Bridging Ethnobotany, Autecology and Restoration:
The Study of Wapato (*Sagittaria latifolia* Willd.; Alismataceae) in Interior British Columbia

by

Ann Catherine Garibaldi
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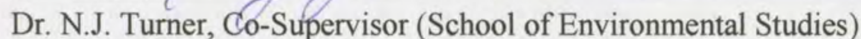

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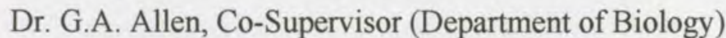

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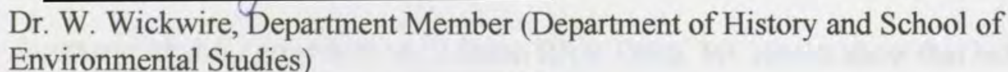

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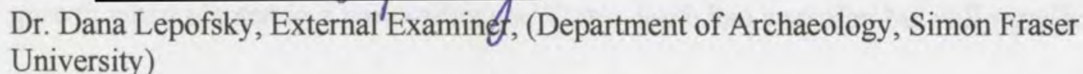

Dr. Dana Lepofsky, External Examiner, (Department of Archaeology, Simon Fraser University)

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Co-Supervisors: Drs. Nancy J. Turner and Geraldine A. Allen

Abstract

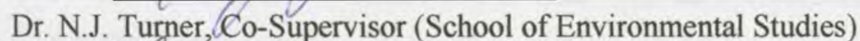
The goal of this research is to explore the cultural and ecological restoration of an aquatic perennial, wapato (*Sagittaria latifolia* Willd.: Alismataceae) in the Salmon River Delta, Salmon Arm, British Columbia. Wapato has been extirpated from this area, a traditional Secwepemc (Shuswap) gathering site, within the past 80 years. This research explores some of the repercussions of this loss as well as methods for this plant's restoration.

I conducted a series of interviews that provided information on landscape and ecological characteristics of this area from the 1920s when Secwepemc elder Mary Thomas was a child. The Salmon River Delta has experienced significant changes over the past century that have resulted in a decline of some native plant species and an increase in exotic ones, as evidenced by interviews and literature research.

I also experimentally investigated the effects of animal herbivory and water depth on *Sagittaria latifolia* growth in the Salmon River Delta. My results show that herbivory significantly (P = 0.00) limited *S. latifolia* growth in this study; plants showed prolific growth when planted in a wire exclosure. Water depth had a smaller but still significant (P = 0.016) effect on *S. latifolia* growth for plants inside the exclosure. I surveyed wapato populations to assess the current distribution of *S. latifolia* in the region and a traditionally harvested congener, *S. cuneata*. I located 16 patches of *S. latifolia* and *S. cuneata*

at 10 sites in the southern interior of British Columbia. I found no new populations of *Sagittaria* and failed to locate *Sagittaria* at four sites that have documented populations.

Research objectives facilitated the development of a model of cultural refugia, as a parallel concept to that of ecological refugia. Just as ecological refugia are havens from disturbance for various species and can serve to retain "resource populations" to promote conservation and resource protection, I propose that cultural refugia can take on a similar role. These refugia can serve as centres for the maintenance and expansion of traditional ecological knowledge. Restoration, within a cultural context, can facilitate this expansion thereby augmenting the knowledge system associated with a cultural refugium.



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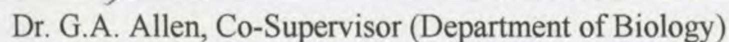

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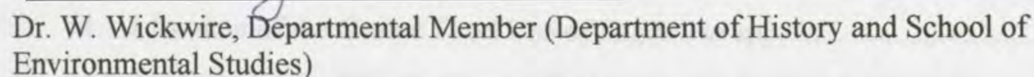

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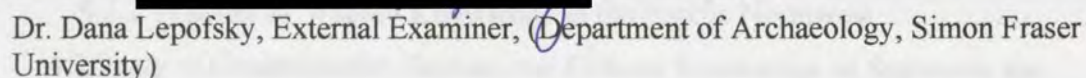

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I sit at my window and I look out and I have memories of that delta. I have memories of that wetland and how it used to be
(Secwepemc elder Dr. Mary Thomas 2001, referring to the Salmon River Delta at Salmon Arm, British Columbia)

1.0 Introduction

When Meriwether Lewis and William Clark made their famous journey across North America in 1804-1806, wapato (*Sagittaria latifolia* Willd. or *S. cuneata* Sheldon[1]) was in such abundance that they named what is now the Lower Columbia Valley, *Wap-pa-too Valley*, after this prolific aquatic perennial (Clark, in Bergon 1989) (Figure 1.1). Wapato tubers have been a part of the diet of aboriginal peoples throughout the plant's North American range (Figure 1.2). For this study, I recorded a history of wapato use in the Salmon Arm Delta of Shuswap Lake, British Columbia by the Secwepemc (Shuswap) First Nations in the early 1900s to the present, noting its decline and eventual extermination in the Salmon River Delta (see Figure 1.3). This led me to a search for the reasons behind this change.

For the Secwepemc and other aboriginal people in the Pacific Northwest, wapato was formerly managed to promote its growth, producing a reliable and abundant food source and item for trade (Suttles 1955; SCES in prep. 1; Mary Thomas pers. comm. to Ann Garibaldi 2001). Recent activities such as channelization, dyking and filling have altered

[1] Wapato is used in this section to refer to either *S. latifolia* or *S. cuneata*. These two species were frequently not distinguished in historical reports. I use the term wapato to denote either species and the full binomial when species name is certain.

Figure 1.1 *Sagittaria latifolia* grown in a nursery in Victoria, British Columbia.

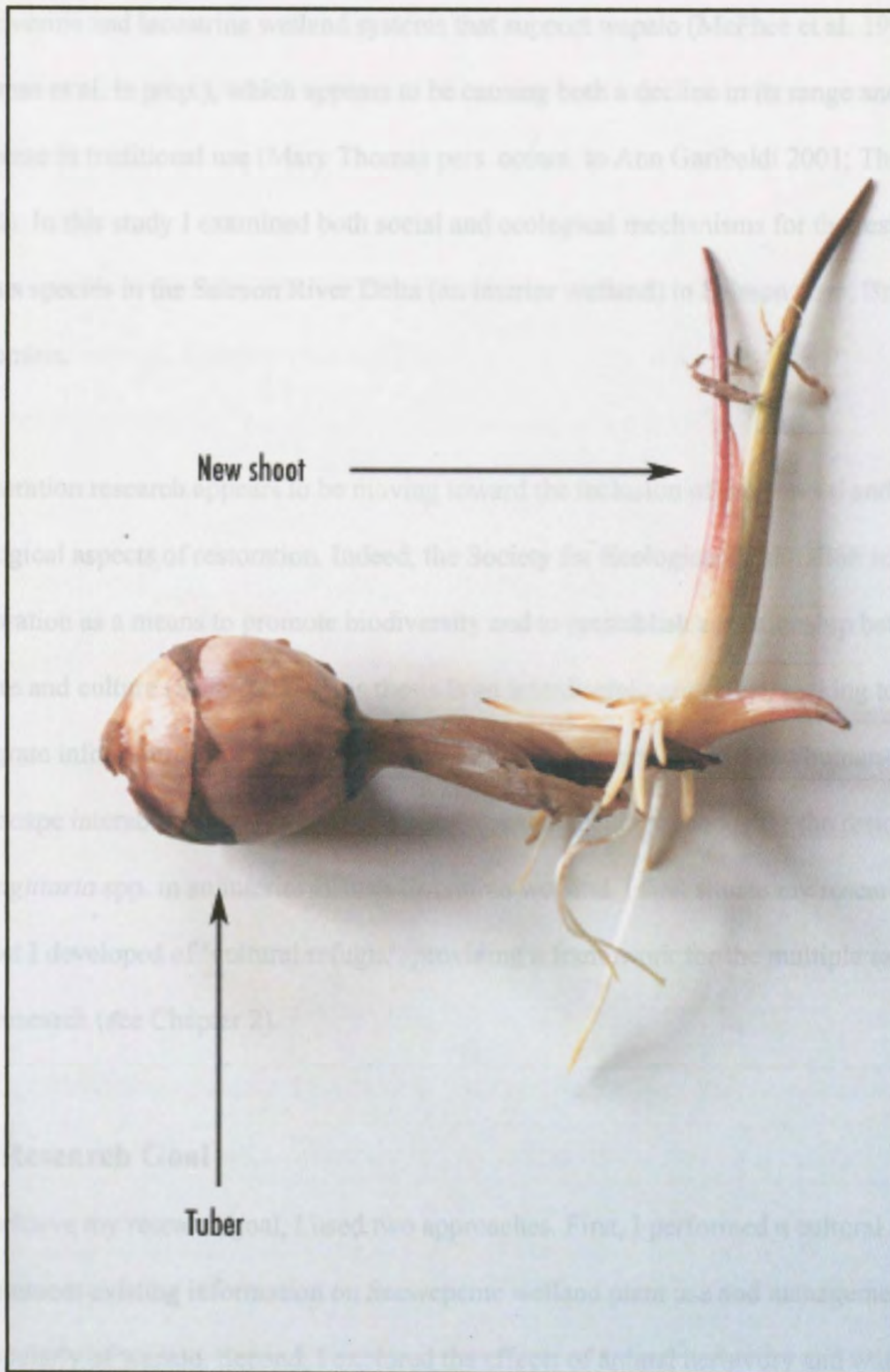

Figure 1.2 *Sagittaria latifolia* tuber grown in a nursery in Victoria, British Columbia.

the riverine and lacustrine wetland systems that support wapato (McPhee et al. 1996; Thomas et al. in prep.), which appears to be causing both a decline in its range and a decrease in traditional use (Mary Thomas pers. comm. to Ann Garibaldi 2001; Thomas 2002). In this study I examined both social and ecological mechanisms for the restoration of this species in the Salmon River Delta (an interior wetland) in Salmon Arm, British Columbia.

Restoration research appears to be moving toward the inclusion of both social and biological aspects of restoration. Indeed, the Society for Ecological Restoration sees restoration as a means to promote biodiversity and to reestablish a relationship between nature and culture (SER 2003). This thesis is an interdisciplinary effort, seeking to integrate information on autecology[2], ethnobotany, herbivory studies, and human-plant landscape interactions to understand the ecological and cultural needs for the restoration of *Sagittaria* spp. in an interior British Columbia wetland. I first situate my research in a model I developed of 'cultural refugia', providing a framework for the multiple aspects of my research (see Chapter 2).

1.1 Research Goal

To achieve my research goal, I used two approaches. First, I performed a cultural study to supplement existing information on Secwepemc wetland plant use and management, particularly of wapato. Second, I explored the effects of animal herbivory and water depth on *Sagittaria latifolia* growth in the Salmon River Delta. Finally, to augment the

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[2] Autecology is the study of a single species in relation to its ecosystem.

limited information on *Sagittaria* spp. distribution in interior British Columbia, I surveyed the distribution of *Sagittaria latifolia* and *S. cuneata* in the region surrounding the city of Salmon Arm.

At first glance these two approaches may seem disjointed, related only through the plant focused on in each. However, these approaches do not exist in isolation. Each informs and influences the other in a complex web of processes and interrelationships. Ethnobotanical researchers frequently encounter situations in which the socio-cultural factors and ecological factors of a research question are intertwined (see Ford 1994; Loewen 1998; Peacock 1998; Chambers 2001; Lantz 2001; Becker and Ghimire 2003; Watson et al. 2003).

I have approached my research by linking ethnobotanical interviews and ecological studies that converge around the Salmon Arm Indian Reserve No. 3[3] land that encompasses the Salmon River Delta (hereafter, the Delta) at Shuswap Lake, British Columbia (Figure 1.3). The Delta is a traditional gathering site for the Secwepemc Interior Salish from the Salmon Arm area. This area formerly contained extensive patches of wapato and other culturally significant species. As such, it provides a unique

[3] The Salmon Arm Indian Reserve No. 3 (= Switsemalph No. 3) is adjacent to the town of Salmon Arm and is one of three reserves in the Neskonlith Indian Band. This reserve is located on the west shore of Salmon Arm, Shuswap Lake and has also been referred to as the Neskonlith Reserve No. 3. The official title from The Department of Indian Affairs is Switsemalph No. 3. The Neskonlith Reserve No. 1 and Neskonlith Reserve No. 2 are located close to Chase, roughly 30 miles west of Salmon Arm. Members of the Neskonlith Indian Band may sometimes refer to the Salmon Arm Indian Reserve No. 3 as the Neskonlith Indian Reserve No. 3. Mary Thomas has most commonly referred to this reserve as the Salmon Arm Indian Reserve (No. 3) when speaking about it to me.

opportunity to explore social and ecological requirements for restoration. This work has resulted in a model of cultural refugia that contextualizes the idea of multidisciplinary restoration.

Figure 1.3 Aerial photo, August 31, 1998, of Salmon River Delta at Shuswap Lake, Salmon Arm, British Columbia. The red box outlines the site of the herbivory and water depth study.

1.1.1 Overview of Ethnobotanical Research Methods

Cultural Research Methods

For this study, I conducted a series of five semi-structured interviews[4] with Secwepemc elder Mary Thomas of the Neskonlith Indian Band, Salmon Arm Indian Reserve No. 3, on Secwepemc wetland management, as well as the traditional cooking methods and harvesting regimes for wapato. I formerly interviewed Mary on five occasions:

- February 15, 2001. Victoria, B.C. with Nancy Turner
- February 25, 2001. Victoria, B.C.
- April 16, 2001. Salmon Arm, B.C.
- July 4, 2001. Driving from Salmon Arm to Three Valley Gap, B.C.
- June 22, 2003. Telephone interview.

To supplement the interviews, and to place wapato plant knowledge in a larger context, I reviewed literature pertaining to Secwepemc seasonal plant use and management as well as knowledge of *Sagittaria* spp. use throughout British Columbia and neighbouring territories. A summary of this work and a detailed description of the methods I employed are provided in Chapter 4.

[4] The research methodology for this project was approved by the University of Victoria's Human Research Ethics Committee, Project No. 333-00.

Ecological Research Methods

To ascertain the present distribution of *Sagittaria* spp. in the vicinity of Salmon Arm, I examined herbarium specimens for habitat information and site locations. I then visited areas where records existed in August of 2001 to record site characteristics. In addition, I collected data on the effects of water depth and herbivory on *Sagittaria latifolia* growth through experimental work at the Delta. In the fall of 2001, I planted wapato tubers in an experiment designed to test the effects of water depth and herbivory on plant growth. I then collected results from this research in the fall of 2002 (see Chapter 5: Ecological Considerations).

2.0 Cultural Refugia and Restoration

2.1 Introduction

Biological refugia are havens from disturbance for various species and can serve as "resource populations" (Josh and Gadgil 1991; Gadgil et al. 1998) to promote conservation and resource protection. I propose that cultural refugia can play a similar role serving as locations for the expansion of traditional ecological knowledge[5] and landscape memory. Through the exploration of social and ecological systems, I began to think of cultural refugia as more than a metaphor to reflect a cultural mirroring of an ecological process.

In this chapter I describe a model of cultural refugia, defining a cultural refugium in terms of ethnobotanical knowledge and showing its relevance to restoration. Using this model I address a cultural response to both social and landscape-based disturbance and then discuss mechanisms for restoring cultural practices as they relate to ecological restoration.

2.2 The Model

Just as there is a biosphere – the region of the earth's crust and atmosphere occupied by living organisms - there is an ethnosphere, *the wealth of human diversity, the limitless potential of the human imagination given form through spiritual desires and cultural*

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[5] Throughout this thesis I use the following definition of traditional ecological knowledge: *a cumulative body of knowledge, practice and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment* (Berkes 1999:8).

adaptation (Davis 2001: inside cover). The exploration of this concept has many implications for those interested in both natural and social spheres of study. On a broad level it is an application of a biological concept modified to describe cultural systems. Examined further, it becomes a tool to understand the complex web of human-ecosystem connections. The ethnosphere is born out of the biosphere it inhabits. Conversely the ethnosphere modifies, manages, and therefore influences the biosphere. Disturbances that occur in either 'sphere' therefore have repercussive effects on the other.

Research from such disciplines as ecological anthropology and cultural geography have explored biological concepts in relation to social systems (see Dove 2001) and the relationships between these two systems (see Butzer 1978; Cavalli-Sforza 1983). These studies include cultural and ecological evolution (see Corluy 1985; de Winter1985; Fracchia and Lewontin 1999), cultural adaptability and the interaction between "human and nonhuman components of the human ecosystem" (see Butzer 1982:281; Ortner 1983) as well as cultural knowledge transmission (see Cavalli-Sforza and Feldman 1981; Laland et al. 1995). These studies help to inform the research guiding cultural and ecological restoration by assessing mechanisms and relationships through which these two systems have developed which may be crucial for understanding how they can be restored.

Many people have begun to see these links as not just interesting metaphors, but concrete parallels between social and ecological systems (Berkes and Folke 1998; Seixas 2002; Garibaldi and Turner 2002; Turner et al. 2003). As an example, Turner et al. (2003)

discuss the concept of cultural edges. These sites mirror ecological edges – the boundaries or areas of transition from one ecosystem to another – as areas with potentially high species diversity and cultural richness. The transition zones increase the resilience[6] and flexibility of the ecosystems they border and the peoples occupying or accessing those sites. As Turner et al. states "indigenous peoples whose living territories traverse ecological edges have a correspondingly increased access to culturally important resources and therefore have a greater capacity for flexibility" (Turner et al. 2003). This leads to increased resilience (both culturally and ecologically). This example and others demonstrate that ecological mechanisms that build resilience in the face of change can be useful for studying social models for change.

As noted previously, from an ecological standpoint refugia are sites that serve as protected areas or nodes that allow for the persistence and growth of species (Haffer 1969) and possibly expansion of their range should the surrounding areas become habitable. Current literature discussing biological refugia centres on a wide range of disturbances in diverse habitats. The studies incorporate alterations in wetland systems (Palmer et al. 1995; Chapman et al. 1996; Lancaster 2000), oil spills damage (Cairns and Elliot 1987), glacial movement (Abbot et al. 2000), hurricanes (Elmqvist et al. 1994) and agroforestry impacts (Dix et al. 1997). Size and scale also vary with these disturbances, ranging from one-season floods to several thousand year-long glaciation. Despite

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[6] Resilience, in terms of ecological systems, is a measure of the persistence of systems and of their ability to absorb change and disturbance and still maintain the same relationships between populations or state variables (Holling 1973).

differences however, the studies all discuss the presence of sites that act as refuges and as havens from disturbance.

References to refugia in a cultural sense have been primarily concerned with ecological protection of habitat through social actions (see Gadgil et al. 1998; Debal and Malhotra 2001; Colding and Folke 2001; Colding et al. 2003). While these refugia provide significant contributions to the sustainability of ecological resources through cultural practices, the studies do not address the sustainability of the cultural practices themselves. Setting aside areas for permanent habitat protection is undertaken worldwide (Colding and Folke 2001). These areas may take the form of national parks or nature preserves that are established and managed through government, or of systems which are put in place by local resource users (Colding et al. 2003). The latter are often enforced through religious edicts, such as the sacred groves of India (Joshi and Gadgil 1991; Gadgil et al. 1998) that simultaneously act as religious sites and biological reserves.

Communities and cultures have developed methods for maintaining resilience in the face of changes and shifts in both the ethnosphere and biosphere (Kroeber 1998). The magnitude of such disturbances, however, has increased considerably in the past century. Previously used mechanisms for absorbing and responding to those changes may not be sufficient. For example, factors and events including epidemics, establishment of residential schools, colonial settlement, agriculture and broad-scale development have heavily affected the traditional social structure of the First Nations people of British Columbia. The transmission and practice of ethnobotanical knowledge, among many

other cultural elements, have been forced to adjust to these large scale cultural and environmental changes.

One mechanism for absorbing and managing those changes is through what I term *cultural refugia* – individuals or groups that serve as a source of traditional/local knowledge during times of cultural disturbance. The model I present has three components: 1) Potential Cause 2) Potential Consequence and 3) Potential Outcome (Figure 2.1). I will begin by describing this model in a general sense and then showing how it applies to my research project.

Potential Cause

Disturbance events such as glaciation, floods and urban development can result in habitat fragmentation. These disturbances can lead to habitat loss and species extinction as explained in the island biogeography model (MacArthur and Wilson 1967). Although equations derived from the island biogeography model for predicting percent of species loss do not translate into predictive models for assessing percent loss of cultural knowledge per se, we can gain understandings of processes involved in cultural loss through examining related processes in ecosystems (see Cavalli-Sforza and Feldman 1981; Laland et al. 1995). Both cultural and ecological processes shape a community's response to the transmission of ethnobotanical knowledge. The repercussions are complex. Examples include the following: the cessation of indigenous ecological management; replacement of traditional economy with industrial style wage economy; introduction of non-native foods and crops through interaction with neighbouring settlers;

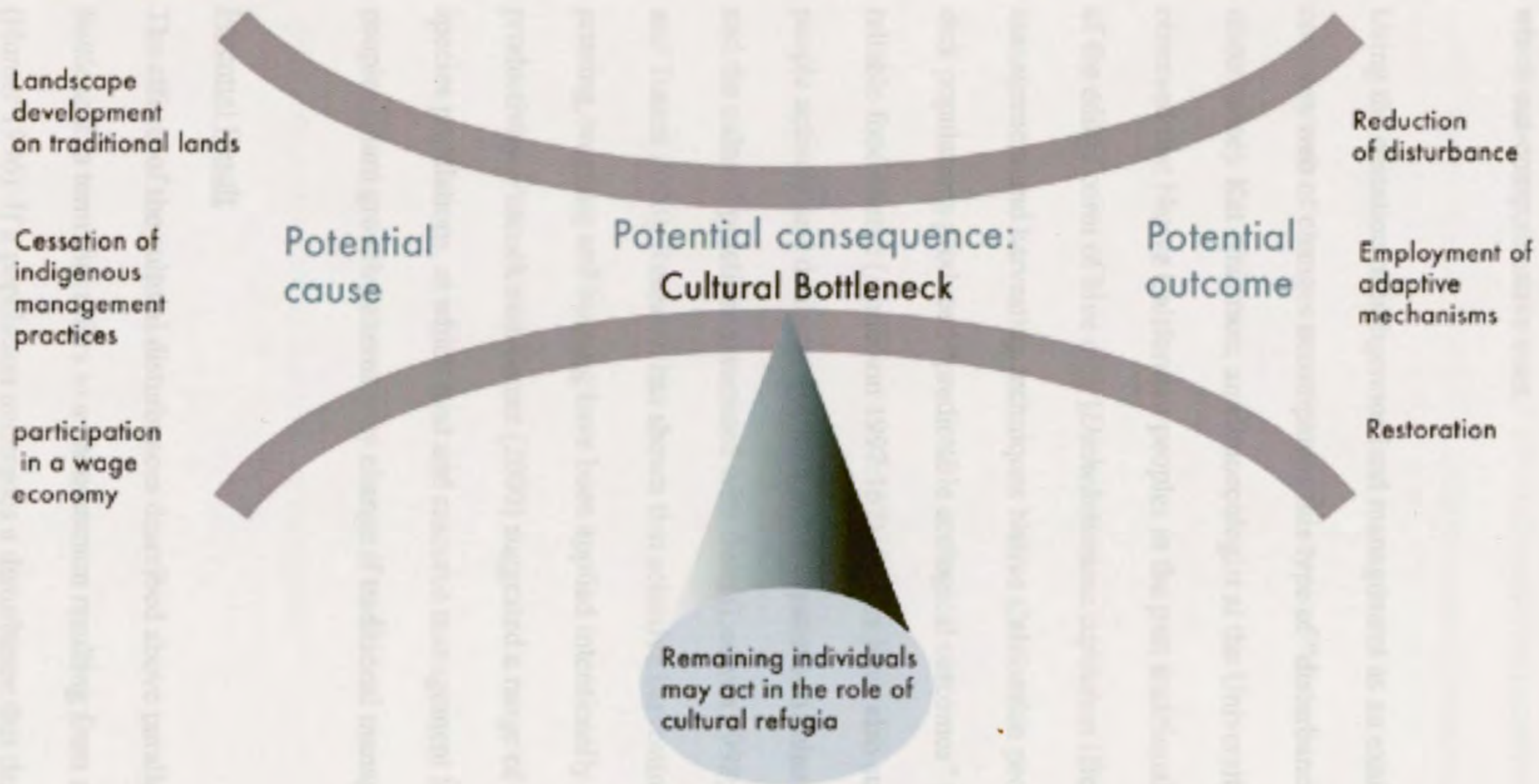

Figure 2.1 Illustration of potential impacts from social and ecological disturbances that affect the transmission of traditional knowledge with potential to expand this knowledge via cultural refugia.

industrial development on traditional lands; and, the prolific growth of introduced species which out-compete native ones.

Using the cessation of indigenous land management as an example, we can see that a complex web of changes accompanies this type of "disturbance" (or the cessation of disturbance). Kat Anderson, an ethnoecologist at the University of California Davis, has observed that Native Californian peoples in the past traditionally encouraged the growth of the edible corm of blue dick [*Dichelostemma capitatum* (Benth.) Wood]. The management and harvesting techniques Native Californian peoples employed with blue dick populations produced "predictable ecological outcomes" thereby encouraging a reliable food source (Anderson 1997:162). Others have also suggested that indigenous people actively and deliberately managed ecosystems to enhance resource availability and the cultural practices associated with them (Loewen 1998; Peacock 1998; Peacock and Turner 2000). Research has shown that selective harvesting, replanting propagules, pruning, weeding and burning have been applied intentionally to enhance plant resource productivity. Peacock and Turner (2000) suggested a range of scales, from landscape to species populations, at which land and resource management has been enacted by Plateau peoples. Plant growth patterns may change if traditional management ceases.

Potential Result

The effects of the cultural disturbances described above parallel those of a *genetic bottleneck*, a term that refers to a phenomenon resulting from a population decline (Hunter 1996). If a population undergoes a disturbance that drastically reduces population

size a "bottleneck" may be formed. This restricts genetic variability by decreasing the availability of certain alleles and ultimately reducing genetically determined characteristics (Hunter 1996). Culturally, a similar phenomenon happens (see Laland et al. 1995). When cultural knowledge is diminished, a 'cultural bottleneck' is formed, thus reducing knowledge transmission. What remains are a few individuals who sometimes play the role of "safeguards" of the culture.

For instance, when the disease epidemics reached southern British Columbia's indigenous populations along the Strait of Georgia in 1782, many communities experienced major losses (Harris 1997). Most affected were the elderly – the knowledge holders – and the young – the future knowledge holders. The remaining individuals shared the burden of disseminating cultural knowledge in an atmosphere of trauma and despair. When social struggles are accompanied with the loss and degradation of traditionally important areas, the ability of people to share and transmit knowledge environmental knowledge may be severely compromised. This is evidently what happened from the extirpation of wapato from the Salmon River Delta; the altering of landscapes occurred simultaneous with large cultural change. Mary Thomas and many others of her generation were sent to residential schools as young children, the same time agriculture and industrial development increased.

