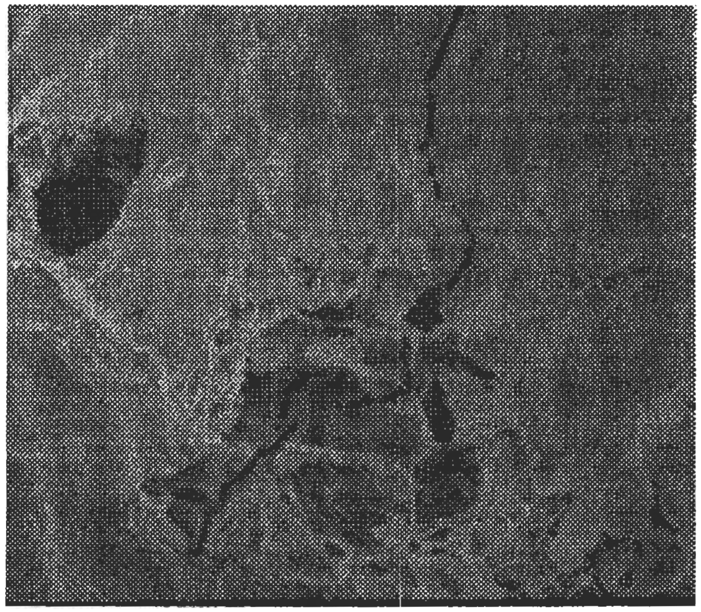
Low Power Microscope Image of Charred Wapato Tuber



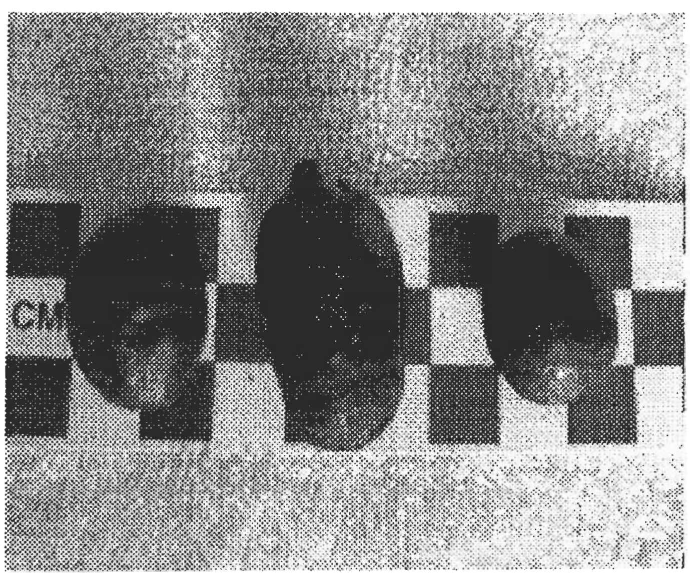
- 10x

Figure 19

SEM Image - Nodal perforation and adjacent
epidermal patterning



400 μM



Charred Wapato Tubers

of charred wapato. Figure 14b shows the distal end of a charred tuber where the apical bud emerges from the tuber with the base of the bud material still attached. A similar structural patterning is likely at the proximal end of the tuber where the rhizome attaches. Figure 15a is an image of the distal end of a tuber from a side angle showing where the apical bud connects or emerges from the tuber. Figure 15b is an end-on image of the distal end of the tuber where the rhizome enters. The SEM imagery in Figure 16 shows the external epidermis of the charred tuber along the nodal line present around the circumference of all wapato tubers. The nodal line is visible as are larger perforations or openings along the nodal line. The larger holes, referred to as leaf trace scars, are the result of vascular bundles passing into scale leaves according to David Simpson (personal communication 2001, Kew Gardens Herbarium). Remnants of scale leaf tissue are visible in Figure 16a. Figure 17 is a low power microscope image of the nodal line shown in the previous figure. Figure 18 is the end of a charred tuber from the same side as the view in Figure 15a.

Comparing the SEM images in Figure 14, 15 and 16 with Figure 13-11 shown in Stenholm (1987:15) leads to the conclusion that there are many similarities in the images. The glassy nature of the tissue as described by Stenholm (1987: 13) furthers this comparison as the glassy nature of charred wapato tissue from this experiment is evident in Figures 17 and 18 . Stenholm (1987:10 and 13) in her section on "Other Floral Tissues" created a category of remains referred to as "possible edible tissue" (PET), a category which accounted for 12% of her entire botanical inventory. While Stenholm did not identify the illustrated starchy root material from the PET category by species, she concluded that it was "precisely the kind of material which may give information on plant processing and use." It is possible based on comparison of parenchyma patterning and the glassy nature of the tissues shown in the images that some of the starch root material shown by Stenholm (1987) is *Sagittaria latifolia*.

A similar comparison of the SEM images in Figures 14 and 15 with the SEM images of *Sagittaria sagittifolia* shown in Hather (1993: Figs. 412-418) and Kubiak-Martens (1996: Fig. 2) indicates that SEM can be used to supplement the macroremain identification of charred wapato tissue from this experiment. In contrast to Hather's (1993:110) claim that "preservation is poor"- a claim likely directed at the preservation of detailed morphological features and not archaeological preservation - we noted earlier the charred material is not fragile and would likely preserve in archaeological contexts with some identifiable features. The only way to demonstrate this is to find and identify wapato from an actual archaeological context.

The low power microscope imagery of Figures 17 and 18 indicates that it may be possible to make a preliminary identification of charred wapato tissues without resorting to the efforts of producing SEM imagery. These images show considerable reflection, are glassy and are not sharp or distinctive as SEM. The nodal line is clearly visible at low power on the charred tuber in Figure 17. Of particular note associated with the nodal line is the presence of scale leaf remains visible at low power. In general the scale leaf (see Figure 12) remains are more evident on tubers subjected to lower temperature, shorter durations. Some of the leaf ribs and veins are also visible in addition to the generalized leaf tissue. The presence of the leaf parts diminishes as temperatures rise and durations lengthen until they disappear altogether at the highest temperature/longest durations where they are burned away. The glassy nature of the charred wapato tissue and the general shape of the charred tuber remains might also assist with preliminary identification. Low power examination of charred epidermis reveals a pattern which preserves the pre-charring sub-surface cellular pattern despite surface bubbling and distortions. Low power examination shows the epidermal pattern to be aligned perpendicular to the nodal line from the proximal to distal end of the tuber. The epidermal patterning is also evident on the right-middle portion of the SEM image in Figure 19. For more certain identification results it appears that distinctive features such as nodal pores, tissue alignment, epidermal patterning and internal patterning can best be identified with SEM imagery.

While this experiment is concerned with the potential to leave charred tuber remains in archaeological deposits and the potential for preservation and recovery, it is appropriate to say something about cooking. The results indicate that for eating/nutrition purposes the tubers would have to be cooked in the lower temperature, shorter duration regimes. The loss of edible remains due to charring or overcooking, and the potential destruction or conversion of nutrients would be a concern when cooking wapato tubers. Anyone embarking on roasting wapato tubers in an open fire, or cooking/steaming them in pits, would have to have control over the parameters of temperature and time to avoid tuber loss. Of course, this brings us back to the accidental nature of charred plant remains in the archaeological record and the reduced likelihood of anything remaining if cooking was done properly. Nevertheless, the potential remains that preserved charred remains of wapato tubers have the same potential as other food plant remains to be found in archaeological contexts.