Characteristics of Cultural Refugia

These 'cultural bottlenecks', in essence the cultural refugia that remain after loss and disturbance, vary across communities and regions but they seem to have similar

characteristics. First, they retain some limited amount of accumulated knowledge that has been passed down and fine-tuned through many generations, and can therefore be viewed on a temporal scale. The individuals that comprise the cultural refugia are the present holders of cultural knowledge that is generations-old. Second, sites of cultural refugia vary in size. They may range from a single individual to a large group or community.

Third, cultural refugia are a source of knowledge expansion. Before a bottleneck is formed, cultural knowledge is held by a larger number of individuals. Cultural practices dictate who has this knowledge. For example, specific plant knowledge may be reserved only for healers; conversely, food plant knowledge may be shared freely within a community. Regardless of the type of plant knowledge, social practices dictated the dissemination of this knowledge and these norms may be severely disrupted during times of disturbance. Following a disturbance, an individual, family group or large group of people able and willing to maintain and adapt cultural practices keep these practices viable. Their collective knowledge can serve as a source for expanding a knowledge base. This can occur through applied practice (e.g., harvesting or managing traditional sites), sharing of knowledge (e.g., enabling children to participate in root digging), remembering and speaking a language, or telling oral traditions (e.g., origin stories of different species).

Finally, 'refugia' like the traditional knowledge they perpetuate, are generally adaptable, engendering resilience in changing environs (e.g., extending traditional cultivation practices to new crops). The level of resiliency an individual or group displays may

depend in part on the predisposition and guidance of the previous knowledge holders. For example, the willingness of an individual or group to explore new mechanisms for communicating and teaching traditional knowledge (e.g., collaborating with researchers, developing school curriculum) may in part be a reflection of the guidance from their teachers. There are essentially limitless ways in which cultures adapt to new and changing circumstances while still retaining their essential features, provided there is cultural memory to mediate these changes.

Potential Future

The individuals who maintain cultural refugia are key to expanding traditional knowledge within a family, community, or linguistic group. An abatement of the disturbance that caused the bottleneck in the first place may directly facilitate an expansion of knowledge, including ethnobotanical knowledge. The scale of the disturbance may determine if this is realistic or even possible. For example, the effects of epidemics, participation in a wage economy, and large-scale development on traditional gathering sites may not be reversible. However, small-scale changes and reversals may be feasible. Some examples include the removal of a dam that changed hydrologic regimes and therefore species composition, the re-enactment of traditional management practices through cultural revitalization projects, and the collaboration with professional ethnobotanists in threatened areas. These may facilitate increased use and learning of ethnobotanical knowledge.

Before the creation of the bottleneck, the need to explore new methods for transmitting

cultural knowledge may have been less. Existing social mechanisms may have provided enough resilience to absorb most changes. However large-scale disturbances, such as the smallpox epidemic or loss of access to traditional land, may require creative methods to continue to enable communication of traditional ethnobotanical knowledge. Current examples of this include the formation of youth/elder camps and the development of community cultural revitalization projects such as native plant gardens, ethnobotanical gardens, or ecocultural centres. Furthermore, the lifting of prior cultural restrictions around ownership of plant knowledge may facilitate knowledge sharing. Yet, another method for 'moving beyond the bottleneck' is through restoration.

Restoration and Cultural Refugia

There is increasing attention paid to the role of humans in landscape restoration (see Higgs 1993, 1994, 2003; Whittey 1997; Naveh 1998; Geist and Galatowitsch 1999; Gobster and Hull 1999). Many researchers seek to develop methodologies that address the relationship between humans and ecosystems in the area of restoration (Nabhan 1991; Naveh 1998; Jordan 1999; Beckwith 2002).

The use of ecosystems by First Nations peoples is of particular interest to researchers and others (see Anderson 1993a, 1993b, 1996, in press 2004; Plowman et al. 1971; Schultes 1976; Schultes and Hoffman 1992; Davis 1986; Nabhan 1997; Collier 1998; Phillips 1998; Sewid-Smith 1998; Kimmerer 2000; Luna 2000; Meurk and Swaffield 2000; Peacock and Turner 2000; Robertson et al. 2000). The results of this work are shaping the design and goals of restoration projects. According to Kat Anderson (in press 2004), this

facilitates the reproduction of

> *the forces that shaped the model* [reference] *community. Analysis of former indigenous cultural practices and potential impacts will provide a baseline of historical ecological information about the diversity, dynamics, and functioning of different plant communities under former indigenous disturbance regimes.*

Individuals and groups familiar with traditional landscape use and management can provide the best information on reference landscape conditions, such as physical structure and composition, at the time before a major disturbance. If we seek to restore not only landscape conditions but cultural connections to those landscapes, ethnographic work is paramount in the process. Through restoration the "refugia" may now have an opportunity to extend and facilitate the reestablishment of traditional practices. For example, elders of the Western Mono tribe of California were taken to traditional gathering grounds and asked to describe what the site looked like when they were young (Anderson in press 2004). Their recollections have aided restorationists in the identification of reference conditions, which in turn influence a project's objectives. Restoration of this type provides a venue for knowledgeable people to share information that might otherwise remain suppressed. It allows the people that serve in the role of cultural refugia to help inform restoration, and ultimately, the resumption of some cultural practices. Though, these "restored" traditional activities may be modified or limited due to their retention in a limited number of individuals, as more people begin to practice these activities a culture's ability to absorb and persist following a disturbance is increased.

2.3 Case Study of Wapato and Cultural Refugia

Wapato serves as a case study to examine the changing roles of plants and traditional plant knowledge in a given place and among a particular group of people (Figure 2.2). The cultural role of wapato has shifted dramatically in the Pacific Northwest over the past two centuries. Though this food is little used now, wapato is documented for nine First Nations groups in British Columbia and neighbouring areas. There is a re-emerging interest in this plant as a formerly important and alternative food source as well as for restoration purposes.

Potential Cause

Several factors have compromised the use of wapato by the people of the Salmon Arm Indian Reserve No.3. Some of these are discussed in greater detail in Section 3.2. They include:

1) *The introduction of the table potato* (*Solanum tuberosum* L.). The exact source of the introduction of the table potato in the Pacific Northwest is a matter of debate. Anthropologist Wayne Suttles (1987) argues that the most likely origin is the fur trading companies. Regardless of the source of introduction, potato gardens were planted at different trading posts and "the company may have encouraged the Natives to take up cultivation in order to have another source of supply in emergencies" (Suttles 1987:139). The 'new potato' may have been easily incorporated into the diet of the First Peoples in British Columbia because of its similar taste to wapato or other native root vegetables, its cash value, and its ease

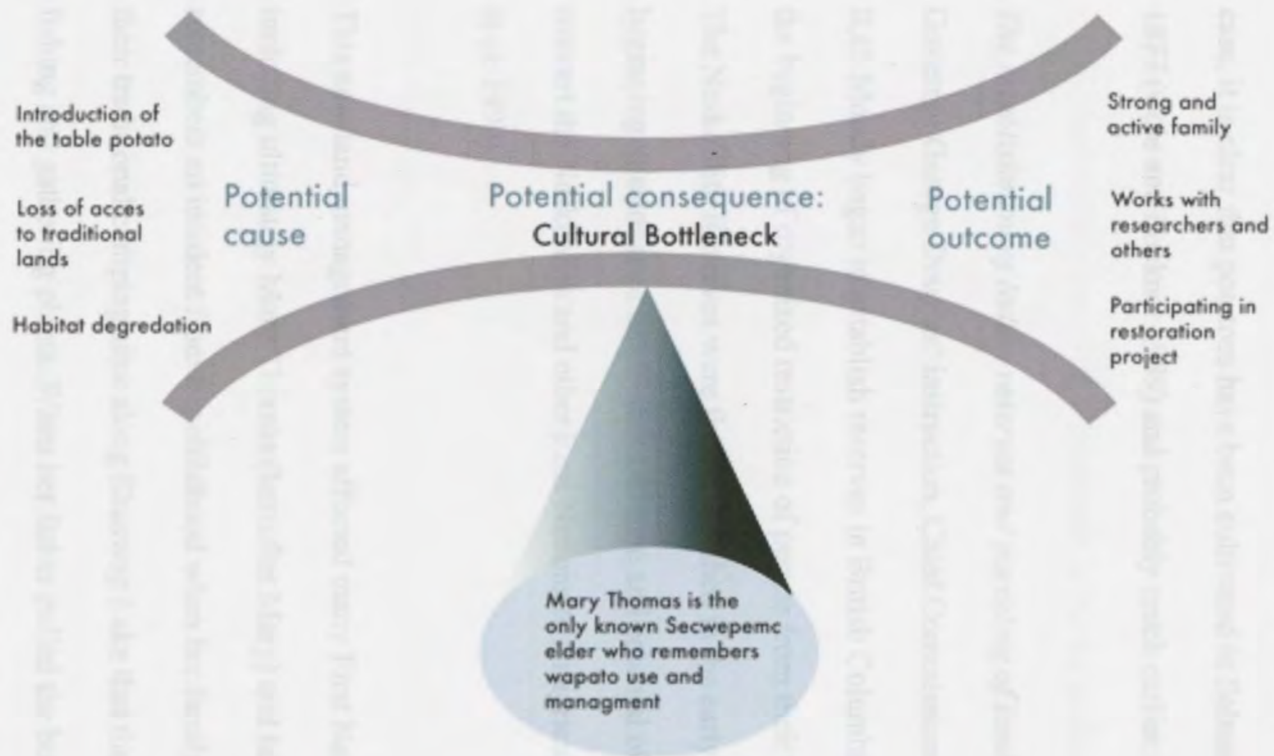

Figure 2.2 Illustration of some impacts from cultural and ecological disturbances that affect the transmission of Secwepemc knowledge of wapato use and potential opportunities to spread this traditional knowledge.

of cultivation and harvesting. Potato growing probably spread to the Salmon Arm area via nearby Fort Kamloops, where it was planted when the trading post, later to called Fort Kamloops, was established in 1812 (Coffey et al. 1990). In any case, it is clear that potatoes have been cultivated in Salmon Arm since at least 1877 (Cole and Lockner 1989) and probably much earlier.

2) *The establishment of Indian reserves and parceling of land* (SNTC 1989). Under Governor George Douglas' instruction, Chief Commissioner of Lands, Colonel R.C. Moody began to establish reserves in British Columbia in 1861. This marked the beginning of organized restriction of people from their traditional territories. The Neskonlith Reserves were first established in the early 1860s and from the beginning missionaries like Father LeJeune and colonial officials attempted to convert the Neskonlith and other First Nations to an agricultural lifestyle (Coffey et al. 1990).

This new land management system affected many First Nations peoples, including ultimately Mary Thomas (hereafter Mary) and her family. Mary remembers an incident from her childhood when her family had gone to one of their traditional camping sites along Shuswap Lake that they used for hunting, fishing and gathering plants. When her father pulled the boat up to shore, a man came out and told them he had purchased the land and they couldn't use it anymore. Her parents knew this man – he owned the local general store and often

sold mittens and gloves made by Mary's mother. Mary recalls that as they pulled away she saw her father cry for the first time.

3) *Urbanization, development and associated activities*. Landscape changes that affected wetland habitat may have been the most direct cause of the cessation of wapato harvesting among the Secwepemc. With the decline and possible extirpation of wapato from its original wetland habitat, harvesting was no longer possible. Many of the events that caused habitat changes are outlined in the Site History (Section 3.2).

Other factors leading to a decrease in the use of wapato may be as yet unrecognized, having taken place with no record of its occurrence. As discussed further in Chapters 3 and 4, both social and ecological influences may have affected ethnobotanical knowledge transmission of wapato.

<u>Potential Result</u>

The results of the disturbances described above are key in the case of wapato use. Mary may be the only known Secwepemc elder who remembers extensive wapato harvesting. In this case, the cultural refugium is restricted to a single person. Mary is dedicated to passing on her knowledge, particularly about plants. As she explained to a group of students at the University of Victoria, "because you young people are so important to me. You are our future. And I'd go through Hell just as long as I know its helping" (Thomas 2002:19).

As a child, Mary learned about plants through watching and participating with her grandparents, particularly her paternal grandmother, "Macreet" (Marguerite Parrish) from the Salmon Arm Indian Reserve No. 3, and other elders. Now in her mid-80s, she works with her community members, such as her son Louis Thomas, and university-based researchers (Loewen 1998; Peacock 1998; Bannister 2000; SCES in prep. 1), to pass on this knowledge to her children, grandchildren and others. Mary's sharing of knowledge and experiences of wapato harvesting exemplify the strength, persistence and flexibility she plays in this role of cultural refugium.

Potential Future

Through her participation in the University of Victoria's and the Secwepemc Cultural Education Society's "Secwepemc Ethnobotany Project" and the upcoming publication, *Plants of the Secwepemc People* (SCES in prep. 1.) Mary helped identify wapato as a key traditional Secwepemc food source. Through Mary's participation and support of my thesis research I have been able to collect information on limiting factors for its reestablishment. She provided the use of her land [land apportioned to her family and passed on to her] for field experiments and shared valuable information that informed my research design. Now, through this research, wapato is currently growing in the Salmon River Delta and is available for others. Recently, Mary spoke with other Secwepemc elders in the Salmon Arm, Chase and Enderby area about wapato. She could find no one who knew of its use as a traditional food. This underscores the significance (and fragility) of 'cultural refugia'.

In the end, perception or loss of cultural knowledge defies any model that attempts to outline a simple disturbance-result equation. There are many factors, both social and ecological, that make each situation applied to this model unique. Through this notion of cultural refugia I seek to understand some of the cultural mechanisms that may help maintain resilience during change in terms of ethnobotanical knowledge and practices. Its true test resides in its resonance with other individuals.

3.0 Background: The Secwepemc People and Their Lands

3.1 Introduction

To understand better the role that cultural refugia can fulfill in restoration, a deeper examination of the people and the ecosystem they inhabit is necessary. This chapter contextualizes my research with the Secwepemc on the Salmon Arm Indian Reserve No. 3 in the Salmon Arm Delta. First, I provide an overview of the history of the Secwepemc people and the landscape they inhabit, particularly in relation to traditional seasonal rounds and plant use and management. Secondly, I outline general Salmon River Delta site history, with a particular focus on potential impediments to wapato growth.

3.2 The Secwepemc

The traditional territory of the Secwepemc people of the Interior Plateau of British Columbia spans nine biogeoclimatic zones[7] (Pojar and Meidinger 1991) (Figure 3.1). Differences of over 1500 mm in mean annual precipitation and 12 °C in mean annual temperature over this area produce a varied patchwork of vegetation and resources. The peoples of the Interior Plateau, including the Secwepemc, have taken advantage of this rich supply of resources, utilizing at least 135 species of plants for food, beverages or flavoring (Hunn et al. 1998, SCES in prep. 1.). Root vegetables, including wapato,

[7] These nine zones are: Alpine Tundra, Sub-Boreal Pine-Spruce, Sub-Boreal Spruce, Engelmann Spruce - Subalpine Fir, Montane Spruce, Bunchgrass, Ponderosa Pine, Interior Douglas-Fir, Interior Cedar-Hemlock

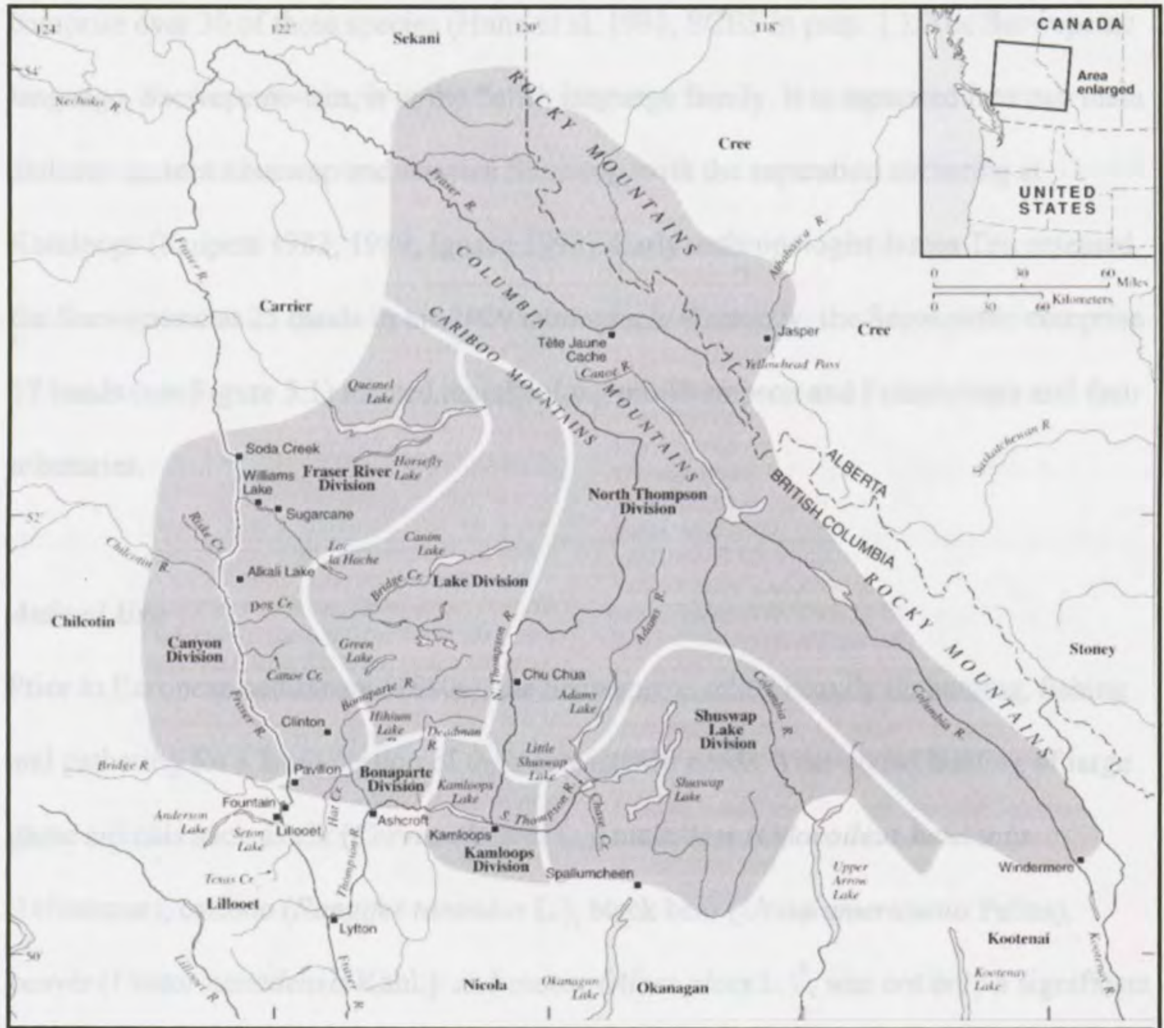

Figure 3.1 Traditional Secwepemc (Shuswap) territory in Interior British Columbia (from Ignace 1998).

comprise over 30 of these species (Hunn et al. 1998, SCES in prep. 1.). The Secwepemc language, Secwepemc-tsìn, is in the Salish language family. It is separated into two main dialects: eastern Shuswap and western Shuswap, with the separation occurring at Kamloops (Kuipers 1983, 1989; Ignace 1998). Early anthropologist James Teit assessed the Secwepemc at 25 bands in his 1909 monograph. Currently, the Secwepemc comprise 17 bands (see Figure 3.1) located mainly along the Thompson and Fraser rivers and their tributaries.

Animal Use

Prior to European settlement (1880s), the Secwepemc relied heavily on hunting, fishing and gathering for a large portion of their subsistence needs. Year-round hunting of large game animals such as elk (*Cervus elaphus* L.), mule deer (*Odocoileus hemionus* Rafinesque), caribou (*Rangifer tarandus* L.), black bear (*Ursus americanus* Pallas), beaver (*Castor canadensis* Kahl.) and moose (*Alces alces* L.)[8], was not only a significant source of protein, but was more ritually significant and esteemed than fishing (Teit 1909; Ignace 1998). Snaring of smaller animals (rabbits, grouse, porcupines, gophers, groundhogs and waterfowl)[9] supplemented the meat supply from large game (Ignace 1998). During the fur trade (1808-1858), the Secwepemc combined this activity with trapping for trade purposes (Palmer 1975a).

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[8] Elk, caribou and many runs of salmon have dwindled from their formerly high numbers of the late nineteenth and twentieth centuries (Ignace 1998; Palmer 1975a).
[9] Species identification and therefore scientific names of these small mammals is not possible without additional information.

Productive runs of salmon, including Chinook (*Oncorhynchus tshawytscha* Walbaum), sockeye (*Oncorhynchus nerka* Walbaum ex Artedi), coho (*Oncorhynchus kisutch* Walbaum) and pink (*Oncorhynchus gorbuscha* Walbaum), determined the establishment of villages along the waterways. Anthropologist Marianne Ignace notes that the peoples inhabiting the Fraser-Chilcotin Canyon maintained a fairly permanent residency due to the bountiful fishing grounds adjacent to their camps (Ignace 1998). Other fish such as rainbow trout (*Oncorhynchus mykiss* Walbaum), ling cod (= burbot, *Lota lota* L.), grayling (*Thymallus arcticus* Pallas) and sucker fish (*Catostomus* spp.) were harvested as well (Ignace 1998). The Secwepemc complimented meat and fish with considerable stores of root vegetables, greens, berries and other plant foods.

Plant Use

It has been argued that the traditional dietary contributions of plant material for some peoples of the Interior Plateau was more than 50 percent (Hunn 1981). This is in contrast to other hypotheses that fish (or meat) comprised the vast majority of dietary needs (Hewes 1973; Palmer 1975a). In 1975, anthropologist Gary Palmer remarked that,

> *the contribution of plant foods to the Shuswap caloric requirements was probably much less than the portion supplied by deer and elk, but the plants may have provided indispensable vitamins which, if true, would have made scarcity of plant foods just as critical as scarcity of venison and salmon* (Palmer 1975a: 217).

Hunn (1981) argues that Palmer's study, along with most ethnographic studies prior to 1981, focused primarily on salmon and did little research into quantifying the nutritional contribution of different plant foods. However, current studies have highlighted the

significant role of plant resources in many aboriginal diets. Research intensification of plant foods supports the concept that aboriginal peoples cultivated or harvested sufficiently large volumes of foods needed to provide a significant portion of their diet (e.g., Anderson 1993a, 1993b for Coastal California; Darby 1996 for Columbia River drainage; Peacock 1998; and Peacock and Turner 2000 for Interior Plateau of B.C.). Regardless of the percent contribution of traditional plant foods, their nutritional value has provided crucial vitamins and minerals supplementing fish and meat to aboriginal peoples of interior British Columbia (Kuhnlein and Turner 1991).

Among the Secwepemc, women were primarily responsible for plant gathering. However, this division of labor was not strictly adhered to – some women hunt large game and men may have assisted in such activities as berry picking (Ignace 1998). Plant gathering was a part of the annual seasonal rounds and which were organized to maximize resource use and seasonal advantages, enabling efficient gathering of foods at their prime. The timing and duration of seasonal rounds varied from place to place, depending on key availability of different food resources. Using phenological cues to mark the onset of different activities, people could accurately gauge events such as the ripeness of berries, the return of the salmon and the reallocation of plant energy to leaves, flowers or roots (Lantz and Turner In press 2003). Knowledge of natural systems and species interactions was paramount to survival. In fact the Secwepemc calendar is demarcated by the timing of harvesting and fishing activities.

The ecological gradient in the mountains allowed communities living along waterways to access resources from multiple habitats without traveling far from settlements (Palmer 1975a). Proprietary rights to gathering sites were held in common (Boas 1891; Teit 1909; Palmer 1975a; Mary Thomas pers. comm. 2002) and all Secwepemc had access to them. However, individual bands acknowledged common root-digging and berry picking grounds which were managed by tribal chiefs (Teit 1909). As will be discussed later, this social structure of resource management was also practiced with wapato and water parsnip roots (*Sium suave* Walt.)[10] harvesting in wetlands (Mary Thomas pers. comm. 2002).

Digging sticks facilitated the harvesting of roots, including *wapato* (Figure 3.2). Root digging activities were the domain of women in traditional Secwepemc society and they became quite skilled at efficient techniques for harvesting. Young girls would practice root-digging during their ritual isolation, so that when they matured they might be experts (Teit 1909).

Physical properties and abundance of individual plants dictated the type of storage and cooking methods employed. Berries were dried individually or mashed and spread out on planks to dry in the sun, forming "cakes" which could be eaten without further preparation or

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[10] Water parsnip closely resembles the extremely poisonous water hemlock (*Cicuta douglasii* (DC.) Coult. & Rose). These two plants are often found growing together and positive species identification is extremely important.

Figure 3.2 Traditional Secwepemc cattail (*Typha* spp.) basket, made by Mary Thomas, with digging stick which might be used for gathering wapato.

rehydrated throughout the winter (Turner 1997). Common berries harvested by the Secwepemc include: Saskatoons (*speqpeq7úw'i* or *speqpeq*) (*Amelanchier alnifolia* Nutt.), thimbleberries (*st'iqwem*) (*Rubus parviflorus* Nutt.), soapberries (*sxusem*) (*Shepherdia canadensis* (L.) Nutt.), choke cherries (*tkwlóse7*) (*Prunus virginiana* L.) and highbush cranberries (*t'nis*) (*Viburnum opulus* (L.) (SCES in prep. 1). The cambium and inner bark, of plants was most frequently eaten fresh, though occasionally dried as cakes and stored. Roots and other underground plant parts were processed and stored in a number of ways. Some were first cooked in underground pits (earth ovens) for many hours, which in some cases facilitated the break-down of complex carbohydrates (such as

inulin), rendering food edible to humans, before being stored in caches.[11] Other plants were stored raw, as they did not require the intensive cooking time of an earth oven. Wapato, for instance, was boiled or steamed and was not usually stored for long periods of time. Other plants such as black tree lichen (*Bryoria fremontii* Tuck.) and cow-parsnip (*Heracleum lanatum* Michx.), supplemented main staples of meat, fish and tubers.

As well as foods, plants provided materials of many types such as wood for fuel and construction, bark for basketry, fibrous stems, bark and roots for mats, and materials for dyes, glues and cleansing agents. Plants have also been the main source of medicine (Turner 1997).

Secwepemc Ethnobotany: An Overview of Research

Early non-aboriginal visitors to the area detailed many aspects of Secwepemc life, including plant use, such as George Dawson (1891), Franz Boas (1891), and James Teit (1909). Their field accounts mark the beginning of "ethnobotanical" investigations among the Secwepemc. Intent on gathering large volumes of cultural data, these researchers catalogued root foods and berries deemed ubiquitous and high in value, thus offering a starting point for future investigations into traditional plant use and ethnobotanical relationships.

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[11] Roots that were commonly pit-cooked include: balsamroot (*tséts'elq*) (*Balsamorhiza sagittata* (Pursh) Nutt., glacier lily bulbs (*scwicw*) (*Erythronium grandiflorum* Pursh), bitterroot (*Lewisia rediviva* Pursh) and nodding onion (*qwléwe*) (*Allium cernuum* Roth.) (SCES in prep. 1)

During his geological surveys in southern interior British Columbia (1877-1890), George Dawson recorded information on Secwepemc life including a list of traditionally used food plants. Though Dawson's ethnographic work was not performed systematically, his "almost constant association with these [Secwepemc] people naturally afforded numerous opportunities of acquiring information respecting them" (Dawson 1891: 3). He was also a naturalist and had much interest in ecology. He described the harvesting and preparation of both roots and berries. He did not mention wapato, however. Dawson (1891) noted that the prominence of root vegetables had decreased by 1891 with an increase in flour use and the cultivation of the potato.

On August 6th, 1877, Dawson visited the Salmon River Delta. His description of the area's vegetation underscores the productivity of the Delta. His notes also demonstrate the marked contrast in the area between 1877 and the present.

> *Skirted round the great bay into which Salmon R. flows [Salmon Arm] & which is low & swampy along shore, everywhere, but may, with the lower part of the Salmon R. valley, which seems quite flat, contain a Considerable area of land eventually arable, - now thickly timbered. If cleared would need no irrigation. Some of the benches would probably answer for agriculture, & the low undulating country about White Lake Creek [White Creek]. Examined & sounded the entrance of Salmon River, & find it too shallow even at this stage of the water, for anything large to go up, being about 4' on the bar, but deeper within. The river itself is also narrow & tortuous & does not look as if it could be navigated under any circumstances, though the Indians say Slack water extends to within a few miles of the waggon (sic) road. They do not go up because of the great quantity of logged timber &c.* (Cole and Lockner 1989: 367).

Franz Boas, the first to document detailed ethnographic information for the Secwepemc, noted in his 1891 report that very few Secwepemc still followed traditional customs and

practices having been "Christianized" by missionaries[12]. This observation may have influenced the extent to which Boas recorded, or was able to record, plant knowledge by the Secwepemc. Boas' documentation of plant use was rather brief, limited primarily to general descriptions of the preparation of roots and other vegetables (e.g., pit-cooking), social organization of berry picking, use of tule [*Schoenaplectus* (Reichenb.) Palla.] and cattail (*Typha* spp.) mats and employment of cottonwood (*Populus* spp.) and redcedar (*Thuja plicata* Donn ex. D. Don) canoes. Boas commonly documented information on plants as part of his ethnographic observations; he had an interest in plants, and often corresponded with botanists C.F. Newcombe and John Davidson. Boas made no mention of wapato, nor did he focus on wetland plants specifically. In fact, ethnobotanical focus on wetland ecosystems is a relatively new phenomenon occurring in the past few decades (Fowler 1990; Morris and Raymond 1993).

With the encouragement of Boas, James Teit (1909) further continued ethnographic work with the Secwepemc as part of the Jesup North Pacific expedition. His detailed account of Secwepemc life, drawn primarily from a few key male informants (particularly one named *Sixwi'lexken*), included the most substantial listing of traditional plant knowledge to date. Though Teit did not mention wapato, he did list 18 commonly gathered roots including water parsnip (a wetland plant associated with wapato).

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[12] Gary Palmer (1975b) later qualified this statement by noting that even in 1975 many Secwepemc people still followed traditional practices. Therefore they could not have "almost entirely disappeared" at described by Boas.

Anthropologist Gary Palmer (1975b) followed Boas and Teit in 1975. He worked with Isaac and Adeline Willard of Chase in addition to sources by Boas (1891), Teit (1909), and Dawson (1891). Palmer was introduced to the Willards by Randy Bouchard and Dorothy Kennedy of the B.C. Indian Language Program, who also undertook ethnobotanical research in the Chase area, especially with Adeline's sister, Aimee August. Nancy Turner helped identify Palmer's plant collections. The result, *Shuswap Indian Ethnobotany*, documents 144 plants known and/or used by the Secwepemc. His work was the first to provide a comprehensive listing of Secwepemc ethnobotany. Though quite extensive, his list did not include wapato. It did however include water parsnip. Palmer also published a paper on the cultural ecology of the Shuswap (1975a). This report provides substantial information on the changes to Secwepemc lifestyle throughout the 20th century, thereby providing possible reasons for a decline in wapato use during that time.

From 1990 to the present, ethnobotanist Nancy Turner (from the University of Victoria) and anthropologist/ linguist Marianne Boelscher Ignace (from Simon Fraser University), together with colleagues and student researchers, have conducted ongoing research projects with many Secwepemc individuals from over a dozen Secwepemc communities detailing traditional plant use and their associated management. Their work has resulted in *Plants of the Secwepemc People* (SCES in prep. 1.) and a compendium volume *Secwepemc People and Plants: Research Papers in Shuswap Ethnobotany* (SCES in prep. 2). The latter was a collaborative effort of 10 major researchers and documented many wetland plants and their use. It is the most detailed and comprehensive, systematic

inventory of Secwepemc plant knowledge to date. More than 42 elders were interviewed over a 15-year period, including work by Marianne Ignace in the 1980s. It was during this research that wapato use by the Secwepemc was first documented through interviews with Mary Thomas. At the present, interest in participating in and conducting ethnobotanical research is rising among the Secwepemc. Much of this work is managed or performed by the Secwepemc themselves (Murphy et al. 1999; Louis Thomas pers. comm. 2002).

3.3 Salmon River Delta Site Use History

By combining scientific literature and regional histories with oral interviews conducted with elder Mary Thomas, one learns much about the history of the Delta. My interviews with Mary Thomas, for example, have drawn my attention to the effects of industrial development on the wetlands. Without this there would be little information about the former existence and loss of wapato. Today knowledge of its former abundance exists only in Mary's memory. See Table 3.1 for a summary of the site history.

The town of Salmon Arm lies at the eastern edge of the Interior Plateau of southern British Columbia and is part of the Thompson-Okanagan Plateau Ecoregion (Environment Canada 2003b). A strong precipitation gradient occurs with elevation within this ecoregion: the major valleys receive roughly 250 mm of precipitation, the alpine and subalpine areas receive 1000 mm and the plateau regions receive 400-600 mm (Environment Canada 2003b). The Salmon River, which flows into Shuswap Lake at Salmon Arm, is considered a tributary of the Thompson River. This watershed is part of

the Fraser Basin and is located between the Fraser River and Columbia River watersheds. The Salmon River has supported rich populations of various types of salmon for which the river was named (Doe 1971). As a resident of Salmon Arm remarked, "... [a] long time ago, the salmon stocks were so great that [it seemed like] you could actually walk across the river on their backs" (SRWR 1995). Similarly, Mary remembers substantial runs of salmon from her childhood in the 1920s. This history, embedded in the collective memory of the Salmon River watershed residents, speaks to the former productivity of the river. Mary Thomas herself remembers from the days of her childhood the vast Salmon River salmon populations. The Salmon Arm Indian Reserve No. 3, where Mary grew up, is located on the northern tip of the Salmon River watershed (Figure 3.3).

For the Secwepemc people who have lived in this area for thousands of years (Peacock 1998), the riparian habitats provided by the major rivers and their tributaries served as important sites for fishing, dwelling, hunting, plant gathering and transportation (Palmer 1975a; Ignace 1998). The Salmon River Delta has been, and continues to be, an important site within this watershed for the people who live there. The Secwepemc people of the Salmon Arm Reserve No. 3 gathered water parsnip, wapato, cattail leaves (*Typha latifolia* L.), and Indian hemp (*Apocynum cannabinum* L.), collected waterfowl eggs, hunted ducks and fished for salmon and lingcod in and adjacent to the delta (Mary Thomas pers. comm. to Nancy Turner and Ann Garibaldi 2-15-01). Mary Thomas was born in 1918 and harvested these plants, including wapato, with her family as a child. As recently as the early 1900s, these activities still took place – the plants still grew in the delta (Mary Thomas pers. comm. to Ann Garibaldi 2-25-01).

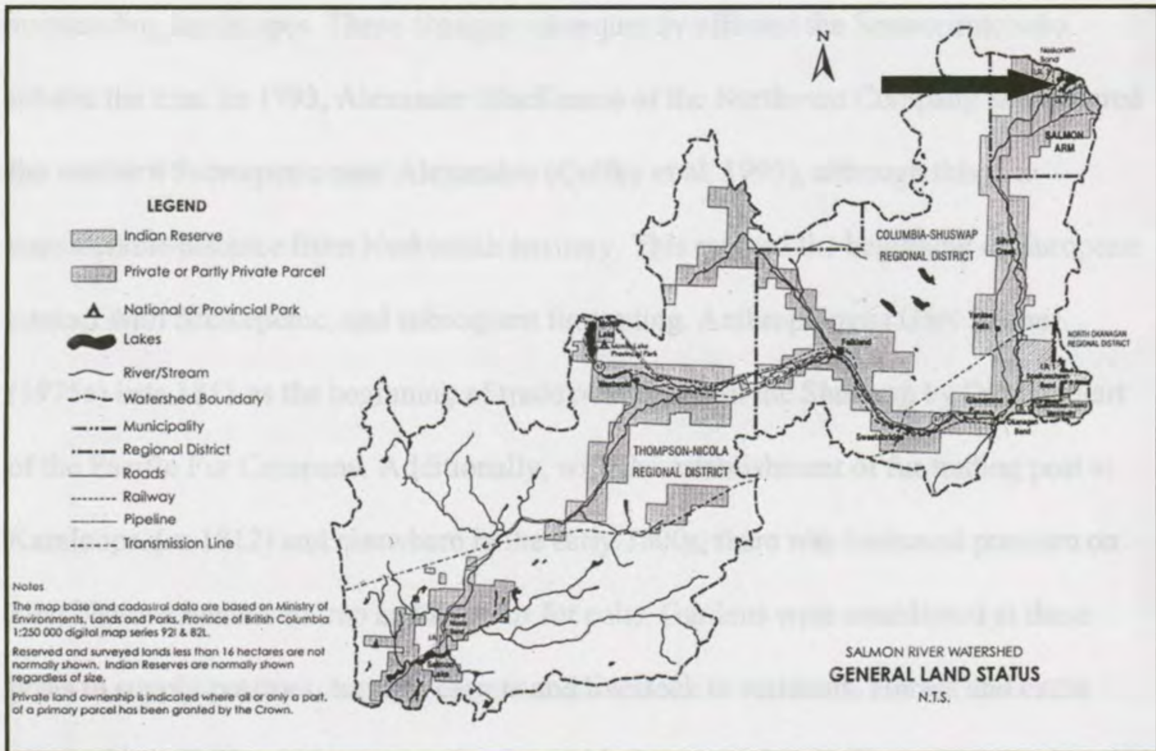

Figure 3.3 Map of the Salmon River Watershed. The arrow points to the Salmon River Delta on the Salmon Arm Indian Reserve No. 3.

Some key landscape changes and events, leading ultimately to the incorporation of the City of Salmon Arm, have undoubtedly impacted the Salmon River Delta and its surrounding landscapes. These changes subsequently affected the Secwepemc who inhabit the area. In 1793, Alexander MacKenzie of the Northwest Company encountered the northern Secwepemc near Alexandria (Coffey et al. 1990), although this is a considerable distance from Neskonlith territory. This marked the beginning of European contact with Secwepemc, and subsequent fur trading. Anthropologist Gary Palmer (1975a) lists 1811 as the beginning of trade relations with the Shuswap by David Stuart of the Pacific Fur Company. Additionally, with the establishment of fur trading post at Kamloops (in 1812) and elsewhere in the early 1800s, there was increased pressure on First Nations hunters to trap and hunt for fur pelts. Gardens were established at these posts to supply potatoes, turnips, carrots and livestock to residents. Horses and cattle required hay fields and hay crops (Suttles 1987; Demerritt 1996). These introductions led to major changes in lifestyle for the Secwepemc at the early part of the 19th century.

By 1858 when gold prospectors and miners arrived in Secwepemc territory (Coffey et al. 1990), they encountered a people who had already adapted to a much-reduced supply of available pelts and native food for personal use, and were already relying heavily on the imported crops and goods of the European traders. The number of prospectors in the region increased until 1865 when attention turned to other sources for gold. However, the focus of the European newcomers on the area that would become Salmon Arm continued, when in 1866 the first boat to "ply the waters of the Shuswap" was built by the Hudson's Bay Company (Doe 1971). This marked the beginning of intensive use of these

waterways as vital sources of transportation for the European newcomers, and for the developing commerce between them and the Secwepemc (the use of these waterways as avenues for transportation had been long recognized by indigenous people). Ernest Doe noted, "In 1882 there was a settlement of these natives extending along the higher ridges from Sandy Point to the mouth of Salmon River" (1971:4), and the adaptations to European presence was clear:

> *The Indians wandered through the country from Shuswap to the Okanagan, trapping and hunting, living on game, fish and berries. Even in 1887, Indians with their squaws, long muzzle-loading rifles, their canoes piled high with furs, made their way to the Hudson's Bay Co. outposts.* (Doe 1971:4)

Europeans introduced many changes to the region, especially after the opening of the transcontinental railway in 1885-1886 (Turner 2003). With this, settlers arrived in large numbers to procure land for ranching and farming (British Columbia, Government 1875; Coffey et al. 1990). Not surprisingly wapato harvesting and consumption changed as the table potato replaced it as a major carbohydrate source (Suttles 1987). The implications of this will be discussed in Chapter 4.

Another impact on Secwepemc lifestyle was the establishment of the land reserves in 1861 following the appointment of George Douglas as the governor of mainland British Columbia in 1858 (Duff 1969). The appointment of Joseph Trutch as the Chief Commissioner of Lands in 1871 led to a granting of fertile land suitable for agriculture to the settlers and a reduction in the size of the reserves originally established by Douglas in the 1860s (SNTC 1989). With the passing of the Indian Act in 1876 the Secwepemc, as well as other First Nations, became wards of the state, and lost access to traditional

gathering and hunting grounds. This compromised the ability of the Secwepemc to access lands formerly used during seasonal rounds as well as their ability to manage plant and animal species used during those rounds.

A further impediment to traditional land access was the establishment of the town of Salmon Arm. This development was encouraged by the opening of the Canadian Pacific Railway in 1885. "At that time [1888] the town site was completely covered with dense brush with only the right-of-way for the railway cut through" (Doe 1971:12). This quote refers to the area adjacent to the Salmon Arm Delta and along the foreshore of Shuswap Lake. The construction of the railroad bisected the Salmon River Delta and obstructed the migration of salmon in the Salmon River (Palmer 1975a). Although wapato still grew in the delta after this period, as testified to by Mary, large-scale changes to its habitat were beginning. By 1890 there were about 200 settlers living in the Salmon Arm area (Doe 1971). By the time of the cities incorporation in 1905, it was part of a boom in development in the region (Doe 1971).

In 1916 the McKenna-McBride Royal Commission recommended the reallocation of approximately 47,000 acres of what many indigenous peoples feel was high quality Reserve land for 80,000 acres of lower quality land (SNTC 1989). Anthropologist James Teit observed the difficulty the Secwepemc had in continuing their traditional practices, due to the restriction of movement resulting from reserve establishment (1909). European items supplemented traditional foods. Mary Thomas explained that by the time she was 4 or 5 years old (1922-1923) traditional foods were not harvested in the same quantities

they once were. This might indicate that wapato harvesting, among other root vegetables, were being replaced with crop plants such as the potato.

The 1930s saw an introduction of logging (Andre Arsenault pers. comm. 2003), fruit tree planting, irrigation, and other types of farming (including extensive potato farming) (Doe 1971) (Figure 3.4). Mary Thomas' parents participated in this shift to European style agriculture. Mary recalls, "... by the time I was little, they were already planting potatoes, they adopted the European way of putting in plants, carrots and corn and stuff like that" (Mary Thomas pers. comm. to Nancy Turner 1994). Mary's father (Jack Allen) farmed land on the Salmon Arm Indian Reserve No.3. In addition, he worked for early European settlers clearing land for hay and according to Mary "he earned next to nothing" for his labor. He used some of his wages to purchase staples such as flour, sugar, tea and coffee to supplement food that Mary's family hunted and gathered. The lifestyle and diet changes taking place during this period affected both the amount of time spent harvesting traditional foods, such as wapato, and the ecosystems in which traditional food plants grew.

Water issues, primarily a result of increased use for irrigation and need for potable city water, were becoming apparent in the 1930s and 1940s. All of these development activities affected the functionality and flow of the Salmon River and consequently the original ecosystem that was present in pre-industrialized times, the ecosystem that supported wapato growth.

Figure 3.4 Potato harvesters on Calhouns' Ranch, Tappen, British Columbia ca. 1913-1915. Photo by Francis King Duncan, used with permission from the R.J. Haney Heritage Park, Salmon Arm, British Columbia.

The delta where the Salmon River flows into Shuswap Lake is a highly functioning wetland ecosystem that still today provides important nesting and feeding habitat for a number of migrating waterfowl (Hayes et al. in McPhee et al. 1996). The high productivity of this site has been clear to a number of people, particularly farmers. The area referred to as the Salmon River Estuary (= Salmon River Delta) is classified primarily as Class 2 in the agricultural land capability classification. This identifies it as an area with potential for a wide range of crops (on a scale of 1 to 7, where the Provincial Agricultural Land Commission considers class 1 to have no significant limitations for agriculture and the widest crop range and class 7 to be unsuitable for agriculture) (Provincial Agricultural Land Commission 2003). This notably productive area, which formerly supported extensive patches of wapato, water parsnip, cattails, and other native wetland vegetation, " ... is the largest area of contiguous high capability agriculture land in the watershed. The area contains the highest suitability lands for a very significant list of soil bound crops" (McPhee et al. 1996:31).

The desirability of the area for farming continues to put increased pressure on its use and therefore its functioning and habitat capabilities. Irrigation, pesticides, and the soil changes that accompany farming in the delta and along the riparian zone of the Salmon River, affect the water and nutrient cycling of the delta and its ability to support stands of natural vegetation.

During the past decade, there has been considerable impact on both the ecosystem and the people of Salmon Arm. A recent study (McPhee et al. 1996) has identified two main

issues relating to the sustainability of health and functioning of the Salmon River watershed: timber harvesting and water supply. Although timber harvesting impacts river systems (Toews and Moore 1982), I focus here on issues of water supply as these relate directly to the functioning of the Salmon River Delta. According to a watershed report compiled in 1996:

> *The water supply in the Salmon River cannot sustain fish populations and meet agricultural needs at certain times of the year. Although this issue is being addressed, there is no provincial regulation of groundwater withdrawal and more and more wells are being dug near the river, helping to keep water levels low* (McPhee et al. 1996:1)

The impacts on the watershed are ongoing.

> *Meander cutoffs and ditches have also been excavated to drain wetlands and reduce the area occupied by the Salmon River... These impacts are significant in terms of channel stability, water storage, bio-diversity and ecological stability for the affected and surrounding areas* (Miles in McPhee et al. 1996).

It is clear from this report that decreasing water levels have an influence not only on vegetation, but on fish, waterfowl and other animals that use the wetlands. Water levels have certainly changed in the past century (Bob Harding pers. comm. 2002), but the current state of water in the Salmon River watershed is complex. As agriculture has expanded, irrigation for new farms has increased the demand for water. The resultant water changes have affected salmon spawning and in turn the wetland plants and wildlife.

In 1991, 58% of farms within the watershed supported livestock, and in 1981 this figure was as high as 74.5% (McPhee et al. 1996). As of 2003, cattle grazing occurs on a limited basis in the delta area –approximately 15 cattle grazed in the area around my field site

from May to September. The owner of these cattle, Ed Blackburn, leases the land from Mary Thomas.

Much research has been conducted on the impacts of livestock grazing in wetlands (see Hilliard 1971; Brown 1986; Schultz 1987; Hoff 1993). When grazing is carried out improperly or too intensively, cattle can cause heavy soil compaction, changes to plant community structure, and promote the growth of weedy exotic plant species by keeping the land in a disturbed state.

Clearly the pressure from low water levels, cattle grazing, and agriculture has been at least partially responsible for the loss of native vegetation including wapato, but other factors have also played a role. Introduced plants and animals often trigger a series of environmental changes that are difficult to arrest. For example, the common carp (*Cyprinus carpio* L.), an exotic fish species from Europe, now present in large numbers in the Salmon River Delta, can bring about large changes in the ecosystem (Smith et al. 2001). Exotic species often thrive in disturbed environments and can displace native ones. Intentionally introduced from Europe and Asia in the 1800s to North America as a food species, carp reproduce rapidly and feed on both plant and animal matter. Though insects, crustaceans and small mollusks make up the bulk of their diet, they uproot tender seedlings and eat aquatic shoots. Further, water turbidity increases as a result of carp feeding patterns, which decreases light penetration and consequently plant growth (Weller 1990). These changes allow establishment of exotic species that thrive in

disturbed areas. Under these circumstances, wapato growth and the growth of other native aquatic species are compromised.

Reed canary grass (*Phalaris arundinacea* L.) is native both to North America and Europe. It has been planted for animal forage and erosion control in many wet meadow areas (Hutchison 2001). The concerns of wetland conservationists about the impacts of the species are the consequence of the introduction of the Eurasian ecotype of reed canary grass. Unfortunately the exotic ecotype is very difficult to distinguish from the North American one. The Eurasian ecotype of this species is extremely aggressive in wetland areas and if allowed to establish will form thick stands that eventually eliminate native seeds from the seed bank (Apfelbaum and Sams 1987). In the Salmon River Delta, a thick stand of reed canary grass dominates the area (Figure 3.5). The growth is encouraged by cattle grazing, which spreads the seed and keeps the ground disturbed.

Finally, long-term residents like Mary Thomas have observed changes in the river flow at its mouth in both location and velocity. To accommodate the flow of the Salmon River during the construction of the Canadian Pacific Railway, a railway bridge was erected to keep the river channeled roughly 1 km upriver from the outlet into Shuswap Lake. In addition, Mary Thomas and Ed Blackburn, two residents who grew up in the area, speak of at least one other, possibly unsanctioned, time when the mouth of the river was intentionally diverted (see section 4.4).

This brief overview of the use history of the Salmon River Delta demonstrates the many ways in which the function and structure of the landscape are shaped. Changes are brought about in both direct and indirect ways and produce results that may be immediately clear or may develop slowly over years. The impacts of seemingly innocuous events (e.g., the introduction of carp) may require expensive, time-consuming actions to rectify. The intricate web of actions that decrease populations of macrophytes, like wapato, are extremely difficult to identify yet understanding of them is vital if we are to address restoration needs.

Figure 3.5 Mary Thomas showing the cover of reed canary grass (*Phalaris arundinacea*) in the Salmon River Delta, Salmon Arm, British Columbia in April 2001.

Table 3.1 Events that have influenced Secwepemc use of *Sagittaria* in the Salmon River Delta.

Time Period	**Activity**	**Effect on the Secwepemc and/or growth of wapato in the Salmon River Delta**	**Reference**
Pre-European Contact	Secwepemc People lived along major rivers and tributaries of the Interior Plateau	Traditional fishing, hunting, and gathering taking place	(10)(12)
1793	Alexander Mackenzie of the North West Company met western Secwepemc people on the Fraser River near Alexandria	Beginning of European contact	(9)
1811	David Stuart of the Pacific Fur Company established trade relations with the Secwepemc	Beginning of the fur trade – marked the beginning of a major shift in lifestyle for the Secwepemc	(7)
1812	The fur trading post later to be called Fort Kamloops was established, other fur trading posts followed; First introduction of table potato (*Solanum tuberosum*) and other crop plants, grown at forts	Effects of changing economy began to be felt among the Secwepemc – fewer available mammals meant a shift in subsistence activities and a push towards a cash economy; Gardens and livestock were brought in at the posts	(1)(9)
1858	Fraser River Gold Rush; Gold miners began prospecting in Secwepemc territory	Increased diseases; prospecting and mining activities prevented traditional activities such as salmon harvesting	(7)(9)
1861	Establishment of land reserves following the appointment of George Douglas as the Governor of mainland British Columbia	Beginning of reduced Secwepemc access to traditional lands	(1)(5)
1866	Hudson's Bay Co. built the first boat to ply the rivers of the Shuswap	Beginning of intensive, industrialized use of Shuswap Lake	(6)

1871	Joseph Trutch reduced the size of land reserves established by George Douglas	Further reduction of Secwepemc access to traditional lands	(1)(8)(9)
1876	Passage of the Indian Act	Indians became wards of the state and lost access to some traditional hunting and gathering grounds	(16)
1850-1900	Widespread growing of table potato and other crops	Continued movement away from traditional carbohydrate sources (primarily root foods) such as wapato.	(1)(2)(4)
1885	The Canadian Pacific Railway is constructed along Shuswap Lake at Salmon Arm	Increased movement of goods into area – the railroad bisected the Salmon River Delta and obstructed the migration of salmon in the Salmon River	(6)(7)(17)
1905	The city of Salmon Arm was incorporated	Marked a move toward increased industrial development in the area surrounding the Salmon River Delta	(6)
1916	McKenna-McBride Royal Commission reallocated approximately 47,000 acres of high quality Reserve land for 80,000 acres of lower quality land	Another major reduction in lands available for traditional harvesting and management practices	(8)
ca. 1870-1930	Major clearing of land for agriculture; Diversification of crops, fruit trees, corn and other types of farming; Irrigation begins	Increasing replacement of native flora and fauna by introduced species, including crops and weedy species	(1)(13)(18)
ca. 1880-present	Intensity of cattle grazing increases	Soil compaction; effect on riparian zones	(13)(18)
ca. 1930	Intensive logging begins	Sediment discharge; soil disturbance and compaction; changes in hydrology;	(13)(14)

1870-present	Introduction of exotic flora and fauna	Carp increase turbidity of water and uproot seedlings of aquatic plants such as *S. latifolia*	(11)
1980s-present	Salmon River mouth diversion	Interrupts natural flow of river	(13)(15)

(1) British Columbia, Government. 1875; (2) Dawson 1891; (3) Teit 1909; (4) Suttles 1955; (5) Duff 1969; (6) Doe 1971; (7) Palmer 1975a ; (8) SNTC 1989; (9) Coffey et al. 1990; (10) Peacock 1998; (11) Chow-Fraser 1999; (12) George Nicholas pers. comm. 2000; (13) Mary Thomas, pers. comm. 2001; (14) Andre Arsenault, pers. comm. 2003; (15) Ed Blackburn, pers. comm. 2003; (16) Indian Affairs and Northern Development 2003; (17) Turner 2003; (18) Turner and Brown, in press

4.0 Cultural Considerations

Those who, for one reason or another, did not go to residential school, or were fortunate enough to have learned their language and traditional ways during the times they were at home, have provided the cultural continuity and the language base from which the present cultural and language reclamation has emerged. (SCES in prep. 1.)