Summary

The charring experiment answers questions regarding the potential to find identifiable charred wapato tuber remains in archaeological contexts. Charring wapato tubers in a controlled environment where the remains are easily recovered makes it be possible to observe the morphological characteristics of the resulting charred remains. At the same time the temperature/time conditions conducive to the experimental production of charred tuber remains can be evaluated. Using SEM, low power microscopy and naked eye observation it is apparent that charred wapato remains can be identified on the basis of generalized shape, charred tissue lustre, features of the tuber nodes, internal structure patterning and parenchyma tissue similarities with comparative specimens. For the study area in question, the general shape of the charred tuber remains and presence of nodal characters can be used to eliminate other tuber, bulb and corm species. Charred tuber remains can be compared to the published results of others to determine similarities in morphology where possible. The final results can be used along with ethnographic information to construct a model for the archaeological preservation of wapato remains and contexts which subsequently can be field tested. The charring experiment results indicate that one can expect identifiable wapato tuber remains in archaeological contexts given the vagaries of taphonomic processes.

Chapter 5 - Archaeological Model of Wapato

"I brought my large canoe, loaded, almost straight from S10 T40 across the meadows to the back of the Katzie Village."

Indian Reserve Commission Survey
June 1880, Edward Mohun's Survey Notes

Introduction

In order to detect the archaeological presence of wapato in Katzie traditional territory, and by extension elsewhere, after critically addressing local ethnographies, environments and contexts, several matters require attention. First, consideration must be given to how charred food-plant remains come to be deposited in archaeological contexts. Then it is necessary to identify the plant parts that might be expected to be preserved - done in part in the previous Chapter - and in what archaeological contexts they might occur. As a final matter it is appropriate to consider where the remains might be found in the prehistoric environment of the area being modeled. It has not been the intention here to address local archaeological sites and interpretations in any more detail than was done in Chapter 2. Except to contribute to the earlier critical review, the reports essentially contain little relevant information about wapato, although several do contain information about cooking facilities. Detailed information on the site reports can be acquired from a variety of sources noted earlier (Crowe-Swords 1974; McMillan and Nelson 1989; Patenaude 1985; Peacock 1981; Smith 1903; Spurgeon 1984,1994, 1996, 1998b). A useful summary of the site reports is contained in Driver and Spurgeon (1998). For the general prehistory of southwestern British Columbia and the Puget Sound regions sources such as Fladmark (1982, 1986) and Mitchell (1990) can be consulted. The following discussion begins with a brief review of the information presented in the previous chapter concerning the origins of charred food plant remains, addresses wapato tissues that may be expected and in what contexts, and concludes with a consideration of potential site locations.

Archaeological Considerations of Wapato In Katzie Traditional Territory

We saw earlier that it is generally thought that archaeologically preserved plant tissues are the result of accidents which occur as part of food preparation, consumption and disposal (Ford 1979:300; Hillman 1981; Minnis 1981).This thesis focuses on the deposition of charred plant remains that are produced in combustion conditions which char but do not totally burn the plant tissues. Such charring results in remains that have potential for long term preservation and subsequent archaeological recovery. The type and condition of original plant tissue, the duration of heating, the temperatures achieved and the surrounding fire conditions as seen in the previous chapter are all factors that influence charring potential. It is generally agreed that the best potential for the production of charred plant remains is at the base of fires where temperatures are somewhat lower and the surrounding conditions are oxygen reduced (Hather 1993: viii; Hillman 1981:139). Plant tissues that fall through the upper levels of a fire into these usually basal conditions have an improved chance of surviving. Once deposited, such charred remains must survive the vagaries of taphonomic processes and the biases of recovery to have any potential of becoming the subject of subsequent archaeological research.

With wapato it is possible, based on ethnographic accounts, to eliminate many plant parts such as flowers, leaves, stems, or rhizomes from consideration. There are no reports of these parts being used in this area, although one must consider this possibility as *S. latifolia* plant parts are reported as being used for medicinal purposes elsewhere (see Chapter 2). Seeds of the wapato plant could be present as there are numerous ways they could enter a site according to Minnis (1981:144). Mathewes (1973:Fig. 6) reports the presence of *Sagittaria* pollen in a core from Surprise Lake (UBC Research Forest) dating to circa 8,200 years ago. In any event, the other non-tuber parts would in all likelihood not find their way into a charring situation. Familiarity with the plant and how it is harvested also confirms the elimination of the upper plant parts from charring consideration. This leaves only the tuber with remnant rhizome and apical bud attachments as the more likely subject for charring. The tubers are reported as being dried for storage and later use, eaten raw (rarely), or cooked for immediate consumption. Cooking has the greatest potential for producing charred remains. Given the somewhat bitter taste of the raw tubers (Gibbons 1962:22; Sweet 1976:6) it is likely, given the choice, they were usually cooked prior to consumption.

Reports of wapato cooking usually indicate boiling, steaming or roasting as the preparation methods employed (Duff 1952:74; Haeberlin and Gunther 1930:23). There is potential for charred remains from the latter two of these processes which utilised hearths, earth ovens or roasting pits as the heating mechanism. Boiling in containers holding water and the foodstuff using hot rocks was less likely to produce charred remains. Tubers are described as being cooked while buried in pits containing hot coals, or rock heating elements, overlain with layers of damp vegetable materials and sand to contain the heat and protect the foodstuff being prepared (Turner 1995:14-15). Water was added to promote steaming. Clay lining of cooking pits is also a potential inclusion that must be considered. Being buried likely results in the desired oxygen reduced environment. Another widely used cooking method was to place the tubers directly in hearths or cooking fires where they were roasted or baked in the ashes (Suttles 1955:27; Turner 1995:37). It is likely that the latter process has the greater potential to produce accidental charred remains, although it is possible that with buried cooking some accidental loss might also result, especially when the cook recovers tubers cooked closest to the heating element. The continued reuse of cooking facilities might also increase the likelihood for preserved remains, but the frequent disturbance of the sediments for reuse might also mitigate against preservation by damaging charred remains. The nature of the disposal of the pit sediments, including ashes, is not clear.

As a final consideration it remains to determine the locations that were likely to have been used for the cooking of wapato tubers. The tubers of this plant are harvested from aquatic contexts at a time of year when subsequent preparation in adjacent exposed, wet lowland areas would have been challenging for several reasons unless appropriate shelter was available. The weather during the fall and winter harvest period is generally not conducive to keeping warm in exposed areas (see Figure 10), and the lowland locales are not rife with firewood or supplies of heating element rock. The maintenance of wood and rock stockpiles might help to overcome this lack. Furthermore, the digging of roasting pits would have been very challenging in the lowland area as even shallow holes would quickly fill with water. Winter tides are noticeably high in this area and do affect groundwater levels daily. Earth ovens/roasting pits are found in sites elevated above the wet lowland in the local area (Patenaude 1985, Peacock 1981 and Spurgeon 1998b). Therefore, it can be concluded that it would have been desirable to take the harvested tubers to areas of raised elevation where there would have been protection from the elements, possible heating element rock available, sources of dry firewood and more importantly in the case of roasting pit cooking, a lack of groundwater to seep into the pit.