4.1 Introduction

In the spring of 2001 I visited Mary Thomas at her home in Salmon Arm. She recalled the importance of wapato for her family and other Secwepemc people:

> *Well… we used to just crave for fresh edibles. It was just something we looked forward to. And it wasn't just my grandmother. There was a lot of little old ladies at the time. The neighbours. They'd go down and pack lunch and we'd go down with them as children. And when they'd pop the wapato out of the mud we would grab them and throw them in the baskets… .And then of course we always had to help. And it was like a real picnic. Anything we did was picnic with our grandparents. I have so many happy memories of them. And it was so plentiful. I don't think they could put a dent in it. You know, by digging. It was just all over, right around the bay* [of Shuswap Lake*], past the wharf in town. It was all wapato and water parsnip along with the bulrush. It was just like a real big picnic. And they'd come home with great big huge baskets full of both root edibles* (Mary Thomas pers. comm. to Nancy Turner and Ann Garibaldi 2-15- 01).

Until the mid-1990s the use and management of wapato by the Secwepemc was undocumented. It was generally assumed that the northern limit of wapato use by Aboriginal Peoples in British Columbia was that of the Nlaka'pmx (Thompson) at Spuzzum who obtained the plants primarily through trade with the Halkomelem of the Fraser River Valley (Turner 1978; Turner et al. 1990). While trying to ascertain the identity of a "marble-like" swamp tuber based on a description by Mary Thomas, Dawn

Loewen suggested the tubers of *Sagittaria* spp. as the wetland food described by Mary that she had helped gather as a child (SCES in prep. 1.). Later, Mary Thomas verified this identification from wapato tubers supplied by Melissa Darby to Nancy Turner. It soon became clear that the Secwepemc harvested and managed the wetland sites where this plant grew. They did not obtain it solely through trade. Based on the recollections of Mary Thomas, wapato was evidently not the staple food for the Secwepemc that it was for their neighbours to the west, in the Fraser River Valley, or to the south, along the Columbia River. However, wapato tubers, along with water parsnip roots, played an important role as one of the first fresh edibles of spring (Mary Thomas pers. comm. to Nancy Turner and Ann Garibaldi 2- 15-01).

As noted in the previous chapter, disruptions to the health of the Salmon River Delta came quickly in the early part of the 20th century. In Mary Thomas' lifetime (she was born in 1918) the wetland has transformed greatly. Factors such as increased pressure from cattle grazing, sedimentation and pollution from logging and upstream farms, introduction of exotic species, and a decrease in water levels due in part to increased irrigation have all taken their toll on the functioning of the ecosystem. One such consequence is the shrinking of wapato populations in some areas and a complete loss of it in others.

4.1.1 Review of the Global Food Use of *Sagittaria* spp.

Sagittaria spp. tubers are recognized worldwide as a valued source of carbohydrates (Hedrick 1972). Five species have been, or are currently, cultivated and/or harvested in many areas: *S. sagittifolia* L., *S. latifolia* Willd., *S. macrophylla* Zuccarini, *S. trifolia* L. and *S. cuneata* Sheld. Documentation exits for these species used as food for both humans and animals from Japan (see Yamazawa et al. 1986), China (see Mabberley 1997), North America (see Gillmore 1977; Suttles 1955; Core 1967; Hussey 1974; Galloway 1982; Johnston 1987; Bergon 1989; Kuhnlein and Turner 1991; Turner 1995 Darby 1996) and Mexico (see Wilken 1970; Zepeda and Lot 1999).

4.1.2 Review of the Ethnobotany of *Sagittaria* spp. in British Columbia and Neighbouring Areas (Figure 4.1)

Although tubers of both *Sagittaria latifolia* and *S. cuneata* have been harvested by First Nations people in British Columbia, *S. latifolia* has been more frequently reported as a food source. However, it is likely that either tuber was used in regions where they both occur (Kuhnlein and Turner 1991).

Although wapato harvesting in British Columbia has been documented for both the Coast and Interior Salish peoples, the more detailed accounts exist for the Coast Salish (see Suttles 1955; Turner and Bell 1971; Turner 1995, 1997; Turner et al. 1990; SCES in prep. 1, 2). These tubers were among the four most important underground starch sources for the Halkomelem First Nation, particularly the Katzie. According to Wayne Suttles:

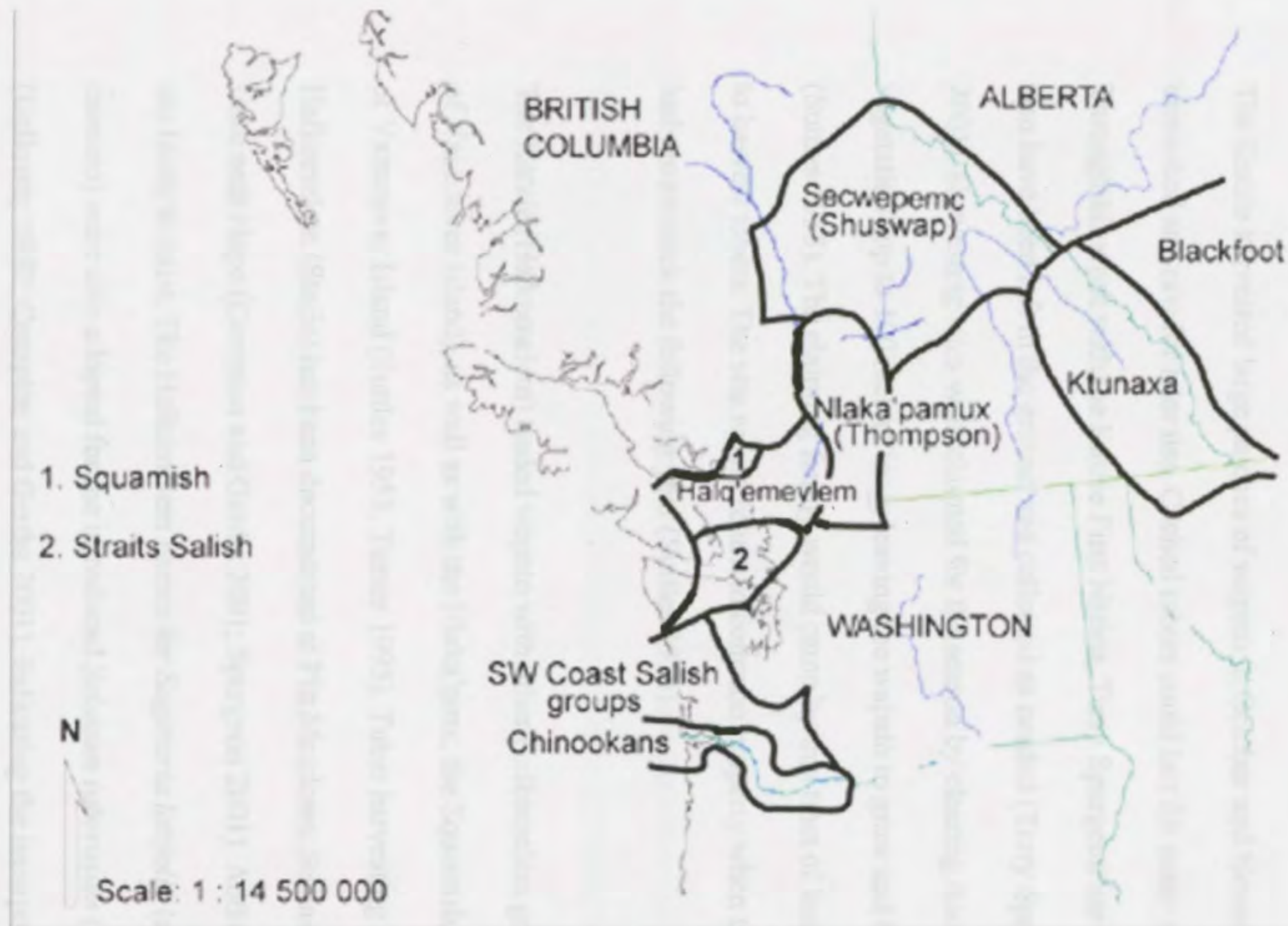

Figure 4.1 Documented use of wapato (*Sagittaria* spp.) by indigenous groups of British Columbia and surrounding areas (adapted from Turner 1997). Lines represent approximate boundaries of traditional territories.

> *Four starchy bulbs or roots were important enough that the best beds were held as family or individual property – camas among the Northern Straits tribes, brake ferns at Musqueam,* wapato at Katzie and perhaps elsewhere on the Fraser, *and wild carrots at Nooksack* (Suttles 1990:459, emphasis added).

The Katzie harvested large patches of wapato in October and November and stored them unwashed and raw for later use. Cached tubers could last for many months (Suttles 1955). Through his work with the Katzie First Nation, Terry Spurgeon has found that tubers may also have been left in the ground and collected as needed (Terry Spurgeon pers. comm. 2001). Harvesting sites were claimed for the season by clearing tracts of "other vegetation" up to 100 meters long, leaving the wapato to grow and harvested more easily (Suttles 1955). The claiming family would camp by that tract of land for a month or more to harvest tubers. The site would return to common property when the cleared vegetation had grown back the following year (Suttles 1955).

The Katzie (Halkomelem) traded wapato with other Halkomelem groups (e.g., Cowichan of Vancouver Island), as well as with the Nlaka'pmx, the Squamish, and the Straits Salish of Vancouver Island (Suttles 1955; Turner 1995). Tuber harvesting by the Upriver Halkomelem (Sto:lo) has been documented at Pitt Meadows, Sumas Lake, and Kawkawa Lake near Hope (Compton and Gerdts 2001; Spurgeon 2001). Additional harvesting sites are likely to exist. The Halkomelem names for *Sagittaria latifolia* (and possibly *S. cuneata*) were also adopted for the introduced *Solanum tuberosum* (table potato) (Galloway 1982; Compton and Gerdts 2001), indicating the incorporation and later substitution of this new starch source (Suttles 1987).

Katzie territory was a major focus of wapato use and exchange for communities in British Columbia and neighbouring territories. Though its distribution on Vancouver Island is limited, wapato use has been documented among the Coast Salish peoples on the Island (Turner and Bell 1971; Arvid Charlie pers. comm. to Nancy Turner 1999; Brayshaw 2000). It is possible that trading occurred between Coast Salish Peoples on mainland British Columbia and Vancouver Island. Robert Sam, former chief of the Songhees (Lekwungen) Nation, of southeaster Vancouver Island, remembers seeing people gathering it as a child in the early 1940s, though he hasn't eaten it since that time (Robert Sam pers. comm. 2002). There is no known use of wapato on Vancouver Island today.

Bordering the Halkomelem groups to the north are the Squamish. One of the Squamish names for wapato is thought to be borrowed from the Mainland Halkomelem Coast Salish (Dominic Charlie in Bouchard and Turner 1976), indicating a trade relationship between the two groups. Details of Squamish wapato use are not clearly understood, nor are the specifics of its trading, including the volume traded (Bouchard and Turner 1976).

The Lower Nlaka'pmx gathered wapato in both the fall and spring in Upper Fraser River Valley around Hope (this is in Halkomelem territory) (Turner et al. 1990). They would also obtain them through trade with their Halkomelem neighbours near Chilliwack (Turner et al. 1990). Though wapato was a valued food of the Lower Nlaka'pmx, the Upper Nlaka'pmx apparently did not eat the tubers (Turner et al. 1990). Elder Annie York of Spuzzum (1904-1991) remembers wapato growing around Frozen Lake and Merritt. However, she noted that the Nlaka'pmx people around Merritt would not eat it;

rather they used it in love charms or witchcraft (Turner et al. 1990). She also considered wapato to be related to *Nuphar lutea* (L.) Sm. *polysepala* (Englem.) E.O. Beal (Yellow pond-lily), *Polygonum amphibium* L. (Water knotweed), and possibly *Caltha leptosepala* D.C. (White-flowered Marsh-marigold), as well as other smaller aquatic plants (Turner et al. 1990).

Early ethnologists in the first half of the 20th century have documented wapato use and cultivation in Washington State. Herman Haeberlin (ethnologist) noted that wapato was an important and cultivated starch source for the people living on the Tulalip Reservation in 1916-17 in the Puget Sound region (primarily Snohomish and Snoqualmi Peoples) (Haeberlin and Gunther 1930). George Gibbs reported potato cultivation among the "sound Indians" in the 1910s. According to Gunther, " this is the only reference of any kind of cultivation. In 1854 the Sound Indians are supposed to have raised 11,000 bushels of potatoes. The species is not stated. These may have been ordinary potatoes, Indian potatoes or wapato " (Haeberlin and Gunther 1930: 21 citing Gibbs).

As noted in the Lewis and Clark journals, wapato was a highly valued vegetable food used extensively by the people of the Lower Columbia River Valley (Bergon 1989; McIntosh 2003). Archaeologist Melissa Darby produced an ethnohistoric review documenting the history and use of wapato by the people living along the Lower Columbia River (see Darby 1996). She notes that it was harvested in both the spring and the fall, and frequently traded (Darby 1996). The table potato, brought by European travelers, supplanted wapato along the coast. She includes one account that notes that in

1795 Captain Charles Bishop had his crew plant table potatoes (among other vegetables) in preparation for their winter stay at the mouth of the Columbia (Darby 1996).

Directly east of Secwepemc territory two indigenous groups are also known to have eaten wapato: the Ktunaxa from southeastern British Columbia and Montana (Hart et al. 1981; Pete McCoy pers. comm. 2001) and the Blackfoot in Alberta and northern Montana. Most Blackfoot ethnobotanical sources do not list *Sagittaria* spp. as a traditional food plant. However, botanist, Alex Johnston included it in *Plants and the Blackfoot* (1982, 1987). He concluded this from second hand sources (Hellson and Gadd 1974). Unfortunately he failed to specify which particular bands or areas were the source of this information.

4.1.3 Transfer of Wapato Knowledge in the Pacific Northwest

The pattern of documented wapato use of First Peoples in the Pacific Northwest may be partially explained through an examination of knowledge transfer among groups and an analysis of linguistic relationships. Contact through trading was a key way that groups exchanged both economic and social goods and information. They traded plant and animal material, technology and vocabulary (Turner and Loewen 1998). Trade networks were often well organized and extensive, and these may reveal much about the relationships of the people that participated in them (Turner and Loewen 1998).

Unfortunately, knowledge of past wapato dispersal along trade routes is limited. Though its dispersal from the Pacific Coast to inland areas has been documented (Suttles 1987;

French 1965; Turner and Loewen 1998), the extent and intensity of this trading is unknown.

> *... along the margins of the lower Columbia River and its tributaries was found* Sagittaria latifolia *Willd., wapato (Alismataceae). The tuberous root stalks were cherished by local Indians and some whites; Plateau Indians received them through trade* (French 1965: 380).

French does not detail which indigenous people in the Plateau traded for wapato tubers or how far into the Plateau wapato trading occurred. He was probably not referring to Plateau people in British Columbia, as his work was in Oregon.

Wapato trading was extensive not only along the lower Columbia River (Bergon 1989; Darby 1996; McIntosh 2003), but it was also heavily used and traded in and from the lower Fraser River Valley. Trade routes indicate another major movement of plant and plant products from this valley into the Plateau Region of British Columbia (Turner and Loewen 1998). Though no documentation exists for the direct trading of wapato between the groups along the lower Fraser River Valley and the Secwepemc, linguistic patterns illuminate a possibly interesting connection.

By examining the term "wapato" from British Columbia linguistic records we see that the Katzie, Stol:lo (Chillawack dialect), Squamish, Nlaka'pmxcin and Secwepemctsìn words for wapato are all cognates, indicating a relationship between the users of this plant (Table 4.1). Two possible directions of plant knowledge seem obvious: east from the Fraser River Valley into the interior Plateau, or west from the interior Plateau to the coast. Based on current documentation of the extensive use of wapato by the Katzie and

Sto:lo and lesser use of the wapato by the Secwepemc, it might be assumed that the origins of this cognate for wapato are from the Fraser River Valley. However, only in the Secwepemc language is the word analyzable: (lit. "yellow/jaundiced eye," from *kwel/kwal-* "yellow/green"; -us "face/eye") (SCES in prep. 1.) and it has been suggested that analyzability is one way to determine linguistic origin. According to Hess in Turner et al. (1998:391):

> *In general, unanalyzability is taken as an indication of a term that is either very ancient, and has, over the years, lost its original meaning to most speakers of a language, or one that is borrowed from another language, where its original meaning may be still perceived (Hess, n.d.).*

Table 4.1 Select First Nations names for *Sagittaria latifolia* or *S. cuneata* in the Pacific Northwest (adapted from Spurgeon 2001).

First Nations Group	Name	Source
Chinookans	wapato	Le Jeune in Spurgeon 2001
Samish, Klallam and Northern Puget Sound (Lushootseed)	*sqáwc*	Suttles 1987
Halq'emeylem (a language family)	*scous* or *skous* *	Duff 1952; Suttles 1955
Katzie (part of Halq'emeylem language family)	*xwaq'wól?s*	Suttles 1955
Sto:lo (Chilliwack dialect) (part of Halq'emeylem language family)	*xwõqw'õ:ls*	Galloway 1982
Squamish	*xwuxwukw'últs* **	Bouchard and Turner 1976 (unpub.)
Nlaka'pmx	*a'wa/q'wúl's*	Turner et al. 1990
Secwepemc	*Ckwalkwalús*, *ckwalkwalul's*, or *tseckwelkwelúl's*	SCES in prep. 1
Ktunaxa	*?awisi*	Hart et al. 1981

* Refers to Halq'emeylem name for wapato used by visitors
** Noted to be borrowed from the Mainland Halq'emeylem Coast Salish by Dominic Charlie [Bouchard and Turner 1976 (unpub.)].

The fact that the Secwepemctsin name for wapato is analyzable provides no conclusive evidence that the term originated in Secwepemc territory, however it does underscore the need for additional research to determine the dispersion of wapato through British Columbia.

Additionally, some evidence points to trading of wapato as far west as Vancouver Island from coastal and interior British Columbia. The phytogeographical distribution patterns of the plant may be related to cultural trading of populations of *S. latifolia* on Vancouver Island. Many of these populations are comprised of male plants only (Brayshaw 2000, Christopher Brayshaw pers. comm. to Ann Garibaldi 2001) leaving vegetation reproduction, from rhizomes and tubers, as the only means for propagation. Some speculate that these populations may have originated through transplanting of tubers either by humans or animals (Christopher Brayshaw pers. comm. to Ann Garibaldi 2001). Since the trading of wapato tubers by the Katzie of the Fraser River Delta is quite well documented, it is likely that some of these tubers were introduced through trade. Furthermore, Halkomelem elder Simon Charlie recently mentioned another possible connection between coastal and Plateau peoples. He said that the Cowichan of Vancouver Island had trading ties as far inland as Kamloops (Simon Charlie pers. comm. to Nancy Turner 2003). This cursory linguistic exploration provides an interesting point of departure to further explore wapato diffusion in the Pacific Northwest through such mechanisms as genetic and archeological studies.

4.2 Study of Contemporary Secwepemc Cultural Knowledge of *Sagittaria* spp.

4.2.1 Introduction

Literature reviews of ethnographic and ethnohistoric material provide much information crucial to understanding a community's relationship to landscape. However, the story is only partially told if contemporary knowledge from people living on that landscape is not included. Their knowledge is a manifestation of the events and interactions that went before them and represents a glimpse into one direction the future may take.

4.2.2 Methods

During the five formal interviews I conducted with Mary I chose to use a semi-structured approach to interviewing. This balanced my research needs of understanding Secwepemc wetland management of wapato with the desire to afford Mary a better opportunity to describe her life and relationships to wetland systems. In addition, I had many informal discussions with Mary while in Salmon Arm undertaking my ecological studies. I spent time with her family and have developed friendships with her and other community members. Interview questions were continuously modified and updated based on previous interviews. I posed some of the following questions and allowed Mary to share what she felt was relevant.

<u>Sample questions</u>

Question for my first interview

1. What do you remember about wapato?
2. Can you tell me about eating wapato? (*How was it cooked, etc.*)
3. How did you obtain wapato?
4. What were conditions like in wetlands when you were young versus now?

5. Describe for me other important wetland plants and animals
   - When (what time of year) would you come down to the wetlands to gather wapato?
   - How long would you stay?
   - Would you come back to the site to gather other plants/animals as well?
   - Would you always go back to the same spot to collect wapato?
   - Was wapato ever traded? With whom?
   - What is the traditional name for potato?
   - When was the last time you remember wapato being harvested?
   - How much wapato would you gather at one time? (*try to obtain information about basket size, amount of time spent harvesting, etc.)*
   - How many families would harvest at one spot?
   - Were there rights or titles to certain gathering sites?
   - What season was each of those harvested in?
   - What do you consider the primary traditional resources of wetlands?
   - Did anyone believe that wapato or wetland areas needed to be harvested to stay healthy? What would happen if you didn't harvest from them anymore?
   - Did certain families have "control" or rights to certain wetlands?

Follow up interview questions

Wapato questions:

1. When (what time of year) would you come down to the wetlands to gather wapato?
2. How long would you stay?
3. Would you come back to the site to gather other plants/animals as well?
4. Would you always go back to the same spot to collect wapato?
5. Who would the Neskonlith trade wapato with?
6. What is the Secwepemc name for potato?
7. Can you show me on a map where you would dig for wapato and other wetland plants?

Wapato Management:

8. Was it with BOTH your grandmother and mother that you would gather wapato with? Was that typical of most families?
9. Can you tell me about how much wapato would you gather at one time? (*try to obtain information about basket size, amount of time spent harvesting, etc.)*
10. How many families would harvest at one spot?
11. Were there rights or titles to certain gathering sites?
12. Did you grandmother use her digging stick to collect wapato? How big was the stick?
13. What would happen the wetlands if you didn't harvest plants from them anymore?

Wetland questions:

14. Ask Mary to list out wetland plants (this may help to see what she feels is a "wetland plant")
15. What other plants and animals aside from wapato would you gather at wetlands?
16. What season was each of those harvested in?
17. What do you consider the primary traditional resources of wetlands?
18. Can you tell me the story about the tule boat?

Wetland Management:

19. Did your grandmother (or mother) believe that wapato or wetland areas needed to be harvested to stay healthy? What did she think would happen if you didn't harvest from them anymore?
20. Did certain families have "control" or rights to certain wetlands?
21. Was any wetland burning performed? Did any other groups burn similar wetland habitats?

General Site questions:

22. What is the history of the reserve land?
23. How was her family affected by the reserve system (i.e. did they move or change gathering sites, etc?)
24. Mary you mentioned that houses were built along the rivers. Did you have to worry about flooding during the high water season?

I taped indoor interviews on a cassette tape and transcribed them in Victoria. During field interviews I took notes and photos that were then later detailed. I often asked Mary similar questions during follow up interviews to see if additional information would be shared. This proved effective. Yet, most of the time I simply listened to Mary. I wanted to give her an opportunity to discuss the issues that she thought were relevant and allow her to provide input for the direction of our discussions.

In addition to interviews with Mary, I reviewed many other sources from previous research with the Secwepemc and neighbouring groups (Compton and Gerdts 2001; Duff 1952; French 1965; Gunther 1945; Haeberlin and Gunther 1930; Hellson and Gadd 1974; Johnston 1987; Palmer 1975a, 1975b; Suttles 1955; Bouchard and Turner 1975 (unpub.);

Turner 1997; Turner et al. 1990). These helped provide a context and history of plant-people relationships.

4.2.3 Background of Mary Thomas

Throughout her lifetime Mary Thomas has actively been a part of the Salmon River Delta at Shuswap Lake. Mary saw her parents take part in the growing wage economy in interior British Columbia in the 1920s and she frequently participated in activities such as plant food gathering and basketry with both her father's and mother's parents. As such, Mary's understanding of the landscape spans a period when Secwepemc people were experiencing "a drastic change in lifestyle." The following account is an overview of Mary's life as it relates to the Delta on Shuswap Lake. It is intended to contextualize Mary's knowledge of wapato and other wetland plants as well as Secwepemc plant harvesting activities. It is not meant to be comprehensive life history.

Mary was born in 1918 on the Salmon Arm Indian Reserve No. 3. Mary's parents, Daniel and Christine Allen, moved before Mary was born to this reserve where her father worked as a laborer clearing land for settlers. Mary's family had two homes. One was located at the Delta of the Salmon River and Shuswap Lake; the other was roughly 5 km upriver from the Delta on higher ground. Mary has indicated that more than one home was used to allow people to move away from wetlands during heavy mosquito season; they would then participate in other subsistence activities during that time.

Mary grew up on a small family farm where her parents raised pigs, geese and horses and grew vegetables such as corn, beans and peas. Because Mary's parents were quite busy working, farming, hunting and processing food (primarily her mother's job), Mary spent much of her early childhood with her grandparents, particularly her father's parents, Marguerite Allen and "Grandpa Allen".

> *My mother and father were very busy trying to adopt a new lifestyle by fencing, clearing land, fencing it in, tilling it, and planting new kinds of food. So our grandparents were the ones took over in raising us* (Mary Thomas in *The Wisdom of Dr. Mary Thomas* 2003).

The Allen's lived near Mary's parents on the Salmon Arm Indian Reserve No. 3. Her mother's "parents", Margaret Dick Andrew and Dick Andrew, lived on the Neskonlith Reserve No. 1 near the town of Chase, 30 km west of Salmon Arm. Mary's mother was orphaned at a very young age and was raised by her aunt and uncle. They became surrogate parents to Mary's mother, Christine Allen, and were like grandparents to Mary.

Both of her grandmothers shared much plant knowledge with Mary. She would gather yellow glacier lily bulbs (*Erythronium grandiflorum* Pursh), among other root vegetables, with her grandmother Margaret Andrew on the Neskonlith Flats outside of Chase. However, Mary doesn't remember wapato growing around that area and only harvested it with her grandmother Marguerite along Shuswap Lake. Mary learned a great deal about Secwepemc plant use from her grandmother Marguerite. When Mary speaks of wetland plants and their use, she often gathered this knowledge from her grandmother Marguerite.

Mary's connection to present-day Salmon Arm and the Delta was truncated when she went to the Kamloops Residential School at 6 1/2 years old, leaving her to return to the Salmon Arm Indian Reserve No.3 only in the summers. During these summer breaks she also visited relatives, such as her mother's parents, on the Neskonlith Reserve No. 1 She attended residential school until she was 16 (in 1934) when she was forced to leave despite her interest in continuing her studies. When Mary left residential school, she returned to the Salmon Arm area and began work for a farmer helping out with various jobs on the farm. Residential school was a painful experience for Mary and one that she spoke very little about with me. However, she did mention that although she was forbidden to speak Secwepemctsín for many years, she is still fluent in it today.