Such locations would likely be associated with other food processing activities. The accidentally preserved remains should be found associated with fire-cracked rock, clay layers, burnt or oxidized sediments, other food product remains and food processing tools. The stratigraphy of associated hearths and roasting pits will likely be complicated by mixing caused when cooked tubers were recovered and by subsequent reuse of these features. Reference to Figure 2 shows that there are elevated locations throughout the lowland where desirable conditions exist for the processing of foodstuffs which required cooking.

Of the local archaeological sites discussed elsewhere, the Park Farm (Spurgeon 1984, 1994, 1996, 1998b), Telep (Peacock 1981), Port Hammond (Smith 1903) and Pitt River (Patenaude 1985) sites are all located on slightly elevated ground resulting in the relative absence of wet conditions below the surface and with the potential for local firewood supplies. In each of these, rock for hearths and heating elements would have to be brought in from nearby sources. In the case of the Carruthers site, where wapato features prominently in the report, despite being a clay mound site the whole area is essentially lowland and unlikely to provide relatively dry conditions during the wapato harvesting/processing season. Its proximity to the Alouette River drainage which was much larger in pre-dike times would only compound the problem during high winter tides.

Should charred tuber remains be found in local pre-contact sites, in the absence of a positive identification of wapato based upon SEM and low power microscopic analysis, it is not unreasonable to assume that PET type remains (see Stenholm 1987) are in fact wapato. Such remains from archaeological sites in the study area are unlikely to be *Solanum tuberosum* if the deposits date to before AD 1775. Given the plentiful nature of wapato locally, camas tuber remains are less likely to occur but in view of the mention of boatloads of camas passing up the Fraser River there is some potential for it to occur as a result of trade (Maclachlan 1998:90).

Summary of the Archaeological Model

The archaeological model for finding wapato in the area of the Pitt Polder and adjacent higher ground is constructed around the availability of relatively dry conditions underfoot for processing, the availability of firewood and rock, the likely plant tissues to be processed and the potential for providing shelter from the winter period elements. Integral to the model building is the critical and contextual analysis of pertinent ethnographic, historic and environmental information. Given that wapato was likely widespread in the lowland area prior to the advent of diking and the existence of numerous waterways providing ready access from camp and village sites, it seems reasonable to conclude that access was not a major challenge even during the more weather challenged winter period when the tubers were available.

The relative paucity of usable high ground that is not bedrock indicates that the highland areas, rising similar to islands in the lowland, were of major significance for food processing. Indeed, it is likely these areas were significant for many other purposes as well. Prehistorically, or at least pre-diking, dry conditions for earth-oven cooking and the potential to erect shelter would best be found on the elevated areas of the Pitt Polder. Food processing sites involving holes in the ground or plant materials harvested during the winter are likewise probably on higher ground.

Several of the higher elevation areas such as Sheridan/Menzies Mountain, Swaneset and Little Pine/Big Pine provide rock supplies for hearths and heating elements and were likely wooded making the gathering of firewood easier than in the wet lowland areas. While rock is less prevalent in the vicinity of the adjacent higher ground of Maple Ridge and Pitt Meadows it was not too distant. It is probable that these locations had tree cover that provided a source of firewood. On the Coquitlam/Port Coquitlam side of the Pitt River there is higher ground and ready supplies of rock and firewood, plus wapato was nearby along the riverbank.

It is likely that the only remains of *Sagittaria latifolia* to be preserved in archaeological contexts, will be pieces of charred tubers. Other parts of the plant that may have been used such as stems and leaves were unlikely to be subjected to conditions leading to preservation through charring, even if they were brought into processing sites. These parts would soon disappear from view leaving the tubers as the only part with the best potential for preservation. The achenes, as noted, have some potential to enter the site (Minnis 1981) and be charred. While wapato tubers were sometimes stored for several months before cooking (Suttles 1955:27; Kuhnlein and Turner 1991:71) it is unknown how long they might survive archaeologically. During my research several tubers were left to air dry and after a year were intact and extremely hard such that hard pressure from a thumbnail only superficially dents them. How long similar dried tubers would survive in the moist sub-surface conditions of local archaeological sites is problematic. Storage caches of dried wapato might be found in large village sites.

While the model is specifically directed at the traditional territory of the Katzie it has elements that are applicable elsewhere. The identification parameters for charred wapato remains established in the charring experiment coupled with critical and contextual assessment of relevant ethnographic, historic, linguistic and environmental information for the period and locale in question can each make a valuable contribution. Perhaps not all elements of the model are applicable or available in other locales but certainly each has its appropriate place in archaeological research.

Chapter 6 - Conclusions

Introduction

Hodder (1991:151) says we can only understand the human world through asking questions of it. Interpretation and understanding in his view emanate from an endless spiral of asking logical questions and seeking logical answers. Just as Hodder (1992) employed the notion of an hermeneutic spiral, I have experienced a journey of several years along such a critical and contextual spiral to arrive at a better understanding of wapato. The journey is complete for the questions asked in Chapter I but there remain many more turns of the spiral to negotiate, particularly where the recovery of charred wapato remains from archaeological sites is concerned. Typically more questions and issues have arisen from my research than I have had time or the need to answer. The remainder of this Chapter is devoted to summarizing the results of the research concluded and indicating some directions for future turns of the spiral.

The research objectives presented at the beginning of this study were:

- to present a detailed description of the ecology of wapato.
- to critically review ethnographies and historical sources.
- to char wapato tubers to evaluate the potential for detecting archaeological remains.
- to construct a model for the archaeological presence of wapato.

The following sections briefly address the results of the research against each of the objectives and ends by presenting several ideas for future research emanating from this investigation.

Wapato Ecology

The local ecology of wapato has been presented in detail from numerous modern botanical studies and as a result of field studies which essentially involved much all season walking, wading and boating in the wet Pitt Polder lowlands. Environmental and climate data gathered provides a more accurate and clearer view of the Pitt Polder as it exists today. A much better understanding of wapato is the result.

The extensive field activities, review of botanical literature and analysis of wapato site locations from ethnographic information has led to the conclusion that diking has shifted wapato from the ethnographically reported locations inside the modern dike systems to only locations outside the dike system. Knowledge of the wapato growing season is essential to finding it and given the nature of tides and animal predation of the above ground plant parts in conjunction with the recent arrival of the table potato (*Solanum tuberosum*) and other domesticated root foods onto the scene, it is not surprising that wapato has all but passed from view.

Critical and Contextual Review

The critical review alerts us to the fact that there is much potential for bias to enter into the history and ethnology of wapato. There are numerous sources for this bias and the researcher must be on the alert for such instances. Fortunately there are good ethnographies and historic sources available addressing the Katzie. There are also several useful archaeological investigations reported in detail but as with the ethnographies and histories their treatment of wapato is cursory, repeating a prevalent ethnographic view of wapato use, but lacking any substantive archaeological data . The establishment of the historic impacts affecting wapato use as detailed in Table 3 served as the catalyst which ultimately initiated the success of the field work.

Charring Experiment

The charring experiment has led to the conclusion that charred tuber remains can be expected to occur in archaeological contexts, although recovery of such remains is yet to happen locally. The resulting remains are likely to be identifiable as wapato based on macroremain features. Low power microscope imagery, naked-eye observations and comparative analysis using other similar imagery inform the process. SEM can provide additional support to aid with identifying some macroremain features. The criteria for identification includes generalized tuber shape, epidermal patterning, the glassy lustre of the charred tissue, the presence of nodes and scale leaf remains, internal parenchyma pattern and the alignment of internal structure associated with proximal rhizome and distal apical bud attachments.

Archaeological Model

The charring experiment was a necessary step in confidently building a model for finding archaeological wapato remains. The model suggests that sites on raised sediments in the Pitt Polder/Pitt Highland area are the likely candidates for finding preserved charred wapato tissues.
The model is based upon the use of the charring experiment data in conjunction with critical and contextual assessment of relevant ethnographic, historic, linguistic and environmental information. Use of the model, or relevant parts of it, should assist researchers in finding and identifying possible archaeological wapato remains.

Future Research

There is plenty of additional research to be done. It has already been noted that the finding of wapato in archaeological contexts has yet to be accomplished locally. Fortunately there are several high potential sites for this work, my own research at the Park Farm (DhRq 22) is now at the stage to do this. The archaeological model and the identification methodology should facilitate this activity, especially for the archaeologically little known northern parts of the lowland area around Grant Narrows and Widgeon Creek.

Finding wapato remains sites well removed from the local area *i.e.*, the Fraser Canyon, Vancouver Island might serve to provide an archaeobotanical indicator for trade. For wapato and other plant remains to be found, regardless of site location, archaeologists must begin to routinely incorporate paleoethnobotanical considerations into their research designs, and do more flotation and analysis of plant remains. This will enable them to escape from the methodological paradigms of the past.

Having charred wapato remains at hand provides the potential to bury some charred and air dried tubers to see what happens to them in the natural environment. Waiting out the results will take some time, a luxury not available to all researchers. The charring experiment also provides a time/temperature basis for further research on actual pit and hearth cooking of wapato. This would be useful replication as an adjunct to nutrition studies, to determining the nature of charring under actual cooking conditions and might lead to more definitive conclusions regarding the best and prevalent cooking methods for wapato. Another area for future study that might provide some interesting insights would be in comparing harvesting/energy consumption requirements with the energy available from the tuber harvest, especially in cold winter conditions. Essentially, this would be an energy cost/benefit study of wapato. Protection from the inclement winter conditions raises issues associated with identifying types of tuber processing shelters and heating fires. Likewise, the tools of tuber harvest such as canoes, baskets and digging sticks deserve more attention. In the final analysis, additional research might lead to more tantalizing views into whether cultivation and horticulture were in fact a major part of the prehistoric cultures of the region.

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Appendix 1

Language Information

Linguists employ a variety of systems to classify languages. In this instance while researching North American native languages for wapato words reference was made to the Ethnologue Internet site (http://www.sil.org/ethnologue/ethnologue.html) to classify the source languages referred to in this study.

Ethnologue is a searchable language database covering the world. Language family information is presented as in the following example:

Language Family:

- Salishan-
  - Bella Coola
  - Central Salish
    - Halkomelem
    - Nooksack

Information is provided for each of the listings. At the level of local languages such as Halkomelem a three letter identification code is provided and detailed information is given *i.e.*, geographic area, number of speakers, total population, dialects, availability of language courses, grammars, dictionaries, the prevalent language of the area, and the status of the language such as extinct, expanding or in jeopardy.

Language Group Information

Language (Code*)	Language Group	Geographic Location
Chinook Trade Jargon (CRW)	Pidgin	Northwest Coast from Oregon to Alaska
Halkomelem (HUR)	Salishan - Central	South Central Vancouver Island - Gulf of Georgia and Fraser Valley
Straits (STR),	Salishan - Central	Southeast Vancouver Island and adjacent Washington and Gulf Islands
Nooksack (NOK)	Salishan - Central	Northwest corner of Washington state
Samish (STR),	Salishan - Central	Olympic Peninsula
Klallam (CLM)	Salishan - Central	Olympic Peninsula
Comox (COO)	Salishan - Central	Vancouver Island - Comox and Powell River region.
Squamish (SQU)	Salishan - Central	Howe Sound to Pemberton region
Twana (TWA)	Salishan - Central	East Puget Sound
Lillooet (LOO)	Salishan - Interior	Lillooet and Middle Fraser River area
Thompson (THP)	Salishan - Interior	South central British Columbia
Coeur d'Alene (CRD)	Salishan - Plateau	Northern Idaho
Nootka (NOO)	Wakashan	West central Vancouver Island
Haida (HAI)	Haida (isolate)	Queen Charlotte Islands
Kalapuyan (KAL) - Tualatin/Wappato Lake	Penutian	Northwest Willamette Valley, Oregon
Lake Miwok (LMW)	Penutian	Small area south of Clear Lake, California
Klamath (KLA)	Penutian	South central Oregon
Wishram (WAC)	Penutian	North Central Washington, South Central Oregon
Chinook (CHH)	Penutian	Columbia River mouth to The Dalles.

Language (Code*)	Language Group	Geographic Location
Salinan/Miqueleño (SAL)	Hokan	Central California coast
Quileute (QUI)	Chimakuan	Pacific side of Olympic Peninsula
Mohawk (MOH)	Iroquoian	Southwest Quebec, Southern Ontario, Northern New York
Seneca (SEE)	Iroquoian	Six Nations Reserves Ontario, Western New York
Ojibwa (OJG,B,I)	Algonkian	Great Lakes Region, Eastern Plains

* Ethnologue Language Identification Code

APPENDIX 2

Charring Experiment Results

The detailed results of the charring experiment reported in Chapter 4 are presented here in a total of sixteen data sheets. The data is summarized in a table of descriptive statistics which precedes the data sheets.

Appendix 2 - Descriptive Statistics

Statistic	Ambient	Reduced
Range of tuber weights gm - before charring	3.5 - 12.2	2.5 - 10.6
Range of tuber weights gm - after charring	0.1 - 3.2	0.15 - 2.3
Range of tuber weight loss gm	2.9 - 12.0	2.2 - 9.85
Mean tuber weight gm- before charring	5.9	5.6
Mean tuber weight gm - after charring, all runs	0.73	1.01
Mean tuber weight loss gm- all runs	5.16	4.57
Mean tuber weight loss % - after charring, all runs	87.1	81.8
Mean tuber weight loss gm - at 200°C	4.85	4.73
Mean tuber weight loss gm - at 250°C	4.2	4.33
Mean tuber weight loss gm - at 300°C	5.05	4.29
Mean tuber weight loss gm - at 350°C	6.53	4.95
Mean tuber weight loss by % - at 200°C	80.88	76.63
Mean tuber weight loss by % - at 250°C	83.15	78.7
Mean tuber weight loss by % - at 300°C	89.85	85.53
Mean tuber weight loss by % - at 350°C	94.43	86.33
Mean tuber weight loss gm - 30 mins.	3.53	4.03
Mean tuber weight loss gm - 60 mins.	5.43	3.28
Mean tuber weight loss gm - 90 mins.	4.3	4.66
Mean tuber weight loss gm - 120 mins.	7.38	6.33
Mean tuber weight loss by % - 30 mins.	74.3	66.15
Mean tuber weight loss by % - 60 mins.	88.1	84.1
Mean tuber weight loss by % - 90 mins.	92.1	84.9
Mean tuber weight loss by % - 120 mins.	93.8	92