Mary married, and with her first husband purchased a piece of land about 1 km upriver from the Delta (part of the Salmon Arm Indian Reserve No. 3) when he returned from active duty during World War II. Mary's father owned land on the reserve adjacent to their site, including land that encompassed the Delta. In fact, in the 1920s her father cleared the property where she currently lives for her uncle, though she has since purchased it from a family member. This property has remained in Mary's family since the time of purchase.

Mary left the reservation in the 1950s and lived in outside communities for 38 years, raising 9 children as a single parent. She has explained that she left the reserve to protect her children from the trauma, anger and abuse she saw on the reserve following World War II.

While living off of the reserve, Mary spent many years working various jobs, primarily housekeeping, to support her family and was not heavily involved in teaching traditional Secwepemc activities. However, a turning point came in Mary's life in the 1970s when she began work with Ursula Surtees at the Kelowna Museum. She was hired to help develop a school kit on native culture for provincial schools. "We would put questionnaires together, and I'd go to the reserves, all the way from Williams Lake to Radium, and interview the elders." Mary describes this process and what it meant to her:

> *I became really interested, and I began to see things from a different perspective. Slowly I began the change. That terrible feeling I had in my heart began to slowly disappear. And down the road, after a few years, I began to look at the situation that I ran away from, the reservation. That gave me double the strength to try and be a role model for my people* (Mary Thomas in *The Wisdom of Dr. Mary Thomas* 2003).

As her children became adults many of them returned the Salmon Arm Indian Reserve No. 3. Mary visited them on the reserve as well as other relatives on Neskonlith Reserve No. 1 and Neskonlith Reserve No. 2 while living of the reserve. She was able continuously visit the sites of her childhood during that time.

Mary moved back to the reservation, specifically the area surrounding the Delta, three years ago and is quite active speaking about the changes she has seen in the area during her lifetime. The land her family has lived and worked over the past century is still being used for agriculture, though only in a limited capacity. Mary has rented[13] some of her land to Ed Blackburn, a rancher who lives adjacent to the Delta just off the reservation,

[13] Mary is able to rent or lease her land to both Native and non-Native people. However, since it is reserve land she is not permitted to sell it to non-Native people.

for 30 years. He clears Mary's land for hay and pastures his cattle (approximately 15 head of cattle) in the Delta. In return she receives half of the earnings from hay sales.

As an adult she has become a tireless teacher of and advocate for Secwepemc knowledge and cultural practices for the past 30 years, since she began working at the Kelowna Museum. Much of her time is spent drawing awareness to the current state of the Salmon River Watershed. In fact, together with her son Louis, she helped create the Salmon River Watershed Roundtable, a non-profit organization dedicated to promoting a healthy watershed. She is recognized both nationally and internationally for her work. She has recently received honorary doctorates from the University of Victoria and University College of the Caribou and the first Aboriginal person in North America to receive the Indigenous Conservationist of the Year award from the Seacology Foundation. She has also received the prestigious Aboriginal Achievement Award in the category of the environment. Presently, she is in the final stages of securing funds for The Shuswap Centre that is to be located on the property where her first husband bought land just upriver from the Salmon Arm Delta. This reserve land has remained in Mary and her family's ownership since that time and she has donated it for The Shuswap Centre.

4.2.4 Findings

Wapato

Management and Use

Whenever Mary spoke of wapato, she often included water parsnip, and cattail. Wapato and water parsnip roots were harvested together in the spring; cattail leaves were gathered in late summer for weaving. As I spoke with Mary about my surveys of

potential wapato patches around Salmon Arm and Kamloops, she suggested I look for water parsnip because, "where you find one you usually find the other". This turned out to be a useful identifier of potential wapato sites, as water parsnip is a bit taller than wapato and therefore easier to see. Many wapato patches I surveyed were adjacent to sites containing water parsnip.

Mary described wapato populations during her childhood, before she went to residential school, as quite abundant. As Mary explained it, along with water parsnip they, "grew right clear around the bay. They multiplied like crazy. Just about anywhere we camped [on sandy beaches] it grew" (Mary Thomas pers. comm. to Ann Garibaldi 11-13-01). During the spring harvest, a lot of "little old ladies" along with neighbours collected these plants. The women would "pop" wapato out of the mud and the children would collect them in baskets. Mary's grandmother would wade out into the water about halfway up her shins. She would then tie up her skirt with a piece of string and place some of the loosened tubers in the "cloth container". Mary mentioned that women would use a digging stick to dislodge some of the tubers – it was about a foot long with a small cross bar at the top, sometimes made of deer antler though it could also be made out of wood if deer antler wasn't available (Figure 3.2). Wapato tubers could also be loosened by wading into the water and dislodging them with their feet. The tubers would then float up to the surface and be collected. Not all tubers are buoyant at the same time (Darby 1996). Buoyancy facilitates tuber dispersal and establishment of new populations (Wooten 1971).

Water parsnip was a favorite treat of for many children. The long clusters of succulent roots could be rinsed off and eaten right away, unlike wapato tubers which had to be cooked first. People collected large baskets of both roots. Mary remembers, "it was so plentiful. I don't think they could put a dent in it, you know by digging"(Mary Thomas pers. comm. to Nancy Turner and Ann Garibaldi 2-15-01). Large baskets (much larger than 2' X 1' X 1' at the upper rim) were filled for each root. Mary doesn't remember anyone "putting away wapato [for storage]"; the tubers were considered a seasonal vegetable. Both wapato and water parsnip were the first fresh vegetables for the season – the first crunchy foods after the winter season.

The wapato tubers were harvested in different spots every year as, "there was so plenty of them all over." After the fourth year they would come back to the first spot to harvest there again. There were no leaves on the plants when the tubers were harvested; people just remembered where the plants were. Tubers from one small site could easily feed two to three families during the spring season.

<u>Cooking</u>

Wapato was eaten over a period of at least two to three weeks "…and then they begin to sprout and once they begin to sprout the root gets kind of watery" (Mary Thomas pers. comm. to Ann Garibaldi 2-25-01). Many families would travel to beaches along Shuswap Lake during this two to three week period and harvest wapato and water parsnip on the beach. Wapato grew at Canoe (roughly 10 kilometers north of Salmon Arm) and all along the lakeshore when Mary was young, before she went to residential school. There is a small patch of *S. cuneata* still growing there today. She and her family would camp on

the sandy beach, and gather wapato and freshwater clams to make chowder. They added dumplings to a boiling pot of the tubers and clams. Mary explained that all of the sandy beaches where they formerly camped are now filled in or developed.

Tubers were cooked by a steaming or roasting method in hot ashes. For steaming, they were placed in a kettle or over boiling water for five to ten minutes. For roasting (the more common cooking method), they were buried loose in the hot ashes with a fire on top and cooked for 1/2 to 1 hour. They were then taken out of the hot ashes and peeled before eating.

Other Wetland Plants in the Vicinity

Discussions with Mary about wapato almost always led to other culturally important wetland plants. Some of these grew adjacent to wapato in the Salmon River Delta (eg., *Typha latifolia*; cattail) and some further upriver (eg., *Viburnum opulus* L., highbush cranberry). In late July, Mary's grandmother Marguerite would collect cattail leaves for weaving. She would take leaves from shoots that did not have flowers - the "younger" ones. Mary doesn't recall the wetland plants decreasing from year to year as a result of this activity. This indicates sustainable harvest levels for these wetland plants.

Mint (*Mentha arvensis* L.) also used to grow at the mouth of the Salmon River in places that are now covered by reed canary grass (*Phalaris arundinacea* L.). Mary remembers

her father collected fine meadow hay[14] along with red top (*Agrostis gigantea* Roth) and clover[15] for animal feed (horses)[16]. These plants have been slowly replaced by the reed canary grass. Meadow hay also grew mixed with mint, and was used as bedding:

> *You laid down and you could just smell that mint and I remember my grandmother used to just love stuffing a great big bed made out of flower heads. She'd stuff it with meadow hay and there's a lot of mint in it and your bed just smelled like mint. It was really good, healthy* (Mary Thomas pers. comm. to Nancy Turner and Ann Garibaldi 2-15-01).

Mary explained how skunk cabbage (*Lysichiton americanus* Hultén and St. John) and "rope hemp making" (Indian hemp – *Apocynum cannabinum* L.) used to grow along river bottoms in the area, including the area at the mouth of the Salmon River. Small patches of Indian hemp still grow there. In the delta area Mary used to help her family collect bundles of Indian hemp stems to begin the process of turning the tough fibre from the outer part of the stalks into rope. Skunk cabbage roots [rhizomes] were washed, cooked and pounded into flour. According to Mary, this was a key source of flour before the availability of wheat flour.

Cow parsnip (*Heracleum lanatum* Michx.) and highbush cranberry grew upriver from the Salmon River Delta. Cow parsnip stalks were eaten in early spring, around the middle of May before the plant flowered (later it is too old, tough and strong tasting). The younger stalks were peeled and eaten on the spot. "And when you peel it you can eat it right away. And it's crunchy. I guess when you crave for something fresh – those were a treat" (Mary

[14] This has also been referred to a "slough grass". Possibly "slough sedge", *Carex obnupta* Bailey. This may have likely been a mix of species.
[15] Possibly white sweet-clover (*Melilotus alba* Medikus) or red clover (*Trifolium pratense* L.).
[16] Mary's father worked on a local farm and subsequently ran a small family farm.

Thomas pers. comm. to Ann Garibaldi 2-25-01). Later, the hollow flowering and fruiting stalks of cow parsnip (also *Angelica* spp.) were sometimes home to a small moth larva that was used as bait for fishing. These hollow stalks, angelica and cow parsnip, could also be used to aid breathing while one was submerged underwater. This was particularly handy while hiding from enemies (Mary Thomas pers. comm. to Ann Garibaldi 2-25-01). Highbush cranberry used to grow in profusion in the moist thickets along the river. Mary explained that there is now very little of it left in the Salmon River Delta. There has been heavy invasion of climbing nightshade (*Solanum dulcamara* L.), an exotic species, in the highbush cranberry patches.

Mary also spoke of coltsfoot (*Petasites* P. Mill. spp.). It used to grow in the wetland areas adjacent to the delta and was used for menstrual pads. To prepare them for this purpose the leaves were dried and then the larger veins pulled away. The main, soft part of the leaf was crushed and worked over with the hands until it formed a soft matted wad, which could be wrapped in a cloth for use. Mary explained that the former gathering site for coltsfoot leaves is now home to a large housing development. The sloughs where it once grew have been drained or filled in and the land in this area no longer supports coltsfoot.

Impact to Wetlands

Mary spoke often about the changes she witnessed in the wetlands due to decreasing water levels, pollution, the introduction of new species and the loss of native ones. The wapato and water parsnip disappeared before the cattails, but the cattails were decreasing long before Mary moved back to Salmon Arm in 1999.

Mary mentioned different types of land use, such as ranching, that have had an impact on landscape conditions.

> *... the cattle trampling on the roots and just deteriorated. And now there isn't one bulrush* [Typha latifolia] *plant down at that delta. That, a long time ago my mother was saying that you can eat the root at a certain time of the year of the bulrush. It was* [a] *survival type of food. And I asked her 'do you ever have to eat that?' And she said 'no because there was a lot of the wapato and water parsnip down there.' Today there isn't one plant left* (Mary Thomas pers. comm. to Nancy Turner and Ann Garibaldi 2-15-01).

Today there are growing housing developments along Shuswap Lake. This has resulted in a replacement of less desirable cattail zones with beaches constructed from trucked-in sand and gravel. Mary's elders taught her that cattails and some other wetland plants filter pollutants from the water. With a decline in cattail patches "there is going to be a lot of pollution heading into the lake" (Mary Thomas pers. comm. to Nancy Turner and Ann Garibaldi 2-15-01). For this reason Mary has stated that she is hesitant to eat any plants, including restored wapato, taken from the vicinity of the lake.

Mary laments the loss of red-winged blackbirds, bluebirds and western grebes today as compared to her childhood. Although the newly established annual grebe festival in Salmon Arm is helping to restore this species, their habitat is heavily modified. Currently they have to nest among the stems of reed canary grass because there is very little cattail marsh left.

While I was driving from Salmon Arm to the Wap Valley with Mary in July of 2001, she pointed out many landscape features and shared her recollections of events important to

her and the Secwepemc community. All along Shuswap Lake to Sicamous was the territory of the Neskonlith Secwepemc. The lake served as the traditional "highway" for Mary's people. When I asked Mary where the people built their homes, she explained that "although it looks today as if the houses were built away from the river, that is not really true" (Mary Thomas pers. comm. to Ann Garibaldi 7-04-01). The water levels were higher when Mary was young and people lived along the rivers as they were formerly situated.

When I asked Mary about the decrease in water levels of both Shuswap Lake and the Salmon River she responded by first talking about the hillsides, and logging.

> *Why isn't there much water coming?* [My mother] *said you know there's a big difference in the evergreens and the leafy trees... she said you take the leafy trees, in the spring sap goes up the tree and creates the leaves. And its' collecting solar energy - the wind, the rain, the sun. In the fall the sap will go back down in the ground and the other plants it feeds the creeks, the leaves drop and create compost. But now, she said, they are chopping them all out* (Mary Thomas pers. comm. to Nancy Turner and Ann Garibaldi 2-15-01).

She explained the decrease in forested areas, especially the removal of birch and other leafy species, has led to not only more water running off the mountains, but in fewer trees to store and cycle the water. Mary remembers from her time before residential schools many more creeks coming down off the mountain than are there today. She would go up Mt. Ida on horseback to collect high quality birch bark that was both flexible and durable for basketry. She has recently noticed one hotspring that they used to visit before she went to residential school has now dried up.

Mary attributes lower water levels, in part, to increased irrigation. Most of the sloughs along the Salmon River have either been filled in, drained, or have dried up. The last really high water that Mary remembers was in 1948 during a high flood. The water in the delta came up almost to the railroad tracks that year.

Mary believes the two primary reasons the original plants don't grow in the wetlands are due to cattle (and horses) and pollution. Cattle and horses trample the soil and the plants that live there, preventing new growth - "they cut deep with their hooves" (Mary Thomas pers. comm. to Nancy Turner and Ann Garibaldi 2-15-01). Pollution comes from many sources, for example, from boat engines, highway runoff, and trains. She remembers as a child, one summer, the sloughs were filled in with oil to control the mosquitoes. Mosquitoes were never a problem for the Secwepemc people originally because during thick mosquito season the people moved from the low wetland area to drier, breezier sites further upslope.

One other major disturbance Mary described was the changing river mouth.

> *People up here* [by the wharf in Salmon Arm] *were saying they were getting flooded out because the river wasn't flowing down fast enough, it was backing up. So what they did was changed the mouth of the river towards the mud flat. And a few years later the wharf people were saying that the river is pushing silt into their channel. So without my permission they cut another channel and cut my meadow in half... and that's where it is today. And I told them it's over my dead body before you guys ever touch that mouth of the river again* (Mary Thomas pers. comm. to Nancy Turner and Ann Garibaldi 2-15-01).

Mary's knowledge of this area provides information on traditional Secwepemc use and management of wapato. It also sheds light on changes to the wetland area in general.

This information can be used to narrow the focus on present potential limitations to its growth, thereby aiding ecological experimentation for restoration purposes.

4.2.5 Discussion

Originally I had intended to research Secwepemc traditional wetland management using wapato as a focal species for restoration. While I have learned much valuable information about wapato use and harvesting methods, much of my time with Mary was spent discussing landscape changes and the repercussive impacts of those changes on traditional lifeways, including wapato use. The story that has emerged from my research is one of transformation and adaptation – both social and ecological. Landscape modifications certainly force a shift in cultural activities. Historically these modifications have tended to be of a lower intensity, the result of cultural management and/or localized natural processes. However, the past century has brought about radical shifts in both landscape and cultural systems, limiting the ability for adaptation.

Currently there seems to be a movement towards re-enforcing cultural practices. As Secwepemc leader and cultural specialist Ron Ignace states, "we [Secwepemc] set out to build our own place where we could teach according to our ways, so that we could sensitize ourselves to the teachings of our ancestors and begin the journey of taking control over ourselves and our lives, to begin defining our own destiny" (Murphy et al. 1999: preface). This goal is seen in the stories that Mary has shared and the activities of Secwepemc community. Restoration facilitates the already existing desire of

communities to reconnect in a spiritual and physical way with their traditional territory and their traditional lifeways.

5.0 Ecological Considerations

5.1 Introduction

The literature and ethnobotanical interviews presented above underscore the cultural significance of the restoration of wapato. Biological literature on *Sagittaria latifolia*, particularly in northern portions of its range, is sparse. Much of the data on *S. latifolia* provides little information on growth responses to fluctuations in wetland conditions. Given the increasing interest in *S. latifolia* for restoration purposes (Marburger 1993), there is a need for additional research into its autecology. In this chapter, I provide an overview of research to date on *S. latifolia* that pertains to herbivory and water level requirements. This provides a background for the discussion of my experiments on the effects of herbivory and water depth on wapato growth in the Salmon River Delta of Salmon Arm, British Columbia.

5.1.1 Selection of *Sagittaria latifolia* versus *S. cuneata* in Restoration

Though both *Sagittaria latifolia* and *S. cuneata* occur in southern British Columbia, it is not known which species of *Sagittaria* formerly grew in the Salmon River Delta. It could have been either, or both. Furthermore, even if the species was known, local races may differ genetically as well as in response to environmental conditions. Without knowledge and possession of the genetic source from a specific area, growth response is somewhat unpredictable. The decision to use *S. latifolia* for field experiments was based primarily on its wider availability, as tubers of *S. cuneata* are not available commercially. I was not able to locate any nurseries in the Pacific Northwest that sell *S. cuneata*. I purchased

S. latifolia tubers from Streamside Native Plants in Courtenay, British Columbia. The original genetic stock is from Washington State.

The decision to plant *S. latifolia* tubers for field research does not answer the question, *what species of tubers were harvested by the Secwepemc?* Many ethnographic reports documenting traditional wapato gathering in British Columbia list the species as *S. latifolia* rather than *S. cuneata* (Duff 1952; Suttles 1955; Bouchard and Turner unpub. (1976); Gilmore 1977; Galloway 1982; Spurgeon 2001; Hart et al. 1981.). Yet, reports differ in their methodological detail, and how or even whether plant species was verified is not always clear. *Sagittaria* spp. distribution studies, including examinations of herbaria, provide some insights which species was likely to have been harvested.

In coastal British Columbia *S. latifolia* is more common than *S. cuneata* (Brayshaw 2000), though both species occur in coastal wetlands. I have observed that the former produces larger tubers, which may have been more desirable for the Katzie and other coastal communities *S. latifolia* to cultivate. Though *S. latifolia* is still growing in parts of traditional Katzie territory, there is no way to be sure that both species were not harvested opportunistically and simply not distinguished in reports.

For the interior Secwepemc community of Salmon Arm, the question becomes even more complex. The *Plants of the Secwepemc People* (SCES in prep. 1.) lists wapato as either *Sagittaria latifolia* or *S. cuneata*. With no original plants growing in the delta and without further evidence, conclusive identification is impossible. Both species grow in

interior British Columbia but in contrast to the coast, *S. cuneata* is more common (Brayshaw 2000). This suggests that *S. cuneata* is the species traditionally harvested by the Secwepemc. Though size and vigor of both the plant and tubers that Mary Thomas describes best fits *S. latifolia*, I have observed some variability in tuber size and biomass production across the two species. The three sites closest to where the Salmon River Delta *Sagittaria* spp. grew all contained *S. cuneata.* Again however, with the exception of the Canoe site, no specimens of *S. cuneata* fit the description of the size and vigor of the plants Mary Thomas remembered. Two possible reasons are evident: 1) *S. cuneata* currently growing outside of Salmon Arm are stressed and not able to exhibit more robust growth; or 2) the original plants growing in the Salmon River Delta were, at least in part, *S. latifolia.* This debate remains unsolved, yet its relevance to the experimental study should be underscored throughout this thesis.

5.1.2 Biology of *Sagittaria latifolia*

Taxonomy

Sagittaria is a member of the Alismataceae, or water-plantain family. Haynes and Hellquist (2000) list 34 species of *Sagittaria* in North America, two of which occur in British Columbia: *S. latifolia* Willd. and *S. cuneata* Sheldon. Two varieties have been described for *S. latifolia* in North America (Kartesz 1994) based primarily on the pubescence on the vegetative part of the plant: var. *latifolia* and var. *pubescens* (Muhl. *ex* Nutt) J.G. Sm. (Haynes and Hellquist 2000). The pubescent variety of *S. latifolia* is restricted to the southeastern portion of the United States (Wooten 1971). Therefore only

S. latifolia var. *latifolia* occurs in British Columbia (Douglas et al. 2001). Haynes and Hellquist (2000) do not recognize these varieties in their treatment of *S. latifolia*.

Morphology

Sagittaria latifolia is a perennial emergent wetland plant with thick tuber-bearing rhizomes. The stems range from 20 to 90 cm tall (Douglas et al. 2001; Pojar and MacKinnon 1994).

Plants contain rosettes of glabrous, sagittate (arrow-shaped) leaves ranging from 5-40 cm long and 2-25 cm wide (Gleason and Cronquist 1991). Leaves from the lower nodes tend to be linear or lanceolate and smaller in size than the sagittate leaves. Tubers are spherical to ovoid and creamy-white in colour (Figure 1.1). I have observed tubers ranging from 5 to 9 cm in diameter and from 4 to 6 cm in length. One common name for this plant, duck potato, refers to the starchy tubers that are highly prized by wildlife, including ducks, geese and swans (Martin et al. 1951; Darby 1996).

The inflorescence grows on a central leafless stalk with 2-15 whorls of three male and female flowers, each with three white petals and three green sepals. The flowering stalk generally is taller than the leaf stalks. Occasionally the lowest whorl of flowers produces a lateral stem instead of a flower (Muenchow and Delesalle 1992). This branch also produces a central stalk with whorls of flowers. In monoecious (bisexual) forms of the plant, the female whorls appear at the base of the inflorescence, below the male whorls. In dioecious forms, the male and female flowers are found on separate plants. The fruits

are achenes (single-seeded, non-fleshy fruits). Each plant may yield up to 20,000 viable achenes (NRCS 2000).

Distribution and Habitat

Sagittaria latifolia is found in southern Canada, south through the United States, and into Mexico, Central America (Guatemala) and South America (Columbia, Ecuador and Venezuela) (Haynes and Hellquist 2000) (Figure 5.1, Figure 5.2). Brayshaw (2000) considers *S. latifolia* uncommon in British Columbia. It is found along the coast as well as the interior (Figure 5.3, Figure 5.4).

Habitat

Because it prefers wet, silty unconsolidated soils, *Sagittaria latifolia* is generally found in the slow moving waters of ponds, sloughs, marshes, and stream edges (Guard 1995; Fortner and White 1998). It is found in both brackish coastal and inland freshwater sites and can tolerate a pH range of 5.9-8.8 (Marburger 1993). Along the Mississippi River, the plant prefers sandy-loam soils rather than clay-silt with a finer particle size (Clark and Clay 1985). Achene production of *S. latifolia* in an Illinoian lake was much lower on hard-packed clay than on soft, black silt (Low and Bellrose 1944).

Sagittaria latifolia can be found growing in varying depths of water, but approximately 30 cm of standing water has been suggested for optimal growth (Whittey et al. 1990).

Figure 5.1 North American range of *Sagittaria latifolia* Willd. The shading and dots both indicate plant range and location (adapted from Haynes and Hellquist 2000).

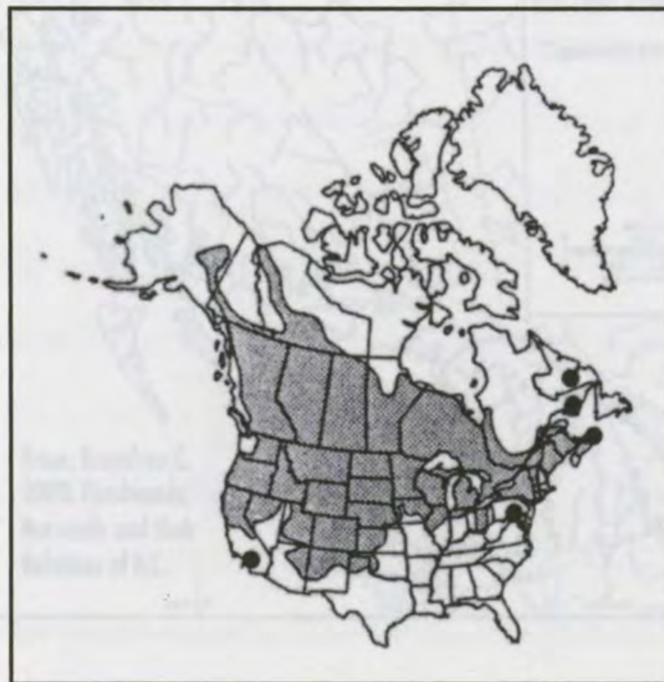

Figure 5.2 North American range of *Sagittaria cuneata* Sheldon. The shading and dots both indicate plant range and location (from Haynes and Hellquist 2000).

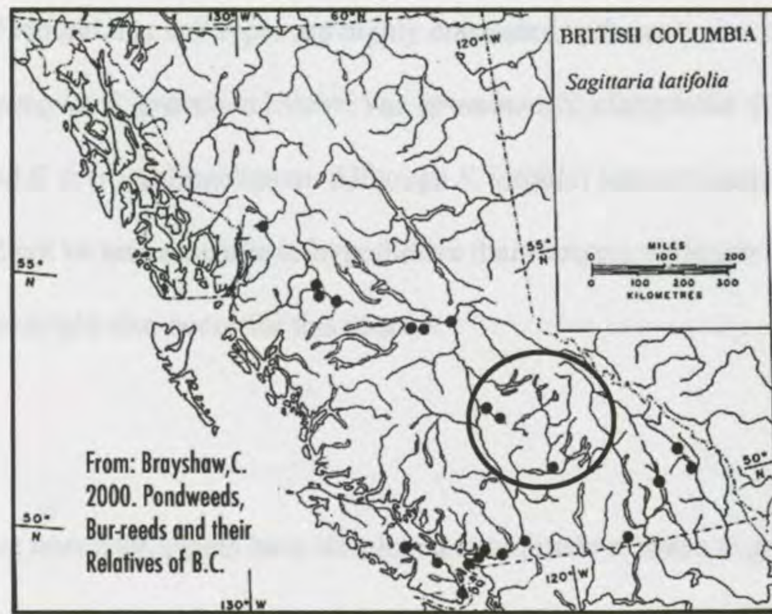

Figure 5.3 Distribution for *Sagittaria latifolia* in British Columbia (from Brayshaw 2000). The circle denotes the general area of traditional Secwepemc territory.

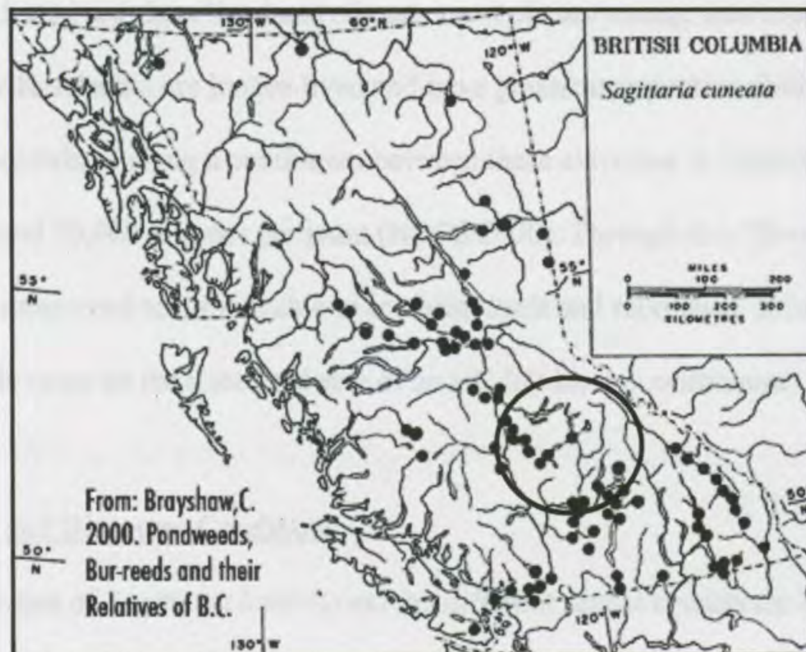

Figure 5.4 Distribution for *Sagittaria cuneata* in British Columbia (from Brayshaw 2000). The circle denotes the general area of traditional Secwepemc territory.

Wooten (1973) found that soil types are highly correlated with ecotypic variation of three species of *Sagittaria*: *S. graminea* Michx. var. *graminea*, *S. platyphylla* (Engelmann) J.G. Smith, and *S. cristata* Engelmann. Although *S. latifolia* was not included in this study it would not be unreasonable to hypothesize that ecotypic variation based on edaphic factors might also occur for this species.

Life History

Out of adaptive necessity, plants have developed a multitude of ways to grow and reproduce in a variety of environments. MacArthur and Wilson (1967) developed one commonly used way of classifying plants, describing them as *r*-selected or K-selected on the basis of their resource allocation patterns and life history traits. Plants that are strongly *r*-selected are short-lived and allocate most of their energy into reproduction; those that are K-selected are longer-lived and have greater competitive ability. Most plants fall somewhere along a continuum between these extremes. *S. latifolia* produces up to 40 tubers and 20,000 achenes per plant (NRCS 2000). Through this "flooding" of the system with tubers and seeds it is able to establish itself and reproduce. *S. latifolia* therefore falls more on the r-selected side of an *r*-K life history continuum.

Monoecious and Dioecious Conditions

The two varieties of *Sagittaria latifolia* exhibit different sexual conditions: bisexual (monoecious) and unisexual (dioecious) reproduction. *S. latifolia* var. *latifolia* exhibits both monoecious and dioecious conditions throughout its range. *S. latifolia* var. *pubescens* produces only monoecious inflorescences (Wooten 1971).

Researchers have used variation in sexual expression in many species of *Sagittaria* as an opportunity to explore the evolution of plant reproduction and environmental factors, such as insect herbivory, that influence it (see Muenchow 1985, 1998; Delesalle and Muenchow 1992; Muenchow and Delesalle 1992, 1994; Sarkissian et al. 2001).

Propagation

Because *S. latifolia* exhibits monoecious and dioecious conditions across North America and reproduces both sexually and asexually, a variable pattern of propagation emerges. Primary reproductive methods may vary by both region and site; however, clonal or vegetative reproduction appears to be quite a common and successful means for propagation. For example, seedlings are rarely found in undisturbed, mature communities of *S. lancifolia,* with primary reproductive means being vegetative (A. Baldwin pers. comm. in Schussler and Longstreth 1996). It is not unreasonable to assume that *S. latifolia* may act in a similar way. Wooten (1971) and Delesalle and Muenchow (1992) found that dioecious populations are associated predominantly with vegetative reproduction. A reliance on vegetative reproduction and subsequent resource allocation to tuber production could increase available food source for some herbivores. Feeding patterns and behaviors might be affected by amount of tuber and achene production.

Plants are able to spread by producing long rhizomes. Internodes are found along the rhizomes at roughly equal distances. *S. latifolia* (and *S. cuneata*) send up vertical growth at intervals up to six internodes away from the parent plant, and reaching a distance of

40-60 cm (Lieu 1979). Large patches of *S. latifolia* (hundreds of ramets[17]) may be produced from a single genet[18] and single gender patches have been found to be several meters wide (Muenchow and Delesalle 1992). Plant growth can be quite dense. For example, Low and Bellrose (1944) measured 25 plants per square meter in an Illinoian lake, producing on average16 fruiting stems and 30 seed heads per stem.

Germination

Seed germination literature for *S. latifolia* is inconclusive and sometimes contradictory (Marburger 1993). It appears that many environmental factors influence germination success rates, including water depth (see Vescio 1979; Keddy and Ellis 1985; Keddy and Constabel 1986), soil particle size (see Keddy and Constabel 1986), salinity and scarification (Kaul 1978).

Kaul (1985) lists scarification as the only requirement for germination. Keddy and Constabel (1986) found that the ten shoreline species they examined (including *S. latifolia*) prefer finer particle size for seedling recruitment and sheltered (less disturbed) bays. They also noted that *S. latifolia* is sensitive to drying and responded better to a wet treatment. Kaul (1985) also documented that seedlings thrive on exposed mudflats.

It also appears that seed banks for *S. latifolia* do not have much longevity, due in part to predation (Leck 1996). The extent to which herbivory affects seed germination and production in *S. latifolia* is unknown and possibly varies depending on ecotype.

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[17] A ramet is an individual stem of a clone

[18] A genet is an plant derived from an individual (genetic) seed source

5.1.3 Possible Factors Limiting *Sagittaria latifolia* in Interior British Columbia

At the Salmon River Delta, pressure has been placed on the aquatic system from exotic species such as carp, cattle, introduced reed canary grass, and Eurasian water-milfoil. While each of these factors certainly affects plant viability, it is most likely a complex of factors that initially limited and then hindered the growth of *Sagittaria* spp. in the Salmon River Delta.

Two primary factors that appear to limit *Sagittaria latifolia* growth are water level requirements and pressure from herbivory (Marburger 1993). The impacts from these factors may be amplified when both are present or occurring in a system. While working with populations of *Sagittaria lancifolia* L., Grace and Ford (1996) discovered that the combined effects of herbivory, salt water, and flooding resulted in reduced plant growth or even plant death. However, each factor alone did not result in long-term impacts. Therefore a review of the literature on water level and herbivory effects on *S. latifolia* and a study of the interactions between the two may inform the restoration needs in the Salmon River Delta. Table 5.1 summarizes these factors.

Table 5.1 Potential factors limiting *Sagittaria* growth.

Condition	Effect
Increase in water depth	• In two studies along the Mississippi River, *Sagittaria* spp. was not found growing in standing water deeper than 30 cm (5) and 50 -60 cm (6). • Plants in Lake Ontario were able to tolerate water levels up to 40 cm only when both herbivory and turbidity were reduced (12). • Increasing water depth has resulted in higher mean and maximum leaf height, though total above-ground biomass was not affected (13). • Achene production increased with deeper water depths (up to 50 cm) in an Illinois River Valley study (1).
Decrease in water depth	• The average water depth of *S. latifolia* along the Upper Mississippi River was 26.4 cm; shallower water depth contained less productive stands of *S. latifolia* (6). • Lower water levels may encourage invasion of exotic species that crowd out alismatids (7).
Seasonally dry conditions	• Low mean water levels have reduced achene production along the Upper Mississippi River (6). • Seasonal Dry conditions caused *Sagittaria* spp. flower production to be reduced or cease altogether (7).
Stable water levels	• Stable water levels during the year have been shown to slightly increase achene production in *S. latifolia* (1).
Increase in above-ground biomass	• There is a positive correlation between an increase in above-ground biomass and an increase in below-ground biomass (6).
Wave action	• Wave action has been noted to limit *Sagittaria* spp. (5). However, in another study, the above-ground standing crop of *S. latifolia* and *S. rigida* were greater in open-water sites despite increased wave action, currents and wind (6).
Siltation	• A dramatic increase in siltation may decrease water depth and affect oxygenation of aquatic plant roots such as *Sagittaria* spp. (6).
Turbid water	• Turbid water has been shown to lower both seed production and plant productivity of *Sagittaria* spp., particularly in the early growing season (6)(1).
Cattle grazing	• Few studies have explored the direct effects of cattle grazing on *Sagittaria* spp., however, cattle increase soil compaction (8) and encourage invasion of

	invasive species such as *Phalaris arundinacea* (reed canary grass) that may crowd out aquatic macrophytes (4). Cattle have also been observed eating *Sagittaria* spp. in Oregon (14).
Waterfowl grazing	• Waterfowl eat both the seeds and tubers of *S. latifolia* (14)(3)(10).
Small mammal grazing	• Nutria (and presumably other small rodents) feed on new shoots (11) of *S. latifolia*. • Muskrats (2)(9) and porcupine (3) eat *Sagittaria* spp. tubers. They have removed about 75% of standing above-ground standing crop of *Sagittaria* spp. in the Mississippi River (9) • Porcupines also eat leafy portions of *Sagittaria* spp. (3).
Carp activity	• Carp increase turbidity of water (12)(15)(16) which negatively affect the growth of aquatic macrophytes such as *S. latifolia* (12)(15)(16). • Carp also scour the lake bottoms and can dislodge young seedlings (16).

(1) Low and Bellrose 1944; (2) Lynch et al. 1947; (3) Martin et al. 1951; (4) Chabreck 1968; (5) Eckblad et al. 1977; (6) Clark and Clay 1985; (7) Kaul 1985; (8) Brown 1986; (9) van der Valk 1989; (10) Gruenhagen and Fredrickson 1990; (11) Evers et al. 1998; (12) Chow-Fraser 1999; (13) Howard and Mendelssohn 1995; (14) Melissa Darby pers. comm. to Ann Garibaldi 2001, 2003; (15) Smith et al. 2001; (16) Tyler Smith pers. comm. to Ann Garibaldi 2002

5.1.3.1 Water Level Requirements and Limitations

The limited information available on optimal growth requirements and plant management for *Sagittaria latifolia* primarily comes from North America from the Great Lakes region south to Florida. The Louisiana Delta is a tidally-influenced wetland ecosystem that contains large populations of *S. latifolia* and its congeners. Studies have documented interactions between species of *Sagittaria* and: hydrologic influences (see Johnson et al. 1985; Howard and Mendelssohn 1995); waterfowl (see Chabreck et al. 1983); and invasive herbivores such as nutria (*Myocastor coypus* Molina) (see Chabreck et al. 1983). Other studies have focused on the Great Lakes region and the effects of different restoration treatments on aquatic macrophytes, including *S. latifolia* (see Chow-Fraser et al. 1998; Chow-Fraser 1999). Still others have examined the influences of edaphic factors and hydrology (in mid-west United States freshwater systems) on multiple wetland plants (see Clark and Clay 1985; Keddy and Constabel 1986; Fortner and White 1988). As with any study, caution should be exercised when applying information ex situ. However, these sources may illuminate factors that impose ecological constraints on *S. latifolia* that relate to my study.

Reports differ slightly on optimal water levels for *Sagittaria latifolia*. This is probably because it can tolerate (and has therefore been found in) a broad range of water depths. In fact, in British Columbia as in other places, it grows in both tidally influenced water along coasts and seasonally fluctuating freshwater in land areas (Brayshaw 2000). In the Upper Mississippi River, Clark and Clay (1985) found that *S. latifolia* grew at an average water depth of 26.4 cm and was not found in water deeper than 60 cm.

Plant distribution patterns in aquatic settings are, in part, a result of water level differentials. Distribution of several species of *Sagittaria* in the Upper Mississippi River was related to a water depth gradient (Clark and Clay 1985). Eckblad et al. (1977) also noted that *Sagittaria* spp. was limited by wave action and water depth in this region of the Mississippi River.

Clark and Clay (1985) found a direct correlation between peak above-ground biomass and water depth. They measured *Sagittaria latifolia* growing in an average of 26.4 cm of water. Plants growing in shallower water developed lower above-ground biomass. There was an additional positive correlation between above-ground biomass and below-ground biomass, with a smaller tuber crop being reported from shallower areas. This might indicate that *S. latifolia* planted at optimal water depths with a high above ground biomass might also have high below-ground biomass, resulting in enhanced tuber production.

Morphological expression in *Sagittaria* resulting from fluctuations in water depth has also been studied. In coastal Louisiana, Howard and Mendelssohn (1995) recorded higher mean and maximum leaf heights of *Sagittaria lancifolia* with a 15 cm increase in water depth. Despite this increase in leaf area, total above-ground biomass was not affected. Wooten (1986) also recorded an increase in petiole length, as well as a decrease in leaf width and length, in six species of *Sagittaria* (not including *S. latifolia*) following higher water levels. An increase in plant height resulting from an increase in water depth has been observed for other macrophytes as well (Grace 1989; Squires and van der Valk

1992), and may occur in *S. latifolia* (see Brayshaw 2000). How an increase in water depth might affect below-ground biomass of *S. latifolia* is not clear. However, it is possible that plants grown in a water depth that produces optimum above-ground biomass may also have optimum below-ground biomass. Further study is needed to quantify this.

Decreasing water levels also impact plant growth. Increased sedimentation rates have been noted in the Salmon River along with a dramatic loss in streamside vegetation (McPhee et al. 1996). High rates of siltation may decrease water depth and this in turn affects *Sagittaria latifolia* growth. Along both the Mississippi River and the Illinois River, siltation resulting from erosion had a negative effect on biomass and decreased reproductive capabilities (both tubers and flowers) by decreasing water levels and possibly affecting the oxygenation of *Sagittaria* spp. roots (Low and Bellrose 1944; Clark and Clay 1985). Both low mean water levels (Clark and Clay 1985) and seasonally dry conditions (Kaul 1985) have been found to reduce achene production or cause flower production to cease altogether. Conversely stable water levels and increasing water depths up to 50 cm may encourage achene production (Low and Bellrose 1944). In the past century, there have been severe changes in water use affecting the peak flow of the Salmon River and the availability of water during droughts. This corresponds to the time period over which *Sagittaria* spp. has ceased to grow in the delta.

Water Level and Invasive Species

Plant responses to cumulative environmental factors may be different than to individual factors. Often is the combined effect of different factors that are observed in plant growth. In Lake Ontario, Chow-Fraser (1999) recorded adverse effects of high water levels on *Sagittaria latifolia*, yet found plants were able to tolerate higher water levels (40 cm) when placed in an exclosure with a silt-screen, effectively reducing both herbivory and turbidity levels. This indicates that high water levels alone may not be responsible for decreased growth.

Though *Sagittaria latifolia* allocates more of its resources to reproduction than it does to competition through the production of tubers, its growth pattern provides an advantage over common invasive plants such as *Phalaris arundinacea* and *Typha* spp.: it is tolerant of deeper water levels. It has been suggested that aggressive planting of such species as *S. latifolia* may help control invasive *Typha* spp. and *Lythrum salicaria* L. (purple loosestrife). Conversely, a study in Nebraska demonstrated that a decrease in water level encouraged the invasion of exotic species that crowd out the alismatids (Kaul 1985). In the Great Lakes region, Tyler Smith (botanist with the Royal Botanical Gardens in Ontario) observed that large patches of *Typha* spp. out compete *S. latifolia* and reduce the latter to small areas within the wetland (Tyler Smith pers. comm. to Ann Garibaldi 2002).

5.1.3.2 Herbivory Effects on *Sagittaria latifolia*

Herbivory can have various consequences for plant fitness (see McNaughton 1983; Paige and Whitham 1987; Visser 1989). The possibilities are summarized as follows (adapted from McNaughton 1983):

1) Herbivores are detrimental to plants;
2) Plants are able to handle low levels of herbivory resulting in no net loss of fitness; and
3) Plants can overcompensate for moderate levels of herbivory and this can cause a net increase in plant fitness

Not always viewed to be harmful, plant-herbivore interactions may help a plant reproduce, reallocate, or in some cases even increase growth (Paige and Whitham 1987) though this is an ongoing controversy (see Forum on Grazing Theory and Rangeland Management, *Ecological Applications* 3(1) 1993). Yet, while grazing has been suggested to encourage plant production in some cases, most studies have shown that high grazing pressure reduces overall plant population biomass (Visser 1989). With differing and sometimes even conflicting views on grazing effects, interactions must really be examined site by site and species by species.

Though cattle grazing may mimic herbivory of large native game animals such as bison, wetlands often face increasingly intense grazing pressure (Hoff 1993) due in part to the fencing or forced localization of cattle (Brown 1986). Combined with other factors such as breaking of above-ground portions of plants and compacting the soil, these herbivores

may help push a plant population beyond a threshold at which it can persist. In the Salmon River Delta, the increased presence of cattle, the introduction of carp and the continued feeding of native herbivores on stressed populations of *Sagittaria* spp. may have contributed to its extirpation.

In addition to cattle, predators of *Sagittaria latifolia* include waterfowl (Evers et al. 1998), muskrat (*Ondatra zibethicus* L.) (Clark and Kroeker 1993), nutria (Evers et al. 1998) and carp (Smith et al. 2001); the effects of these will be discussed in detail in the following sections.

<u>Cattle</u>

The effect of cattle on a wide range of terrestrial prairie plants and some wetland species is well documented (see Hilliard 1971; Brown 1986; Schultz 1987; Hoff 1993). Cattle affect vegetation in two primary ways: trampling and consumption (Hilliard 1971; Hoff 1993). Intensity of impacts also varies with compounding factors such as seasonal timing, duration and intensity of browsing (McNaughton 1983). Secondary effects are many, and may include soil compaction (Brown 1986), changes to water quality, and encouragement of invasive species (Chabreck 1968) such as *Phalaris arundinacea* (reed canary grass). Plant damage often results from injury to meristematic tissue (Schultz 1987). *Sagittaria latifolia* has a basal meristem (as do grasses) that offers some protection from grazing damage by allowing vulnerable regenerative tissue to remain slightly more protected in the soil. However, the soft substrate of aquatic systems provides little fortification against trampling.

Generally, selective grazing has negative effects on particular species (Ellison 1960; Chabreck 1968), presenting a problem if species sought for restoration are the same ones preferred by cattle. Cattle have been observed selectively grazing in patches of *Sagittaria latifolia* in Oregon (Melissa Darby pers. comm. to Ann Garibaldi 2003). However, in my field site there were neither enough replicates nor enough grazing pressure to conclusively determine the effects of cattle grazing on *S. latifolia* in the Salmon River Delta.

Waterfowl and Small Mammals

Waterfowl eat both seeds and tubers of *Sagittaria latifolia* (Martin et al. 1951; Gruenhagen and Fredrickson 1990), and nutria (and presumably other small rodents) feed primarily on new shoots (Evers et al. 1998). As well, *Sagittaria* spp. tubers are a preferred food of muskrats, whose effects on wetland vegetation are well documented (Lynch et al. 1947; van der Valk 1989). Porcupines also eat the tubers as well as leafy portions of *Sagittaria* spp. (Martin et al. 1951). Muskrats, porcupines and river otters all occur in the Salmon River Watershed (McPhee et al. 1996). I saw river otters in the Delta during site visits.

Muskrat foraging affects the dynamics of marsh structure and development (Clark and Kroeker 1993). Muskrats contribute to tuber dispersion and stand diversity in marshes and consequently to avian diversity as well. Though muskrat are not always harmful, their density has reached such high levels in some marshes that they "eat-out" the marsh vegetation, denuding the area of virtually any above ground vegetation (Lynch et al.

1947). In a Lake Ontario wetland, welded wire fencing had to be erected, after plastic fencing was chewed through, to keep marsh vegetation from being grazed. Muskrats' along the Mississippi River have "removed about 75% of the aboveground standing crop of [*Sagittaria* spp.] in areas 4-5 m in diameter around lodges" (WR Clark pers. comm. in Van der Valk 1989:277), though this represented a small portion of the total standing crop in the marsh.

Again, herbivory effects can be cumulative. Evers et al. (1998) found that waterfowl and nutria both reduce biomass equally; however the effects of the two herbivores appear to be additive, with sites grazed by both groups having a significantly higher rate of clearing and changing of plant species composition. Nutria is not documented in the Salmon River Watershed. However, both waterfowl and other small rodents occur there. Although waterfowl grazing is common in natural stands of *Sagittaria latifolia*. (i.e. "duck potato"), ducks and other waterfowl may pose a challenge in reestablishment of a population. Following a failure of planting bare tubers, Melissa Darby (pers. comm. to Ann Garibaldi 2001) found that ducks removed almost all of the tubers that were tied in cotton bags and weighed down with a rock.

Common Carp (*Cyprinus carpio*)

One of the largest challenges to macrophyte reintroduction in wetlands is the common carp. Carp were intentionally introduced to North America from Europe and Asia (the first carp were introduced to Ontario in 1880) in the 1800's, to add to mill ponds " because of their prolific nature, as well as their domestic and economic value" (MacKay

in Environment Canada 2000). However, social perception of the species quickly changed as the fish escaped to nearby waters and increased in numbers (Environment Canada 2000). In less than 50 years the view of carp shifted from desired species to nuisance; unfortunately, by this time vast numbers of carp were already established – and they were spreading. Though the exact date of their introduction to Shuswap Lake is not known, carp are present there and have been for many decades, since Ed Blackburn did not remember a time when they were not present. The ecological repercussions of this introduction are increasingly apparent through a reduction in aquatic macrophytes and an increase in turbidity.

As observed during wetland restoration in the Great Lakes area of Ontario, *Typha latifolia* is more resistant than other wetland macrophytes to the activities of carp. Plants that spread clonally from under the soil are the only ones able to establish themselves if carp are present as they scour the lake and river bottoms, generally precluding seedling establishment. Although *Sagittaria latifolia* spreads by tubers, over time it cannot out-compete *T. latifolia* and only survives in small patches (Tyler Smith pers. comm. to Ann Garibaldi 2002). Furthermore Smith et al. (2001) attributed an increase in emergent vegetation to three factors: water levels, carp exclusion and planting programs. Further, they noted that carp could hinder plant growth even if water levels are optimal.

When Clark and Clay (1985) observed a negative correlation between increasing water depth and productivity of *S. latifolia*, they suggested that the effect might be due to light penetration during shoot emergence rather than to water depth and biomass during the

growing season. Carp (and other factors such as motor boats) certainly affect turbidity. Turbidity negatively affects young shoots but has a smaller effect on plants once they have emerged above water (Low and Bellrose 1944).

Carp also affect *Sagittaria* growth by lowering recruitment from the seedbank and damaging young shoots (Tyler Smith pers. comm. 2002). These effects allow exotic species that thrive in disturbed areas to establish themselves, displacing native ones. The dominant native fish species that might feed on carp cannot get established because they often require submerged vegetation to spawn. This vegetation is churned up by the carp (Chow-Fraser 1999), triggering a series of reactions that are difficult to arrest.

5.2 Selected Distribution of *Sagittaria latifolia* and *S. cuneata* in Interior British Columbia

5.2.1 Introduction

In the summer of 2001, I reviewed herbarium specimens and records of *Sagittaria latifolia* and *S. cuneata* from the Royal British Columbia Museum and the University of British Columbia Herbarium to research site characteristics and establish exact locations of *Sagittaria* in a small region of interior B.C. (Figure 5.5). This region was selected based on its proximity and presumed similarity to my field site at Salmon Arm. I then visited over 36 sites, both those with previously documented populations of *Sagittaria* and new ones with similar characteristics to known patches. Measured site characteristics included: water depth, percent cover of *Sagittaria* in relation to associated species, presence/absence of flowers (and sex), signs of herbivory and soil characteristics

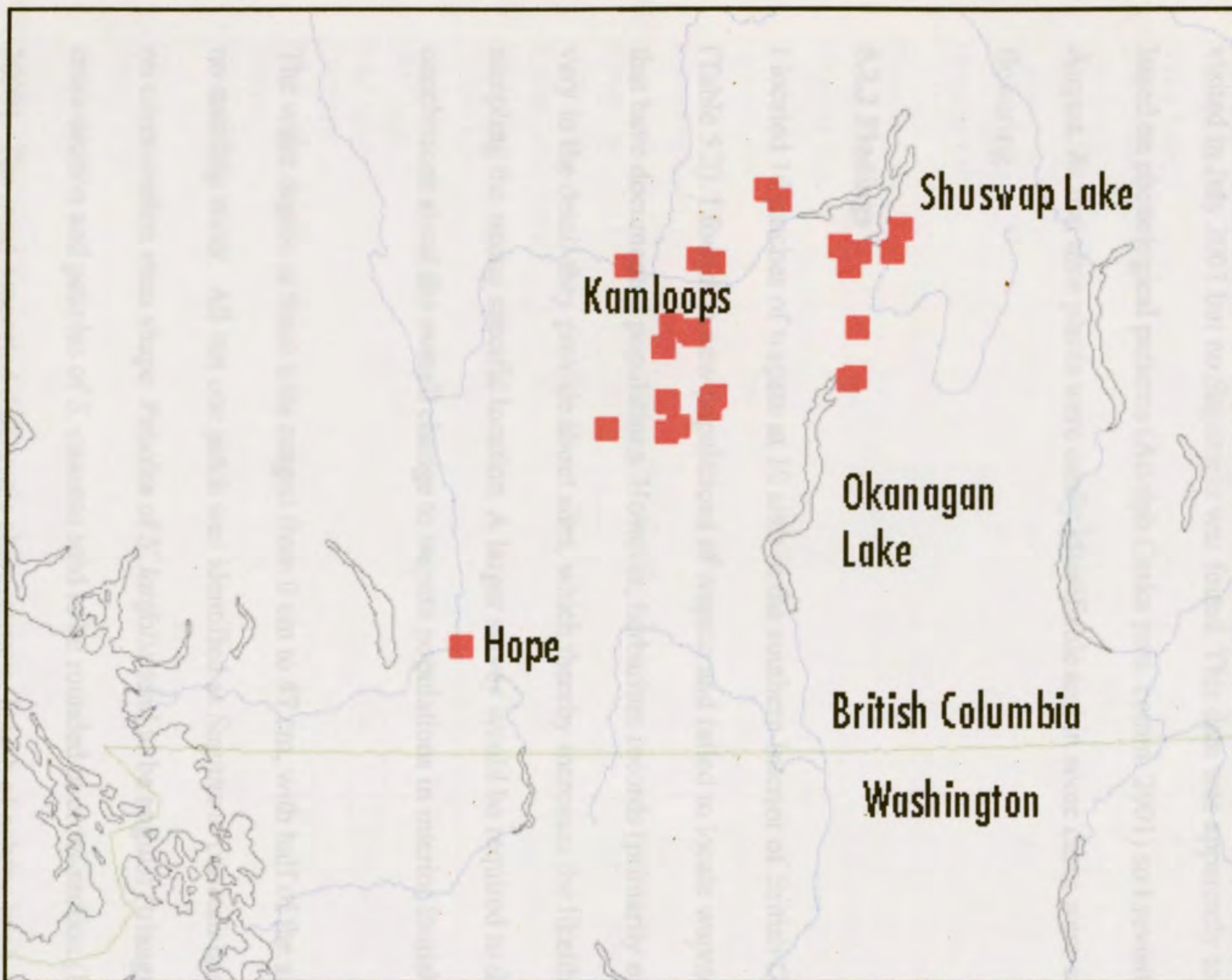

Figure 5.5 Map of sites visited in 2001 *Sagittaria* spp. survey in interior British Columbia.