Wapato Charring Trials

Trial Run #: 1 A/B

The trial runs heat two tubers each run - one tuber (A) uncovered in an aluminum foil crucible and one tuber (B) covered with sand in a similar container.
Trial temperature (degrees C): 300
Trial duration (minutes): 30

	Before charring		After charring		
tuber ID	A	B	A	B	tuber ID
weight (gm)	3.5	6.9	0.6	1.8	weight
diameter	1.43/1.75	1.59/2.13	1.39/1.40	1.58/1.95	diameter
shape	tabular	tabular	retained	retained	shape
length	2.7	3.5	-	-	length
condition	fresh/firm/moist	fresh/firm/moist	intact/charred	intact/charred	condition
time	30	30	2	2	Char score
temperature	300	300	1	1	ID score

After charring weight loss and % weight loss

weight loss	2.9	5.1	82.9	73.9	% wt. loss

Char score: a subjective assessment of charring rated as: -
1 incomplete charring
2 complete charring
3 some tissue ashing or destruction
4 nearly complete ashing

ID score: a subjective measure of feature survivorship rated as: -
1 good potential
2 potentially usable
3 unusable

Comments: general trial observations and specific information on results -

a. tubers selected randomly to eliminate size bias.
b. tubers stored cool and moist in a refrigerator.
c. sprouts were trimmed from all tubers.
d. all tubers were tabular in shape unless specifically noted.
e. tuber diameters recorded as flat diameter and widest diameter.
f. the tubers were heated moist with no pre-drying.
g. the sand was dried to remove all moisture before use.
h. tuber B left in hot sand until it cooled.
i. oven pre-heated to run temperature, tubers then placed in oven, run temp. recovered in less than 1 minute.
j. both charred tubers A and B have visible nodes and rhizome connections.
k. sand discoloration noted above tuber 1B after heating.
l. 1A has brown deposit on crucible surface.

Wapato Charring Trials

Trial Run #: 2 A/B

The trial runs heat two tubers each run - one tuber (A) uncovered in an aluminum foil crucible and one tuber (B) covered with sand in a similar container.

Trial temperature (degrees C): 300

Trial duration (minutes): 60

	Before charring		After charring		
tuber ID	A	B	A	B	tuber ID
weight (gm)	6.2	3.3	0.7	0.5	weight
diameter	1.43/2.29	1.44/1.66	1.39/1.77	1.39/1.43	diameter
shape	tabular	tabular	retained	retained	shape
length	3.53	2.52	-	-	length
condition	fresh/firm/moist	fresh/firm/moist	intact/charred	intact/charred	condition
time	60	60	3	2	Char score
temperature	300	300	1	1	ID score

After charring weight loss and % weight loss

weight loss	5.5	2.8	88.7	84.9	% wt. loss

Char score: a subjective assessment of charring rated as: - 1 incomplete charring
2 complete charring
3 some tissue ashing or destruction
4 nearly complete ashing

ID score: a subjective measure of feature survivorship rated as: - 1 good potential
2 potentially usable
3 unusable

Comments: general trial observations and specific information on results -

a. tubers selected randomly to eliminate size bias.
b. tubers stored cool and moist in a refrigerator.
c. sprouts were trimmed from all tubers.
d. all tubers were tabular in shape unless specifically noted.
e. tuber diameters recorded as flat diameter and widest diameter.
f. the tubers were heated moist with no pre-drying.
g. the sand was dried to remove all moisture before use.
h. tuber B left in hot sand until it cooled.
i. oven pre-heated to run temperature, tubers then placed in oven, run temp. recovered in less than 1 minute.
j. both charred tubers A and B have visible nodes and rhizome connections, 2A has fragile skin.
k .sand discoloration noted above tuber 2B after heating.
l. 2A crucible has brown surface deposit after heating.

Wapato Charring Trials

Trial Run #: 3 A/B

The trial runs heat two tubers each run - one tuber (A) uncovered in an aluminum foil crucible and one tuber (B) covered with sand in a similar container.

Trial temperature (degrees C): 300

Trial duration (minutes): 90

	Before charring		After charring		
tuber ID	A	B	A	B	tuber ID
weight (gm)	5.3	5.1	0.5	0.7	weight
diameter	1.48/2.12	1.62/2.34	1.39/1.56	1.43/1.82	diameter
shape	tabular	tabular	retained	retained	shape
length	2.83	2.91	-	-	length
condition	fresh/firm/moist	fresh/firm/moist	intact/charred	intact/charred	condition
time	90	90	3	2	Char score
temperature	300	300	1	1	ID score

After charring weight loss and % weight loss

weight loss	4.8	4.4	90.6	86.3	% wt loss

Char score: a subjective assessment of charring rated as: - 1 incomplete charring
2 complete charring
3 some tissue ashing or destruction
4 nearly complete ashing

ID score: a subjective measure of feature survivorship rated as: - 1 good potential
2 potentially usable
3 unusable

Comments: general trial observations and specific information on results -

a. tubers selected randomly to eliminate size bias.
b. tubers stored cool and moist in a refrigerator.
c. sprouts were trimmed from all tubers.
d. all tubers were tabular in shape unless specifically noted.
e. tuber diameters recorded as flat diameter and widest diameter.
f. the tubers were heated moist with no pre-drying.
g. the sand was dried to remove all moisture before use.
h. tuber B left in hot sand until it cooled.
i. oven pre-heated to run temperature, tubers then placed in oven, run temp. recovered in less than 1 minute
j. both charred tubers A and B have visible nodes and rhizome connections.
k. sand discoloration noted above tuber 3B after heating, 3A crucible has brown deposit after heating.
l. 3A has fragile grey skin, 3B has flakey black skin.

Wapato Charring Trials

Trial Run #: 4 A/B

The trial runs heat two tubers each run - one tuber (A) uncovered in an aluminum foil crucible and one tuber (B) covered with sand in a similar container.

Trial temperature (degrees C): 250

Trial duration (minutes): 60

	Before charring		After charring		
tuber ID	A	B	A	B	tuber ID
weight (gm)	5.7	5.1	0.8	0.8	weight
diameter	1.38/2.26	1.54/2.10	1.30/1.95	1.58/1.83	diameter
shape	tabular	tabular	retained	retained	shape
length	3.42	2.85	-	-	length
condition	fresh/firm/moist	fresh/firm/moist	intact/charred	intact/charred	condition
time	60	60	2	2	Char score
temperature	250	250	1	1	ID score

After charring weight loss and % weight loss

weight loss	4.9	4.3	86	84.3	% wt. loss

Char score: a subjective assessment of charring rated as: - 1 incomplete charring
2 complete charring
3 some tissue ashing or destruction
4 nearly complete ashing

ID score: a subjective measure of feature survivorship rated as: - 1 good potential
2 potentially usable
3 unusable

Comments: general trial observations and specific information on results -

a. tubers selected randomly to eliminate size bias.
b. tubers stored cool and moist in a refrigerator.
c. sprouts were trimmed from all tubers.
d. all tubers were tabular in shape unless specifically noted.
e. tuber diameters recorded as flat diameter and widest diameter.
f. the tubers were heated moist with no pre-drying.
g. the sand was dried to remove all moisture before use.
h. tuber B left in hot sand until it cooled.
i. oven pre-heated to run temperature, tubers then placed in oven, run temp. recovered in less than 1 minute.
j. both charred tubers A and B have visible nodes and rhizome connections.
k. sand discoloration noted above tuber 4B after heating.
l. 4B skin slightly bubbled.

Wapato Charring Trials

Trial Run #: 5 A/B

The trial runs heat two tubers each run - one tuber (A) uncovered in an aluminum foil crucible and one tuber (B) covered with sand in a similar container.

Trial temperature (degrees C): 250

Trial duration (minutes): 90

	Before charring		After charring		
tuber ID	A	B	A	B	tuber ID
weight (gm)	3.6	4.2	0.4	0.7	weight
diameter	1.26/1.64	1.43/2.08	1.19/1.35	1.44/1.77	diameter
shape	tabular	tabular	retained	retained	shape
length	3.9	2.62	-	-	length
condition	fresh/firm/moist	fresh/firm/moist	intact/charred	intact/charred	condition
time	90	90	2	2	Char score
temperature	250	250	1	1	ID score

After charring weight loss and % weight loss

weight loss	3.2	3.5	88.9	83.3	% wt. loss

Char score: a subjective assessment of charring rated as: - 1 incomplete charring
2 complete charring
3 some tissue ashing or destruction
4 nearly complete ashing

ID score: a subjective measure of feature survivorship rated as: - 1 good potential
2 potentially usable
3 unusable

Comments: general trial observations and specific information on results -
a. tubers selected randomly to eliminate size bias.
b. tubers stored cool and moist in a refrigerator.
c. sprouts were trimmed from all tubers.
d. all tubers were tabular in shape unless specifically noted.
e. tuber diameters recorded as flat diameter and widest diameter.
f. the tubers were heated moist with no pre-drying.
g. the sand was dried to remove all moisture before use.
h. tuber B left in hot sand until it cooled.
i. oven pre-heated to run temperature, tubers then placed in oven, run temp. recovered in less than 1 minute.
j. both charred tubers A and B have visible nodes and rhizome connections.
k. sand discoloration noted above tuber 5B after heating.
l. 5B skin slightly bubbled.

Wapato Charring Trials

Trial Run #: 6 A/B

The trial runs heat two tubers each run - one tuber (A) uncovered in an aluminum foil crucible and one tuber (B) covered with sand in a similar container.

Trial temperature (degrees C): 250

Trial duration (minutes): 120

	Before charring		After charring		
tuber ID	A	B	A	B	tuber ID
weight (gm)	6.3	7.4	0.7	0.8	weight
diameter	1.34/2.23	1.48/2.49	1.29/.82	1.26/2.09	diameter
shape	tabular	tabular	retained	retained	shape
length	4.05	8.63	-	-	length
condition	fresh/firm/moist	fresh/firm/moist	intact/charred	intact/charred	condition
time	120	120	2	2	Char score
temperature	250	250	1	1	ID score

After charring weight loss and % weight loss

weight loss	5.6	6.6	88.9	89.2	% wt. loss

Char score: a subjective assessment of charring rated as: - 1 incomplete charring
2 complete charring
3 some tissue ashing or destruction
4 nearly complete ashing

ID score: a subjective measure of feature survivorship rated as: - 1 good potential
2 potentially usable
3 unusable

Comments: general trial observations and specific information on results -

a. tubers selected randomly to eliminate size bias.
b. tubers stored cool and moist in a refrigerator.
c. sprouts were trimmed from all tubers.
d. all tubers were tabular in shape unless specifically noted.
e. tuber diameters recorded as flat diameter and widest diameter.
f. the tubers were heated moist with no pre-drying.
g. the sand was dried to remove all moisture before use.
h. tuber B left in hot sand until it cooled.
i. oven pre-heated to run temperature, tubers then placed in oven, run temp. recovered in less than 1 minute.
j. both charred tubers A and B have visible nodes and rhizome connections.
k. sand discoloration noted above tuber 6B after heating.

Wapato Charring Trials

Trial Run #: 7 A/B

The trial runs heat two tubers each run - one tuber (A) uncovered in an aluminum foil crucible and one tuber (B) covered with sand in a similar container.

Trial temperature (degrees C): 350

Trial duration (minutes): 30

	Before charring		After charring		
tuber ID	A	B	A	B	tuber ID
weight (gm)	4.4	6.7	0.5	1.6	weight
diameter	1.64/2.02	1.5/2.2	1.39/1.65	1.65/1.93	diameter
shape	tabular	tabular	retained	retained	shape
length	2.63	3.81	-	-	length
condition	fresh/firm/moist	fresh/firm/moist	fragile/intact/charred	intact/charred	condition
time	30	30	3	2	Char score
temperature	350	350	2	1	ID score

After charring weight loss and % weight loss

weight loss	3.9	5.1	88.6	76.1	% wt. loss

Char score: a subjective assessment of charring rated as: - 1 incomplete charring
2 complete charring
3 some tissue ashing or destruction
4 nearly complete ashing

ID score: a subjective measure of feature survivorship rated as: - 1 good potential
2 potentially usable
3 unusable

Comments: general trial observations and specific information on results -

a. tubers selected randomly to eliminate size bias.
b. tubers stored cool and moist in a refrigerator.
c. sprouts were trimmed from all tubers.
d. all tubers were tabular in shape unless specifically noted.
e. tuber diameters recorded as flat diameter and widest diameter.
f. the tubers were heated moist with no pre-drying.
g. the sand was dried to remove all moisture before use.
h. tuber B left in hot sand until it cooled.
i. oven pre-heated to run temperature, tubers then placed in oven, run temp. recovered in less than 1 minute.
j. both charred tubers A and B have visible nodes and rhizome connections.
k. sand discoloration noted above tuber 7B after heating, 7A crucible has brown deposit after heating.
l. 7A fragile grey skin, 7B skin bubbled.

Wapato Charring Trials

Trial Run #: 8 A/B

The trial runs heat two tubers each run - one tuber (A) uncovered in an aluminum foil crucible and one tuber (B) covered with sand in a similar container.