(Appendix 2). New sites were visited to obtain a more thorough baseline for distribution of *Sagittaria* in the region around Salmon Arm as well as to ascertain any similarities and differences among sites that contain wapato and those that do not. Sites were initially visited in July 2001 but no *Sagittaria* was found. This date was apparently too early based on phenological patterns (Adolph Ceska pers. comm. 2001) so I revisited sites in August. At that time plants were easily identifiable and in some cases were even flowering.

5.2.2 Findings

I located 16 patches of wapato at 10 sites in the southern Interior of British Columbia (Table 5.2). I found no new populations of wapato and failed to locate wapato at five sites that have documented populations. However, herbarium records (primarily older records) vary in the detail they provide about sites, which thereby increases the likelihood of sampling the wrong specific location. A larger survey would be required to draw conclusions about the overall change to wapato populations in interior British Columbia.

The water depths at these sites ranged from 0 cm to 47 cm, with half of the sites having no standing water. All but one patch was identified as *Sagittaria cuneata* based primarily on cross-section stem shape. Petioles of *S. latifolia* tend to be angular (triangular) in cross-section and petioles of *S. cuneata* tend to be rounded in cross-section (Brayshaw 2000). The most supported diagnostic characteristic, length of achene beak, was used to distinguish the two species whenever fruits were present.

Table 5.2 Sites visited in 2001 *Sagittaria* spp. survey in interior British Columbia.

Site Name	Presence of wapato	Number of plants	Water depth (standing water) at site (cm) *	Inflorescence	Existing herbarium record
Adams Lake 1	Yes	< 10	70	Not flowering	Yes
Adams Lake 2	No	N/A	N/A	N/A	Yes
Black Lake1	No	N/A	N/A	N/A	No
Black Lake 2	No	N/A	N/A	N/A	No
Bog Lake	No	N/A	N/A	N/A	No
Canoe 1	Yes	10-50	0	Monoecious	Yes
Canoe 2	Yes	10-50	0	Monoecious	Yes
Chapperon Lake	No	N/A	N/A	N/A	Yes
Douglas Lake 1	Yes	10-50	10	Dioecious (male)	Yes
Douglas Lake 2	Yes	< 10	36	Not flowering	Yes
Glimpse Lake 1	Yes	> 50	31	Monoecious	Yes
Glimpse Lake 2	Yes	> 50	33.5	Monoecious	Yes
Glimpse Lake 3	Yes	> 50	40	Not flowering	Yes
Goose Lake	No	N/A	N/A	N/A	Yes
John Frank Lake	No	N/A	N/A	N/A	No
Kawkawa Lake 1	Yes	10-50	25	Dioecious (male)	Yes
Kawkawa Lake 2	Yes	10-50	47	Not flowering	Yes
Mara Lake	Yes	10-50	0	Not flowering	Yes
Napier Lake Ranch	No	N/A	N/A	N/A	No
Nicola Lake 1	No	N/A	N/A	N/A	Yes
Nicola Lake 2	No	N/A	N/A	N/A	Yes
No Name Lake	No	N/A	N/A	N/A	No
Paul Lake 1	Yes	< 10	0	Not flowering	Yes
Paul Lake 2	Yes	< 10	36.5	Monoecious	Yes
Pennaska Lake	No	N/A	N/A	N/A	Yes
Rush Lake	No	N/A	N/A	N/A	No
Salmon Lake	No	N/A	N/A	N/A	No
Salmon Arm Wharf	Yes	< 10	.75	Dioecious (female)	Yes
Shumway Lake	No	N/A	N/A	N/A	Yes
Swan Lake 1	No	N/A	N/A	N/A	No
Swan Lake 2	No	N/A	N/A	N/A	No
Swan Lake 3	No	N/A	N/A	N/A	No
Tappen (Sunnybrae)	Yes	10-50	0-19	Not flowering	Yes
Tranquille/Kamloops Lake	Yes	> 50	0	Monoecious	Yes
Tulip Lake	No	N/A	N/A		No

* Water depth only measured when *Sagittaria* was present.

Voucher specimens from five sites were collected: Sucker Creek, Tappen (Sunnybrae), Glimpse Lake, Tranquille and Canoe. All of these are housed at the University of Victoria Herbarium.

5.2.3 Discussion

Few generalizations about sites can be drawn from this survey. It was primarily descriptive in nature, marking presence/absence and qualitative descriptors of *Sagittaria* spp. populations. Though I failed to locate wapato at four sites where it had been previously documented, it is unclear if I sampled in the exact location where the voucher specimen was collected. It was not uncommon to have limited data for locating populations. Though it is difficult to make conclusive remarks about the health of *Sagittaria* populations at these sites, the majority of sites had small numbers of plants. None of the populations were large enough to support harvesting tubers in the quantities that Mary Thomas has described. The type of harvesting that Mary described easily supported three or four families (at least 20 people) for several weeks. I was hesitant to take more than one or two plants for voucher specimens from most sites.

Based on notes from herbarium records, I did not notice any major changes to the size or health of the populations I visited. Many herbarium records did not indicate the number of plants so trends are difficult to interpret. However, there has been a significant decrease in population size and health in the lower Fraser River Valley (Spurgeon 2001) and I failed to locate any patches in the region around Salmon Arm that would

sustainably support tuber harvesting. These factors suggest a change in species composition of certain wetlands over the past century.

5.3 Replanting Study of *S. latifolia* in Salmon Arm, British Columbia

The literature indicates that *S. latifolia* growth varies with water depth and herbivory. To better understand how these factors would impact growth of *S. latifolia* in the Salmon River Delta, I designed a series of treatments to restrict local herbivores at a series of water depths.

5.3.1 Study Site

The field site is located at the delta where the Salmon River flows into Shuswap Lake, approximately 6 km southwest of Salmon Arm, British Columbia in the Interior Douglas-fir Biogeoclimatic Zone. This land, on the Salmon Arm Indian Reserve No. 3, is owned by Mary Thomas. A pond located on the Salmon River delta provided an opportunity for replanting *S. latifolia* in an area where wapato formerly grew, according to Mary's recollections (Chapter 4). The pond site is approximately 100 m long and 75 m wide. Three primary factors influenced the selection of this site: 1) *Sagittaria* spp. was abundant at this site within the past 80 years; 2) An existing cattle exclosure, erected by Ducks Unlimited, runs through the pond enabling easy establishment of a control group (cattle have access to approximately one third of the pond while the remaining two thirds are closed to cattle). The fence was erected 10 to 15 years ago (Ed Blackburn pers. comm. 2002). The exact year of construction could not be obtained through Ducks Unlimited; and 3) This site has traditional significance to the Neskonlith Indian Band on

the Salmon Arm Indian Reserve No. 3, and to Mary Thomas in particular. It was an important gathering site for aquatic plant foods and waterfowl for many Secwepemc families.

The current rancher, Mr. Blackburn, has been leasing the land for cattle grazing since 1972. Before this, other people had cattle and horses grazing in the area. Approximately 15 head of cattle graze in the delta from May through late September and early October however, if necessary they are removed for a few weeks in June during high water. They are supplementally fed hay and minerals. Horses have also used the area in the past and continue to do so in small numbers.

5.3.2 Methods

Nine transects were placed in the pond, with three transects per treatment (Figure 5.6). The three treatments are: 1) the control (no herbivores excluded); 2) complete exclosure (all herbivores that could not pass through wire mesh 2.5 cm by 2.5 cm were excluded); and 3) cattle excluded. Based on the literature review the following depths were selected for tuber planting: 0 cm, 10 cm, and 20 cm and 40 cm. These depths were measured at the time of planting (September 2001). Water levels in the pond were generally higher than 20 cm at time of planting except in one localized area, inside the cattle exclosure, where the water levels reached 40+ cm. In addition to the transects, 6 plots were established in this area to measure the effects of 40 cm water depth or deeper (Table 5.3).

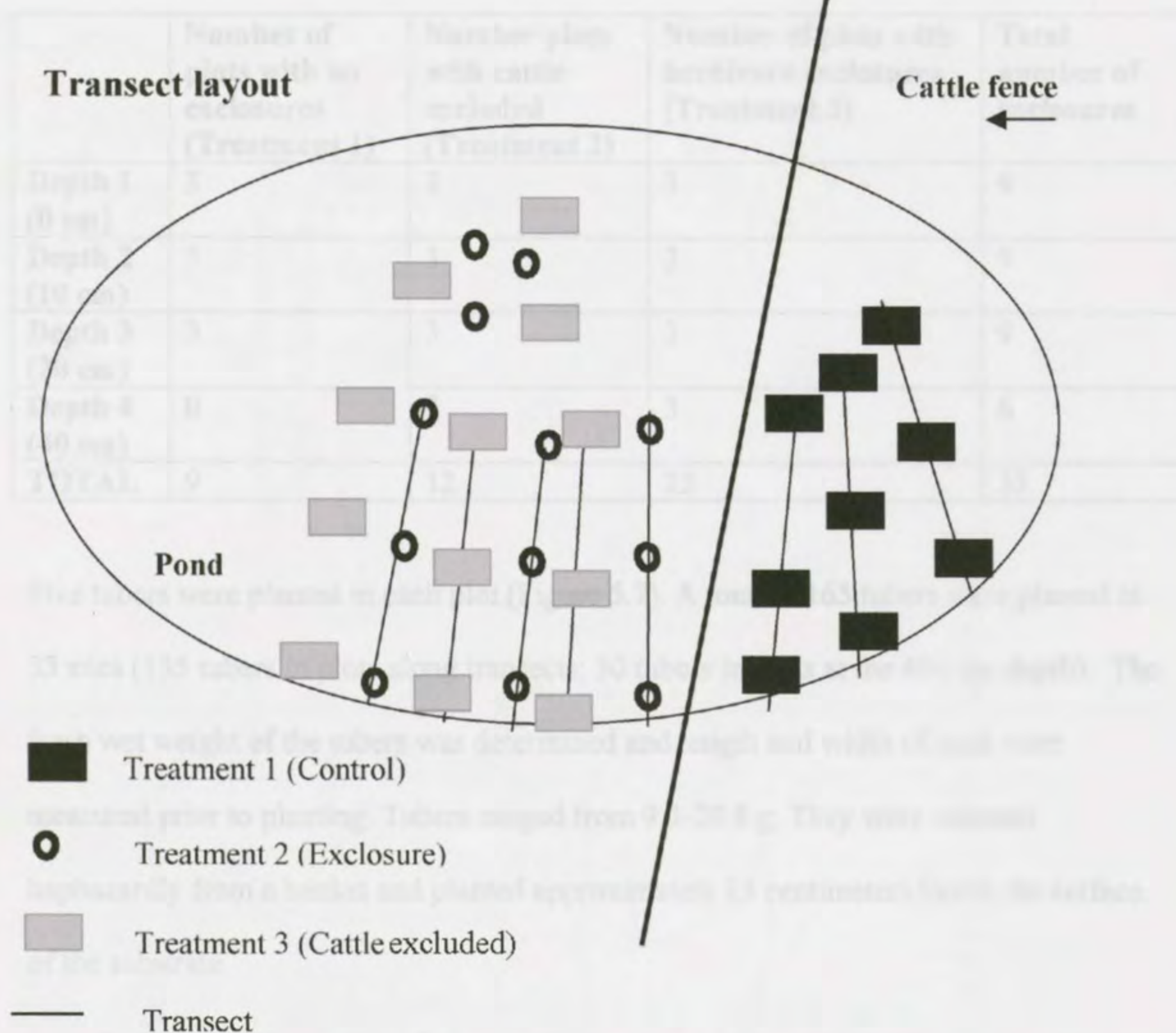

Figure 5.6 Experimental layout at 2001 field site for study of *Sagittaria latifolia* response to herbivory and water depth in the Salmon River Delta, British Columbia, illustrating location of transects and treatment plots.

Table 5.3 Number of sample plots for 2001 water depth and herbivory study of *Sagittaria latifolia* in the Salmon River Delta, British Columbia.

	Number of plots with no exclosures (Treatment 1)	**Number plots with cattle excluded (Treatment 2)**	**Number of plots with herbivore exclosures (Treatment 3)**	**Total number of exclosures**
Depth 1 (0 cm)	3	3	3	9
Depth 2 (10 cm)	3	3	3	9
Depth 3 (20 cm)	3	3	3	9
Depth 4 (40 cm)	0	3	3	6
TOTAL	9	12	12	33

Five tubers were planted in each plot (Figure 5.7). A total of 165 tubers were planted at 33 sites (135 tubers in plots along transects; 30 tubers in plots at the 40+ cm depth). The fresh wet weight of the tubers was determined and length and width of each were measured prior to planting. Tubers ranged from 9.3-20.8 g. They were selected haphazardly from a bucket and planted approximately 15 centimeters below the surface of the substrate.

In September of 2002, one year after planting, the following characteristics for each plant in each plot were measured: plant height, number of leaves, length and width of leaves, number of flowers produced, sex of flowers, number of flowers producing seed, any signs of foraging, and plant mortality. The data form is shown in Appendix 1.

Site Layout

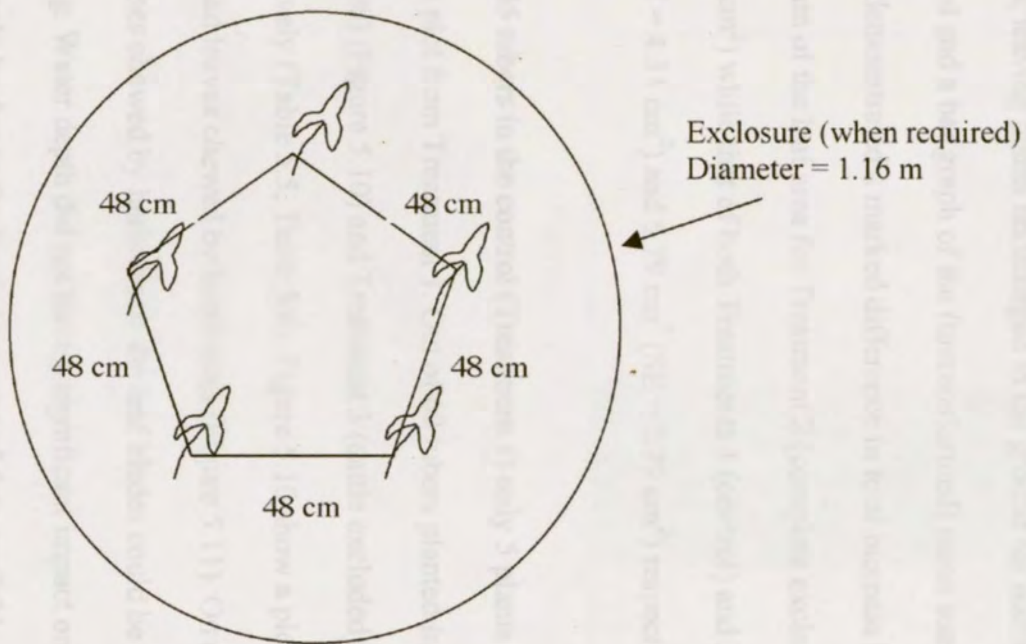

Figure 5.7. Arrangement of planted tubers in each plot in *Sagittaria latifolia* herbivory and water depth study.

5.3.3 Data Analysis and Results

Biomass was estimated by calculating leaf area (cm^2) and analyzed by plot (i.e. summing biomass of all five plants in each plot). Leaf area was used to represent biomass rather than above-ground dry weight because it is a non-destructive method to compare biomass, leaving plants undamaged in the ground for restoration purposes. Data were compiled and a bar graph of the (untransformed) mean sum of the leaf area by plot clearly demonstrated a marked difference in total biomass by treatment (Figure 5.8). The mean sum of the leaf area for Treatment 2 (complete exclosure) was 634.82 cm^2 (SE = 145.59 cm^2) while that of both Treatments 1 (control) and 3 (cattle excluded) was 6.71 cm^2 (SE = 4.31 cm^2) and 5.79 cm^2 (SE = 2.79 cm^2) respectively (Table 5.4).

Out of 45 tubers in the control (Treatment 1) only 5 plants grew (Figure 5.9). Figure 5.9 shows a plot from Treatment 1. Out of 60 tubers planted in Treatment 2 (complete exclosure) (Figure 5.10) and Treatment 3 (cattle excluded), 49 plants and 6 plants grew respectively (Table 5.5, Table 5.6). Figure 5.10 show a plot from Treatment 2. Some plants had leaves chewed by herbivores (Figure 5.11). On other the entire petiole was sometimes chewed by herbivores; the leaf blades could be seen floating in the water and decaying. Water depth did not have a significant impact on these two treatments; this may simply be due to the limited amount of data available (i.e. few plants grew).

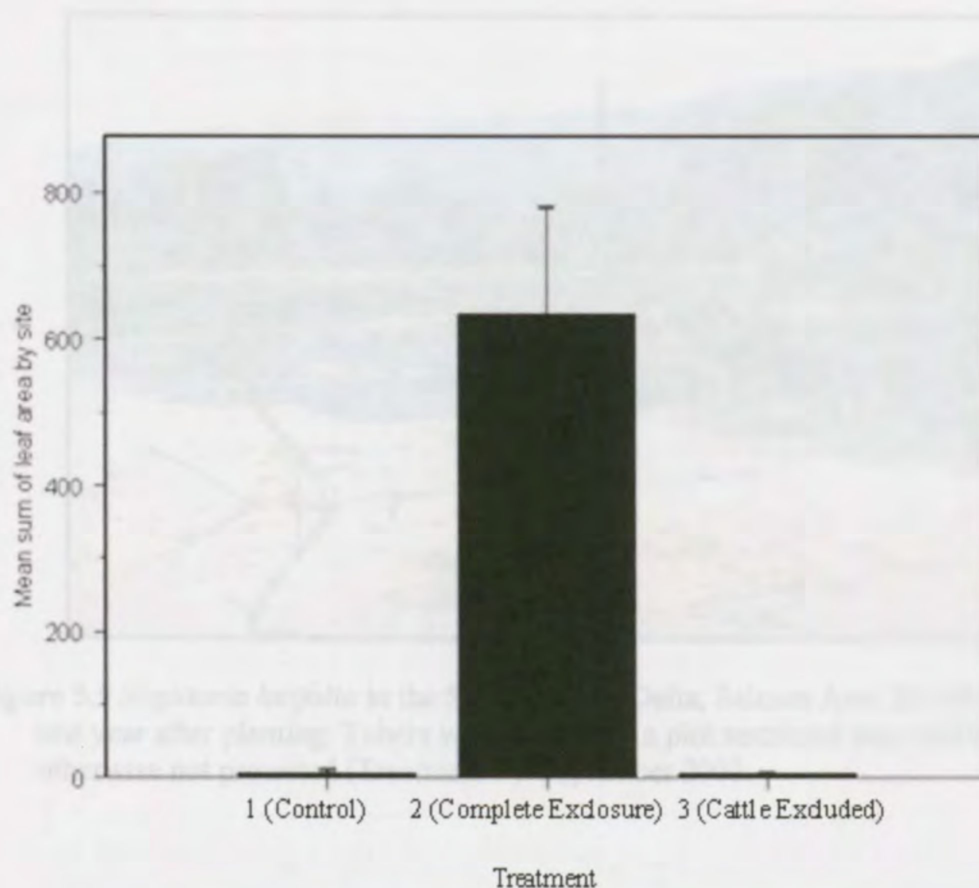

Figure 5.8. Bar graph of 2001 estimated mean sums of above ground biomass (untransformed) of *Sagittaria latifolia* by herbivory treatment with standard error bars.

Table 5.4 Estimated above biomass (untransformed) of *Sagittaria latifolia* by herbivory treatment.

	Mean sum of leaf area (cm^2)	Standard Error (cm^2)	Standard deviation (cm^2)	Median (cm^2)
Treatment 1 (control)	6.71	4.31	12.92	0.00
Treatment 2 (complete exclosure)	634.82	145.59	504.35	617.59
Treatment 3 (cattle excluded)	5.79	2.79	9.67	0.00

Figure 5.9 *Sagittaria latifolia* in the Salmon River Delta, Salmon Arm, British Columbia one year after planting. Tubers were planted in a plot restricted from cattle, but otherwise not protected (Treatment 3). September 2002.

Figure 5.10 *Sagittaria latifolia* in the Salmon River Delta, Salmon Arm, British Columbia one year after planting. Tubers were planted in a plot protected from herbivores by a 3.25 cm X 3.25cm wire mesh (Treatment 2). September 2002.

Table 5.5 Raw data from 2001 herbivory and water depth analysis of *Sagittaria latifolia* in the Salmon River Delta, British Columbia.

Treatment 1 (Control)

Transect No.	Plot No. (1-3)	Planting water depths (cm)	Total calculated leaf area (cm^2)					Sign of plant foraging					Sum of leaf area for plot (cm^2)
			Plant 1	Plant 2	Plant 3	Plant 4	Plant 5	Plant 1	Plant 2	Plant 3	Plant 4	Plant 5	
1	1	0	.00	.00	.00	.00	.00	no	no	no	no	no	.00
1	2	10	.00	.00	.00	.00	.00	no	no	no	no	no	.00
1	3	20	.00	1.65	.00	.00	.00	yes	no	no	no	no	1.65
2	1	0	1.85	.00	.00	.00	.00	yes	no	no	no	no	1.85
2	2	10	.00	.00	.00	.00	.00	no	no	no	no	no	.00
2	3	20	36.17	.00	.00	.00	.00	yes	no	no	no	no	36.17
3	1	0	3.80	16.80	.00	.00	.00	yes	yes	no	no	no	20.60
3	2	10	.00	.00	.00	.00	.00	no	no	no	no	no	.00
3	3	20	.00	.00	.00	.00	.00	no	no	no	no	no	.00

Treatment 2 (Complete exclosure of vertebrate predators)

Transect No.	Plot No. (1-3)	Planting water depths (cm)	Total calculated leaf area (cm^2)					Sign of plant foraging					Sum of leaf area for plot (cm^2)
			Plant 1	Plant 2	Plant 3	Plant 4	Plant 5	Plant 1	Plant 2	Plant 3	Plant 4	Plant 5	
4	1	0	490.37	156.03	131.37	162.80	151.23	no	no	no	yes	no	1091.80
4	2	10	107.74	3.44	52.54	44.28	2.70	no	no	no	no	yes	210.70
4	3	20	195.81	76.77	96.04	225.75	64.39	no	no	no	yes	yes	658.76
4	4	40	.00	12.96	.00	30.66	.00	no	no	no	no	no	43.62
6	1	0	571.57	244.50	217.84	436.70	225.86	yes	yes	no	no	no	1696.47
6	2	10	203.33	74.11	241.75	172.58	529.98	yes	no	yes	yes	yes	1221.75
6	3	20	89.09	15.78	155.54	.00	50.16	yes	yes	yes	no	yes	310.57
6	4	40	.00	.00	21.26	10.05	59.85	no	no	yes	yes	yes	91.16
8	1	0	458.88	.00	193.49	.00	145.36	no	no	no	no	no	797.73
8	2	10	206.61	.00	107.96	.00	363.38	no	no	no	no	yes	677.95
8	3	20	35.87	303.94	208.85	15.75	12.00	yes	no	no	no	no	576.41
8	4	40	57.18	90.24	67.52	.00	26.00	no	yes	yes	no	yes	240.94

Treatment 3 (Cattle exclosure)

Transect No.	Plot No. (1-3)	Planting water depths (cm)	Total calculated leaf area (cm^2)					Sign of plant foraging					Sum of leaf area for plot (cm^2)
			Plant 1	Plant 2	Plant 3	Plant 4	Plant 5	Plant 1	Plant 2	Plant 3	Plant 4	Plant 5	
5	1	0	15.75	.00	.00	.00	.00	yes	no	no	no	no	15.75
5	2	10	3.01	.00	13.72	12.21	.00	no	no	yes	yes	no	28.94
5	3	20	.00	.00	.00	.00	.00	no	no	no	no	no	.00
5	4	40	.00	.00	8.03	.00	.00	no	no	no	no	no	8.03
7	1	0	.00	.00	.00	.00	.00	no	no	no	no	no	.00
7	2	10	.00	.00	.00	.00	.00	no	no	no	no	no	.00
7	3	20	.00	16.73	.00	.00	.00	no	yes	no	no	no	16.73
7	4	40	.00	.00	.00	.00	.00	no	no	no	no	no	.00
9	1	0	.00	.00	.00	.00	.00	no	no	no	no	no	.00
9	2	10	.00	.00	.00	.00	.00	no	no	no	no	no	.00
9	3	20	.00	.00	.00	.00	.00	no	no	no	no	no	.00
9	4	40	.00	.00	.00	.00	.00	no	no	no	no	no	.00

Figure 5.11 Herbivory of *Sagittaria latifolia* leaf in Salmon Arm Delta, British Columbia. Red lines show rough outline of leaf shape before herbivory.

Table 5.6 Summary of 2001 herbivory and water depth study of *Sagittaria latifolia* growth statistics by treatment.

	Number of tubers planted	Number of plants that grew	Number of plants that flowered	Mean sum of site leaf area (cm^2)
Treatment 1 (control)	45	5	0	6.71
Treatment 2 (complete exclosure)	60	49	10	634.82
Treatment 3 (cattle excluded)	60	6	0	5.79

All data analysis was done using SPSS version 10.0 for Macintosh. Residuals were tested for normality using the Shapiro-Wilk test and the results were found to be significant (P = 0.010), therefore the residuals were not normally distributed. Cube root transformation used to reduce departure from normality (P = 0.080), again using the Shapiro-Wilk test

An Analysis of Variance (ANOVA) was performed on the cube root of the biomass to explore the effects of herbivory and of water depth (Table 5.7). An examination of the tests of between-subject effects suggests that both water depth and herbivory treatment are significant factors (P = 0.016 and P = 0.00 respectively), although the interaction between the two is not significant (P = 0.06).