Trial temperature (degrees C): 350

Trial duration (minutes): 60

	Before charring		After charring		
tuber ID	A	B	A	B	tuber ID
weight (gm)	5.4	2.5	0.4	0.3	weight
diameter	1.3/1.91	1.13/1.57	too fragile	1.06/1.18	diameter
shape	tabular	tabular	retained	retained	shape
length	3.89	2.57	-	-	length
condition	fresh/firm/moist	fresh/firm/moist	fragile/grey/intact	fragile/grey/intact	condition
time	60	60	3	3	Char score
temperature	350	350	2	2	ID score

After charring weight loss and % weight loss

weight loss	5	2.2	92.6	88	% wt. loss

Char score: a subjective assessment of charring rated as: - 1 incomplete charring
2 complete charring
3 some tissue ashing or destruction
4 nearly complete ashing

ID score: a subjective measure of feature survivorship rated as: - 1 good potential
2 potentially usable
3 unusable

Comments: general trial observations and specific information on results -

a. tubers selected randomly to eliminate size bias.
b. tubers stored cool and moist in a refrigerator.
c. sprouts were trimmed from all tubers.
d. all tubers were tabular in shape unless specifically noted.
e. tuber diameters recorded as flat diameter and widest diameter.
f. the tubers were heated moist with no pre-drying.
g. the sand was dried to remove all moisture before use.
h. tuber B left in hot sand until it cooled.
i. oven pre-heated to run temperature, tubers then placed in oven, run temp. recovered in less than 1 minute.
j. both 8A and 8B have ashy grey skins.
k. 8B has a visible node.
l. brown crucible surface deposit nearly all burned off.

Wapato Charring Trials

Trial Run #: 9 A/B

The trial runs heat two tubers each run - one tuber (A) uncovered in an aluminum foil crucible and one tuber (B) covered with sand in a similar container.
Trial temperature (degrees C): 350
Trial duration (minutes): 90

	Before charring		After charring		
tuber ID	A	B	A	B	tuber ID
weight (gm)	5.3	3	0.1	0.35	weight
diameter	1.85/2.06	1.2/1.8	too fragile	too fragile	diameter
shape	globular	globular	retained	retained	shape
length	2.77	2.61	-	-	length
condition	fresh/firm/moist	fresh/firm/moist	fragile/intact/grey	fragile/intact/grey	condition
time	90	90	4	4	Char score
temperature	350	350	3	3	ID score

After charring weight loss and % weight loss

weight loss	5.2	2.65	98.1	88.3	% wt. loss

Char score: a subjective assessment of charring rated as: - 1 incomplete charring
2 complete charring
3 some tissue ashing or destruction
4 nearly complete ashing

ID score: a subjective measure of feature survivorship rated as: - 1 good potential
2 potentially usable
3 unusable

Comments: general trial observations and specific information on results -
a. tubers selected randomly to eliminate size bias.
b. tubers stored cool and moist in a refrigerator.
c. sprouts were trimmed from all tubers.
d. all tubers were tabular in shape unless specifically noted.
e. tuber diameters recorded as flat diameter and widest diameter.
f. the tubers were heated moist with no pre-drying.
g. the sand was dried to remove all moisture before use.
h. tuber B left in hot sand until it cooled.
i. oven pre-heated to run temperature, tubers then placed in oven, run temp. recovered in less than 1 minute.
j. tubers were too fragile to handle and essentially an ashed husk retaining its shape.
k. crucible surface deposit is apparently all burned off.

Wapato Charring Trials

Trial Run #: 10a/b
The trial runs heat two tubers each run - one tuber (A) uncovered in an aluminum foil crucible and one tuber (B) covered with sand in a similar container.
Trial temperature (degrees C): 200
Trial duration (minutes): 30

	Before charring		After charring		
tuber ID	A	B	A	B	tuber ID
weight (gm)	7.4	5.3	3.2	2.3	weight
diameter	1.55/2.45	1.5/1.95	1.6/2.3	1.5/1.5	diameter
shape	laterally flattened	laterally flattened	laterally flattened	rounded	shape
length	3.6	3.25	3.4	3.05	length
condition	fresh	fresh	smooth flat skin	wrinkled	condition
time	30	30	1	1	Char score
temperature	200	200	36951	3	ID score

After charring weight loss and % weight loss

weight loss (gm)	4.2	3	56.8	56.6	% weight loss

Char score: a subjective assessment of charring rated as: - 1 incomplete charring
2 complete charring
3 some tissue ashing or destruction
4 nearly complete ashing

ID score: a subjective measure of feature survivorship rated as: - 1 good potential
2 potentially usable
3 unusable

Comments: general trial observations and specific information on results -
a. tubers selected randomly to eliminate size bias.
b. tubers stored cool and moist in a refrigerator.
c. sprouts were trimmed from all tubers.
d. all tubers were tabular in shape unless specifically noted.
e. tuber diameters recorded as flat diameter and widest diameter.
f. the tubers were heated moist with no pre-drying.
g. the sand was dried to remove all moisture before use.
h. double entry Char & ID scores indicate incomplete charring and are entered as inner value/outer value.

Wapato Charring Trials

Trial Run #: 11a/b

The trial runs heat two tubers each run - one tuber (A) uncovered in an aluminum foil crucible and one tuber (B) covered with sand in a similar container.
Trial temperature (degrees C): 200
Trial duration (minutes): 60

	Before charring		After charring		
tuber ID	A	B	A	B	tuber ID
weight (gm)	7.4	4.8	1.1	1	weight
diameter	1.6/2.1	1.5/2.1	1.75/1.75	1.8/1.95	diameter
shape	laterally flattened	laterally flattened	laterally rounded	laterally flattened	shape
length	4.3	2.9	3.75	2.27	length
condition	fresh	fresh	charred	charred	condition
time	60	60	2	1 / 2	Char score
temperature	200	200	1	2 / 1	ID score

After charring weight loss and % weight loss

weight loss (gm)	6.3	3.8	85.1	79.2	% weight loss

Char score: a subjective assessment of charring rated as: - 1 incomplete charring
2 complete charring
3 some tissue ashing or destruction
4 nearly complete ashing

ID score: a subjective measure of feature survivorship rated as: - 1 good potential
2 potentially usable
3 unusable

Comments: general trial observations and specific information on results -
a. tubers selected randomly to eliminate size bias.
b. tubers stored cool and moist in a refrigerator.
c. sprouts were trimmed from all tubers.
d. all tubers were tabular in shape unless specifically noted.
e. tuber diameters recorded as flat diameter and widest diameter.
f. the tubers were heated moist with no pre-drying.
g. the sand was dried to remove all moisture before use.
h. double entry Char & ID scores indicate incomplete charring and are entered as inner value/outer value.

Wapato Charring Trials

Trial Run #: 12a/b

The trial runs heat two tubers each run - one tuber (A) uncovered in an aluminum foil crucible and one tuber (B) covered with sand in a similar container.
Trial temperature (degrees C): 200
Trial duration (minutes): 90

	Before charring		After charring		
tuber ID	A	B	A	B	tuber ID
weight (gm)	4.4	9.9	0.4	1.8	weight
diameter	1.2/2.0	2.15/2.6	1.2/1.7	2.1/2.5	diameter
shape	laterally flattened	laterally flattened	laterally flattened	more globular	shape
length	3.4	3.6	2.9	3.25	length
condition	fresh	fresh	charred	charred	condition
time	90	90	2	1 / 2	Char score
temperature	200	200	1	1 / 2	ID score

After charring weight loss and % weight loss

weight loss (gm)	4	8.1	90.9	81.8	% weight loss

Char score: a subjective assessment of charring rated as: - 1 incomplete charring
2 complete charring
3 some tissue ashing or destruction
4 nearly complete ashing

ID score: a subjective measure of feature survivorship rated as: - 1 good potential
2 potentially usable
3 unusable

Comments: general trial observations and specific information on results -
a. tubers selected randomly to eliminate size bias.
b. tubers stored cool and moist in a refrigerator.
c. sprouts were trimmed from all tubers.
d. all tubers were tabular in shape unless specifically noted.
e. tuber diameters recorded as flat diameter and widest diameter.
f. the tubers were heated moist with no pre-drying.
g. the sand was dried to remove all moisture before use.
h. double entry Char & ID scores indicate incomplete charring and are entered as inner value/outer value.

Wapato Charring Trials

Trial Run #: 13a/b

The trial runs heat two tubers each run - one tuber (A) uncovered in an aluminum foil crucible and one tuber (B) covered with sand in a similar container.
Trial temperature (degrees C): 200
Trial duration (minutes): 120

	Before charring		After charring		
tuber ID	A	B	A	B	tuber ID
weight (gm)	5.4	4.5	0.5	0.5	weight
diameter	1.5/2.2	1.6/1.9	1.45/1.95	1.5/1.8	diameter
shape	laterally flattened	laterally flattened	laterally flattened	laterally flattened	shape
length	3	3.2	2.55	2.8	length
condition	fresh	fresh	charred	charred	condition
time	120	120	2	2	Char score
temperature	200	200	1	1	ID score

After charring weight loss and % weight loss

weight loss (gm)	4.9	4	90.7	88.9	% weight loss

Char score: a subjective assessment of charring rated as: - 1 incomplete charring
2 complete charring
3 some tissue ashing or destruction
4 nearly complete ashing

ID score: a subjective measure of feature survivorship rated as: - 1 good potential
2 potentially usable
3 unusable

Comments: general trial observations and specific information on results -
a. tubers selected randomly to eliminate size bias.
b. tubers stored cool and moist in a refrigerator.
c. sprouts were trimmed from all tubers.
d. all tubers were tabular in shape unless specifically noted.
e. tuber diameters recorded as flat diameter and widest diameter.
f. the tubers were heated moist with no pre-drying.
g. the sand was dried to remove all moisture before use.
h. double entry Char & ID scores indicate incomplete charring and are entered as inner value/outer value.

Wapato Charring Trials

Trial Run #: 14a/b

The trial runs heat two tubers each run - one tuber (A) uncovered in an aluminum foil crucible and one tuber (B) covered with sand in a similar container.
Trial temperature (degrees C): 250
Trial duration (minutes): 30

	Before charring		After charring		
tuber ID	A	B	A	B	tuber ID
weight (gm)	4.5	5	1.4	2.1	weight
diameter	1.4/1.9	1.4/2.05	1.35/1.6	1.1/1.9	diameter
shape	laterally flattened	laterally flattened	laterally flattened	laterally flattened	shape
length	2.9	3.1	2.5	2.9	length
condition	fresh	fresh	charred	browned	condition
time	30	30	2	1	Char score
temperature	250	250	1	3	ID score

After charring weight loss and % weight loss

weight loss (gm)	3.1	2.9	68.9	58	% weight loss

Char score: a subjective assessment of charring rated as: - 1 incomplete charring
2 complete charring
3 some tissue ashing or destruction
4 nearly complete ashing

ID score: a subjective measure of feature survivorship rated as: - 1 good potential
2 potentially usable
3 unusable

Comments: general trial observations and specific information on results -
a. tubers selected randomly to eliminate size bias.
b. tubers stored cool and moist in a refrigerator.
c. sprouts were trimmed from all tubers.
d. all tubers were tabular in shape unless specifically noted.
e. tuber diameters recorded as flat diameter and widest diameter.
f. the tubers were heated moist with no pre-drying.
g. the sand was dried to remove all moisture before use.
h. double entry Char & ID scores indicate incomplete charring and are entered as inner value/outer value.

Wapato Charring Trials

Trial Run #: 15a/b

The trial runs heat two tubers each run - one tuber (A) uncovered in an aluminum foil crucible and one tuber (B) covered with sand in a similar container.
Trial temperature (degrees C): 350
Trial duration (minutes): 120

	Before charring		After charring		
tuber ID	A	B	A	B	tuber ID
weight (gm)	12.2	10.6	0.2	0.75	weight
diameter	1.9/2.95	1.7/3.05	1.6/2.0	1.5/2.4	diameter
shape	laterally flattened	laterally flattened	laterally flattened	laterally flattened	shape
length	4.5	3.7	3.3	2.7	length
condition	fresh	fresh	ashed thru	ashed skin	condition
time	120	120	4	3	Char score
temperature	350	350	3	1	ID score

After charring weight loss and % weight loss

weight loss (gm)	12	9.85	98.4	92.9	% weight loss

Char score: a subjective assessment of charring rated as: - 1 incomplete charring
2 complete charring
3 some tissue ashing or destruction
4 nearly complete ashing

ID score: a subjective measure of feature survivorship rated as: - 1 good potential
2 potentially usable
3 unusable

Comments: general trial observations and specific information on results -
a. tubers selected randomly to eliminate size bias.
b. tubers stored cool and moist in a refrigerator.
c. sprouts were trimmed from all tubers.
d. all tubers were tabular in shape unless specifically noted.
e. tuber diameters recorded as flat diameter and widest diameter.
f. the tubers were heated moist with no pre-drying.
g. the sand was dried to remove all moisture before use.
h. double entry Char & ID scores indicate incomplete charring and are entered as inner value/outer value.

Wapato Charring Trials

Trial Run #: 16a/b

The trial runs heat two tubers each run - one tuber (A) uncovered in an aluminum foil crucible and one tuber (B) covered with sand in a similar container.
Trial temperature (degrees C): 300
Trial duration (minutes): 120

	Before charring		After charring		
tuber ID	A	B	A	B	tuber ID
weight (gm)	7.2	5	0.2	0.15	weight
diameter	2.0/2.15	1.4/2.2	1.65/1.6	2.1/2.1	diameter
shape	laterally flattened	laterally flattened	more rounded	more rounded	shape
length	3.5	3	2.2	2.3	length
condition	fresh	fresh	ashed	ashed	condition
time	120	120	4	4	Char score
temperature	300	300	3	3	ID score

After charring weight loss and % weight loss

weight loss (gm)	7	4.85	97.2	97	% weight loss

Char score: a subjective assessment of charring rated as: - 1 incomplete charring
2 complete charring
3 some tissue ashing or destruction
4 nearly complete ashing

ID score: a subjective measure of feature survivorship rated as: - 1 good potential
2 potentially usable
3 unusable

Comments: general trial observations and specific information on results -
a. tubers selected randomly to eliminate size bias.
b. tubers stored cool and moist in a refrigerator.
c. sprouts were trimmed from all tubers.
d. all tubers were tabular in shape unless specifically noted.
e. tuber diameters recorded as flat diameter and widest diameter.
f. the tubers were heated moist with no pre-drying.
g. the sand was dried to remove all moisture before use.
h. double entry Char & ID scores indicate incomplete charring and are entered as inner value/outer value.