Table 5.7 ANOVA results of 2001 total leaf area (cm^2) of *Sagittaria latifolia* based on water depth and herbivory treatment (n = 33).

Variable	Sum of Squares	df	Mean Square	F	P
Water depth	27.766	3	9.255	4.270	.016
Herbivory treatment	395.643	2	197.822	91.271	.000
Water depth * herbivory treatment	27.516	5	5.503	2.539	.058

R Squared = .901 (Adjusted R Squared = .856)

In a post-hoc Tukey Test of the ANOVA (Table 5.8), Treatment 2 differed significantly (P = 0.00) from both Treatment 1 (control) and Treatment 3 (cattle excluded). Plants growing in exclosures produced significantly higher biomass than either of the other two treatments. All of the tubers growing in exclosures grew into full plants and 10 of these plants produced flowers.

Table 5.8 Post-hoc Tukey Test of leaf area (cube root transformed) of *Sagittaria latifolia* in 2001 for all treatments (n=33).

Treatments	Treatments	Mean Difference	Std. Error	P
1.00	2.00	-6.9738	.8169	.000
	3.00	9.500E-02	.8169	.993
2.00	1.00	6.9738	.8169	.000
	3.00	7.0688	.7563	.000
3.00	1.00	-9.4997E-02	.8169	.993
	2.00	-7.0688	.7563	.000

Post-hoc Tukey tests comparing biomass at different depths were not significant, although depth was significant in the model. This is because there is a large difference between Treatment 2 and the other treatments, and the effect of water depth is obscured. Thus, the effect of water depth on biomass for Treatment 2 (complete exclosure) by itself was explored using an ANOVA. Using the residuals of the leaf area from the ANOVA, the Shapiro-Wilk test for samples in Treatment 2 demonstrated no deviation from normality ($F = 0.552$), therefore no transformation was necessary. The ANOVA reported a significance level for water depth of $P = 0.036$. The only statistically significant difference between water depths occurred between the 0 cm and 40 cm depths ($P = 0.026$) (Table 5.9).

Table 5.9. Post-hoc Tukey Test results of 2001 of leaf area of *Sagittaria latifolia* for Treatment 2 (complete exclosure) by discontinuous water depths (n = 12).

Water depth	Water depths	Mean difference	Std. Error	P
0 cm	10 cm	491.8667	291.4722	.389
	20 cm	680.0867	291.4722	.169
	40 cm	1070.0933	291.4722	.026

The following graph (Figure 5.12) shows the range in means for the total biomass at the four different water depths for Treatment 2 (complete exclosure). It is clear that a significant difference exists between the means of biomass at depth 1 (0 cm) versus depth 4 (40 cm). Though it appears as if a negative correlation (though not necessarily a linear relationship) exists between water depth and biomass production, sample size is too small to determine this.

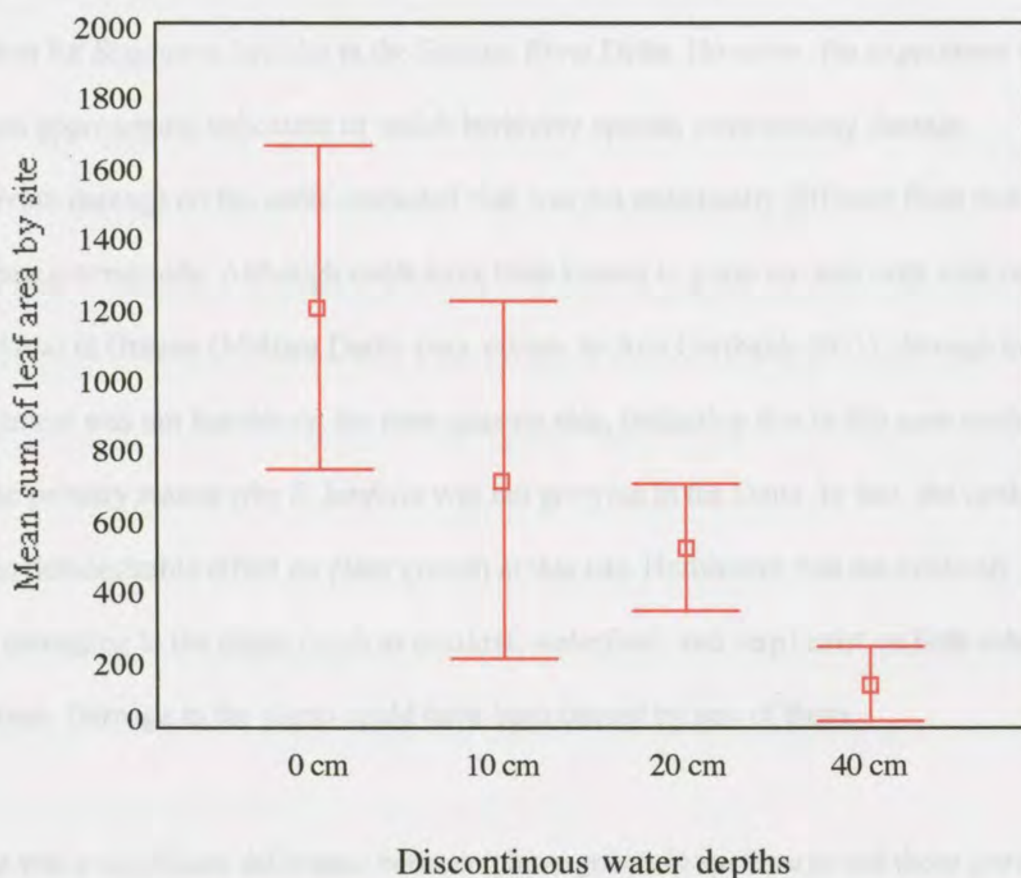

Figure 5.12 Total leaf area (cm^2) of *Sagittaria latifolia* by water depth at time of planting for Treatment 2 (complete exclosure) (n = 12). Error bars represent ± 1 standard deviation. Water levels may fluctuate over 4 m annually in Shuswap Lake (Environment Canada 2003a).

Overall, analysis of data rejects the null hypothesis that herbivory and water depth do not effect total leaf area. A significant difference was noted between planting depths of 0 cm and 40 cm in Treatment 2 (complete exclosure). Further, a significant difference was observed between tubers planted in a complete exclosure (Treatment 2) and those planted outside of it (both Treatment 1 and Treatment 3).

5.3.4 Discussion

The planting experiment showed that herbivory and water depth both affect plant total leaf area for *Sagittaria latifolia* in the Salmon River Delta. However, the experiment only gave an approximate indication of which herbivore species were causing damage. Herbivore damage on the cattle-excluded side was not statistically different from that on the open grazing side. Although cattle have been known to graze on, and even seek out, *S. latifolia* in Oregon (Melissa Darby pers. comm. to Ann Garibaldi 2001), damage in this experiment was not heavier on the open grazing side, indicating that in this case cattle are not the primary reason why *S. latifolia* was not growing in the Delta. In fact, the cattle had no demonstrable effect on plant growth at this site. Herbivores that are evidently most damaging to the plants (such as muskrat, waterfowl, and carp) exist on both sides of the fence. Damage to the plants could have been caused by any of these.

There was a significant difference between plants grown in exclosures and those grown out of exclosures. This strongly indicates that herbivory and associated mechanical damage from animal movement, limit or preclude *S. latifolia* plant growth in the Delta. This also reinforces the conclusion that turbidity (caused by such factors as carp grubbing) does not in itself hinder tubers of *S. latifolia* from growing in the pond.

It is unclear which of the remaining herbivores cause most damage or if it is a combination of all of them – or other animals - that most harm the plants. In September 2002, four river otters were observed climbing on top of exclosures and swimming in the pond during the four days of data collection. Unidentified ducks and geese have also been seen in the pond. The delta is situated in a known major flyway for migratory birds (McPhee et al. 1996). Muskrats have also been seen in the pond by Ed Blackburn (pers. comm. to Ann Garibaldi 2002) and carp have been observed as well.

Water depth was only one factor influencing plants growing in exclosures. Few plants grew well outside the exclosures, so this variable could not be tested with the other treatments. A difference was measured among all planting depths, but the difference was statistically significant only between plants planted at 0 cm and 40 cm – the largest difference in water depths. With only four planting depths it is impossible to determine the exact relationship between water depth and biomass production, although a trend is evident. A negative correlation between water depth and plant vigor of *S. latifolia* and its congeners has also been observed in other areas (Wooten 1986; Giroux and Bedard 1987; Howard and Medelssohn 1995; Smith et al. 2001), though the implication of a linear relationship may not be correct.

5.4 Suggestions for Future Work:

Herbivory and Water Depth Research

This study addressed growth for only one year. Longer-term studies would augment my thesis research and further facilitate the restoration of *Sagittaria latifolia* in the Salmon River Delta. Though the exclosures established during my fieldwork were left in the pond, they will remain there under the discretion of Mary Thomas and her family. Suggestions for future work include:

1. Further exploration of how specific herbivores impact *S. latifolia* growth. This study addressed plant-herbivore interactions on a broad scale. Furthermore, because of practical limitations, it was not possible to ascertain the growth stage in which plants experienced detrimental impacts. One possibility for further experimentation would be to set up exclosures that protect tubers and young shoots, but allow leaves and stems to grow through the exclosure. This would allow for better determination of the timing of herbivore impact (i.e. if herbivore damage occurs more heavily at the time of shoot emergence of *S. latifolia* or later on in its growth cycle).

2. Performance of a multi-year study. Through rhizomatous growth *Sagittaria latifolia* can establish itself outside of the exclosures. Observations of the growth success or failure once the plants have grown outside of the exclosure could help predict the utility of different treatments for restoration.

3. Examination of the relationship between increasing water depth, above-ground biomass and below-ground biomass. Research has shown that while an increase in water depth does correlate positively with an increase in petiole length this does not necessarily

translate into increased above ground biomass. Furthermore, how these factors in turn affect below ground biomass production needs further exploration.

4. Exploration of competitive interactions between *S. latifolia* and other aquatic species. Systematically removing different associate species and measuring the effects on such characteristics as above-ground and below-ground biomass, would elicit a better understanding of the autecology of *S. latifolia* in the Salmon River Delta and increase restoration success.

General Wapato Research

Research that would supplement an understanding of the overall ecology of *Sagittaria latifolia* includes:

1. Controlled laboratory experiments to quantify above-ground and below-ground biomass production following simulated herbivory treatments.
2. Further study of the effect of water depth and fluctuations in water depth on plant biomass production to determine the level at which plant growth is severely compromised or aborted.
3. Explore the relationship between and the factors affecting achene and tuber production.
4. Document seedling recruitment of *S. latifolia* under differing water levels and herbivory treatments.

5. Study the responses to herbivory and water depth of different varieties and ecotypes of *S. latifolia*.

6.0 Conclusions

Ethnobotany has been defined as "all studies (concerning plants) which describe local peoples' interaction with the natural environment (Martin 1995: xx)." The studies that fall under the umbrella of ethnobotany are as broad as the definition itself. As Richard Ford, an archeaobotanist from the University of Michigan, states: "ethnobotany lacks a unifying theory, but it does have a common discourse" (1994:29). This discourse encompasses the exploration of the relationships between people and plants and joins me to the many ethnobotanical researchers who have navigated through the sea of interdisciplinary research. While the exploration of the relationships between people and plants may be the commonality among ethnobotanical research endeavors, the forms this exploration takes are extremely diverse.

The form of ethnobotanical research my work addressed was the restoration of a culturally important wetland food species. This work demonstrated that despite massive disturbances to both the culture and species, restoration might still be possible. Cultural refugia in this work may provide the key to both cultural and ecological restoration.

I sought to understand *Sagittaria* restoration in the Salmon River Delta and the mechanisms that best facilitate that goal. Based on my research, it is clear that wapato is able to grow in the Salmon River Delta, provided certain herbivores are restricted. The reasons for the decline of *Sagittaria* and its eventual extirpation are complex. Studies of the functionality of this wetland and the biological repercussions of low functionality are vital for a successful comprehensive restoration of this delta. A suite of environmental

and social factors, particularly over the past decade, contributed to broad-scale changes in the Salmon River watershed. Restoration projects must be designed with both of these factors in mind.

The role that cultural studies, such as ethnobotanical or ethnographic research, may play in restoration is broad. Local people may inform the species composition of an area at a specified point in time. This may be particularly true for aboriginal people whose history and knowledge of a site predates that of European settlers. Local people may also change the course of a project or even become active stewards of the restored site. The mechanisms for their participation are varied and their involvement is crucial. By acting as joint designers, researchers and implementers, restorationists acknowledge the understanding local people have had to manage the area, sometime for millennia.

I believe the answer to understanding long-term restoration lies at the interface between social and ecological systems. Studying the links between ecological requirements and social forces provide the most accurate way to achieve success. This was true in my research. To set the foundation for system-wide restoration in the Salmon River Delta it was necessary to both engage community members, explore the historical context for wapato extirpation and begin to study key limiting growth factors.

One experience from my thesis research epitomizes the significance of this research in terms of restoration. After I had designed my sampling design and planted 135 wapato tubers in the Salmon River Delta in the fall of 2001, I visited Mary Thomas at her home

overlooking the Delta. She was delighted when I asked if she would like to have my extra wapato tubers. We discussed the importance of wetlands and their health to the Secwepemc and all people of Salmon Arm. It was again clear to me that this plant was part of a valuable and significant habitat for Mary.

It was two weeks before we talked again. I had returned to Victoria and phoned Mary. She told me that she had talked with other Secwepemc elders about wapato and none knew of its traditional use. She was looking forward to growing some in her greenhouse. Furthermore, one of her daughters had planted some of the tubers in the wetland behind her house (where my field site is located). It was another two weeks before I was able to establish the exact location where her daughter had planted out the wapato.

In that two-week period I began to accept that these tubers might have been planted in my field site, which could have rendered my experimental data unusable. Since my design was measuring the number of tubers that grew and their associate aboveground biomass, unidentified additional tubers planted in the same area might have influenced data collection. It was also during that time that I appreciated the true significance of what she had done. Restoration, true ecological–cultural restoration, is not solely a result of my research on herbivory or my ethnographic research; it is both facilitated and enabled with local stewardship of the area. This stewardship is evidenced in the renewed interest in and participation in the process of growing this plant in its former habitat. This traditional territory remains Secwepemc land. Mary's daughter reminded me of that.

Literature Cited

Abbott RJ, Smith LC, Milne RI. 2000. Molecular analysis of plant migration and refugia in the arctic. Science 289(5483): 1343–1346.

Anderson MK. 1993a. Californian Indian horticulture: management and use of redbud by the Southern Sierra Miwok. Journal of Ethnobiology 11(1): 145–157.

Anderson MK. 1993b. The experimental approach to assessment of the potential ecological effects of horticultural practices by Indigenous Peoples on California wildlands. Ph.D. dissertation. University of California at Berkeley. Berkeley.

Anderson MK. 1996. Tending the wilderness. Restoration & Management Notes 14(2): 154–166.

Anderson MK. 1997. From tillage to table: the Indigenous cultivation of geophytes for food in California. Journal of Ethnobiology 17(2): 149–169.

Anderson MK. In press 2004. Tending the wild: indigenous management of California's natural resources and biodiversity. University of California Press, Berkeley.

Apfelbaum SI, Sams CE. 1987. Ecology and control of reed canary grass (*Phalaris arundinaceae* L.). Natural Areas Journal 7: 69-74.

Bannister KP. 2000. Chemistry rooted in cultural knowledge: unearthing the links between antimicrobial properties and traditional knowledge in food and medicinal plant resources of the Secwepemc (Shuswap) Aboriginal Nation. Ph.D. dissertation. University of British Columbia, Vancouver.

Baranov A. 1967. Wild vegetables of the Chinese in Manchuria. Economic Botany 21:140-155.

Becker CD, Ghimire K (authors); Folke C (editor). 2003. Synergy between traditional ecological knowledge and conservation science supports forest preservation in Ecuador. The Journal of Conservation Ecology. Special Edition: Traditional Knowledge in Social Ecological Systems. Online journal [http://www.consecol.org/vol8/iss1/index.html] Accessed 3 August 2003.

Beckwith B. 2002. Colonial Eden or Indigenous cultivated landscape: reconstructing nineteenth century camas meadows on Southern Vancouver Island. In: Burton, PJ, (editor). Garry oak ecosystem restoration: progress and prognosis. B.C. Chapter of the Society for Ecological Restoration, Victoria. p. 64–72.

Bergon F. 1989. The Journal of Lewis and Clark. Viking Penguin Inc., New York, New York.

Berkes F. 1999. Sacred ecology: traditional ecological knowledge and resource management. Taylor and Francis, Phildelphia, PA.

Berkes F, Folke C. 1998. Linking social and ecological systems. Cambridge University Press, Cambridge, UK.

Berry CR, Jr. 1982. Behavior and ecology of carp in the Bear River Migratory Bird Refuge. Final Completion Report. Utah State University, Logan.

Boas F. 1891. Second report on the Indians of British Columbia. In: sixth report of the committee...appointed to investigate the physical characters, languages, and industrial and social condition of the North-Western Tribes of the Dominion of Canada," pp. 562-715. 60th Annual Report of the British Association for the Advancement of Science, p. 553-715. Leeds. Reprinted Northwest Anthropological Research Notes 8:98-174.

Bouchard R, Turner NJ. 1976. Ethnobotany of the Squamish Indian People of British Columbia. British Columbia Indian Language Project, Victoria.

Brayshaw C. 2000. Pondweeds, bur-reeds and their relatives of British Columbia. Royal British Columbia Museum, Victoria.

British Columbia, Government. 1875. Papers connected with the Indian land question, 1850-1875. Victoria, BC: Government Printer (Reprinted 1987, as Indian land question, 1850-1875, 1877).

Brown SM. 1986. The influences of cattle grazing on avian distribution in a seasonal wetland. M.S. Thesis, University of Idaho.

Butzer KW (editor). 1978. Dimensions of Human Geography: essays on some familiar and neglected themes. The University of Chicago, Department of Geography, Research Paper 186. Chicago, Illinois.

Butzer KW. 1982. Archaeology as human ecology: method and theory for a contextual approach. Cambridge University Press, New York, New York.

Cairns DK, Elliot RD. 1987. Oil spill impact assessment for seabirds: the role of refugia and growth centres. Biological Conservation (40): 1–9.

Carlson KT (editor). 2001. A Sto:lo Coast Salish historical atlas. Douglas and McIntyre, Vancouver, British Columbia.

Carlson RL. 1994. Trade and exchange in prehistoric British Columbia. In: Baugh, TG, and Ericson, JE (editors). Prehistoric exchange systems in North America. Plenum Press, New York, New York. pp. 307–361.

Cavalli-Sforza LL. 1983. The transition to agriculture and some of its consequences. In: Ortner, DJ (editor). How humans adapt: a biocultural odyssey. Smithsonian

Institution Press, Washington, D.C. pp. 103-145.

Cavalli-Sforza LL, Feldman MW. 1981. Cultural transmission and evolution: a quantitative approach. Princeton University Press, Princeton, New Jersey.

Chabreck RH. 1968. The relation of cattle and cattle grazing to marsh wildlife and plants in Louisiana. Presented at 22nd Annual Conference of Southeastern Game and Fish Commissioners, Baltimore, Maryland, October 21-23.

Chabreck RH, Pilcher BK, Ensiminger A. 1983. Growth, production, and wildlife use of delta duckpotatoes in Louisiana. Presented at 37th Annual Conference, Southeastern Association of Fish and Wildlife Agencies, Asheville, North Carolina.

Chambers K. 2001. Autecology, ethnobotany and agronomy of *Balsamorhiza sagittata*: Northwestern Plateau, British Columbia. M.Sc. thesis. University of Victoria, Victoria, British Columbia.

Chapman LJ, Chapman CA, Chandler M. 1996. Wetland ecotones as refugia for endangered fishes. Biological Conservation 78(3): 263–270.

Chow-Fraser P. 1999. Volunteer-based experimental planting program to restore Cootes Paradise Marsh, an urban coastal wetland of Lake Onatario. Lakeline (March): 12–39.

Chow-Fraser P, Lougheed V, Le Thiec V, Crosbie B, Simser L, Lord J. 1998. Long-term response of the biotic community to fluctuating water levels and changes in water quality in Cootes Paradise Marsh, a degraded coastal wetland of Lake Ontario. Wetlands Ecology and Management 6: 19–42.

Clark WR, Clay R. 1985. Standing crop of *Sagittaria* in the Upper Mississippi River.

Canadian Journal of Botany 63: 1453–1457.

Clark WR, Kroeker DW. 1993. Population dynamics of muskrats in experimental marshes at Delta, Manitoba. Canadian Journal of Zoology 71: 1620–1628.

Coffey J, Goldstrom E, Gottfriedson G, Matthew R, Walton P. 1990. Shuswap history: the first 100 years of contact. Secwepemc Cultural Education Society, Kamloops, British Columbia.

Colding J, Folke C. 2001. Social taboos: "invisible" systems of local resource management and biological conservation. Ecological Applications 11(2): 584–600.

Colding J, Elmqvist T, Olsson P. 2003. Living with disturbance: building resilience in social-ecological systems. In: Berkes, F, Colding, J, and Folke, C (editors). Navigating Social-Ecological Systems: building resilience for complexity and change. Cambridge University Press, Cambridge, UK. pp. 163–185.

Cole D, Lockner B (editors). 1989. The journals of George M. Dawson: British Columbia, 1875-1878. Volume II, 1877-1878. University of British Columbia Press, Vancouver.

Collier R. 1998. Gitxsan world view: an Aboriginal context for ecosystem restoration in British Columbia. In: Brian Egan (compiler and editor). Helping the land heal, ecological restoration in British Columbia. Conference Proceedings from the B.C. Environmental Network Educational Foundation. pp. 41-42.

Compton B, Gerdts D. 2001. Native peoples, plants and animals: Halkomelem. [http://www.sfu.ca/Halk-ethnobiology/] Accessed: April 2001.

Core E. 1967. Ethnobotany of the Southern Appalachian Aborigines. Economic Botany

21: 198–214.

Corluy R. 1985. The Wilson-Lumsden model of the coevolutionary process of genes and culture. In: Wind, J (editor). Essays in human sociobiology. Academic Press, London, UK.

de Winter KW. 1985. Biological and cultural evolution: different manifestations of the same principle. A systems-theoretical approach. In: Wind, J (editor). Essays in human sociobiology. Academic Press, London, UK.

Darby M. 1996. Wapato for the people: an ecological approach to understanding the Native American use of *Sagittaria latifolia* on the Lower Columbia River. MA Thesis. Portland State University, Portland, Oregon.

Davis W. 1986. The ethnobiology of the Haitian zombi (ethnobotany, vodoun, tetrodotoxin). Ph.D. Thesis. Cambridge Massachusetts, Harvard University.

Davis W. 2001. Light at the edge of the world. Douglas and McIntyre, Vancouver, British Columbia.

Dawson GM. 1891. Notes on the Shuswap People of British Columbia. Transactions of the Royal Society of Canada, Sec. 2, Part 1, pp. 3-44. [http://www.canadian.org/ECO/mtq?doc=14874] Accessed: 21 June 2003.

Debal D, Malhortra KC. 2001. Conservation ethos in local traditions: the West Bengal heritage. Society and Natural Resources 14: 711–724.

Delesalle VA, and Blum S. 1994. Variation in germination and survival among families of *Sagittaria latifolia* in response to salinity and temperature. International Journal of Plant Sciences 155(2): 187–195.

Delesalle VA, Muenchow GE. 1992. Opportunities for selfing and inbreeding depression

in *Sagittaria* congeners (Alismataceae) with contrasting sexual systems. Evolution 6(2): 81–91.

Dermerit D. 1995. Visions of agriculture in British Columbia. B.C. Studies Winter 1995-96 (108): 29-59.

Dix ME, Akkuzu E, Klopfenstein NB. 1997. Riparian refugia in agroforestry systems. Journal of Forestry 95: 38–41.

Doe E. 1971. Centennial history of Salmon Arm. Salmon Arm Observer, Salmon Arm, British Columbia.

Douglas GW, Meidinger D, Pojar J. 2001. Illustrated flora of British Columbia: Monocotyledons. Vol. 6. B. Ministry of Forests, Victoria.

Dove MR. 2001. Interdisciplinary borrowing in Environmental Anthropology and the critique of modern science. In: Crumley (editor). New directions in Anthropology and environment: intersections. Altamira Press. Walnut Creek, California.

Duff W. 1952. The Upper Stalo Indians of the Fraser Valley, British Columbia. Anthropology in British Columbia Memoir No.1, British Columbia Provincial Museum, Victoria.

Duff W. 1969. The Indian history of British Columbia: the impact of the white man. Vol. 1 Anthropology in British Columbia, Memoir No. 5, 1964. Second Edition. British Columbia Provincial Museum, Victoria.

Eckgblad JW, Peterson NL, Ostlie K, Temte A. 1977. The morphometry, benthos and sedimentation rates of a floodplain lake in Pool 9 of the Upper Mississippi River. American Midland Naturalist 97(2): 433–443.

Ellison L. 1960. Influence of grazing on plant succession of rangelands. The Botanical Review 26(1): 1–78.

Elmqvist T, Rainey WE, Pierson ED, Cox PA. 1994. Effects of tropical cyclones Ofa and Val on the structure of a Samoan lowland rain forest. Biotropica 26:384-91.

Environment Canada. 2000. Great Lakes 2000 Cleanup Fund. Fact Sheet. Environment Canada.

Environment Canada. 2003a. British Columbia Environmental Monitoring Networks Station Information Centre. [http://scitech.pyr.ec.gc.ca/climhydro/mainContent/hydrometric/annual_hydrograph_e.asp] Accessed 17 May 2003

Environment Canada. 2003b. Narrative descriptions of terrestrial ecozones and ecoregions of Canada. [http://www.ec.gc.ca/soerree/English/Framework/NarDesc/moncor_e.cfm?tech_id=&issue_id=] Accessed 06 August 2003.

Evers DE, Sasser CE, Gosselink JG, Fuller DA, Visser JM. 1998. The impact of vertebrate herbivores on wetland vegetation in Atchafalaya Bay, Louisiana. Estuaries 21(1): 1–13.

Ford RI (editor). 1994. The nature and status of ethnobotany. Second Edition. Anthropological Papers, Museum of Anthropology, University of Michigan, No. 67. Museum of Anthropology Publications, Ann Arbor.

Fortner SL, White DS. 1988. Interstitial water patterns: a factor influencing the distributions of some lotic aquatic vascular macrophytes. Aquatic Botany 31:

1–12.

Fowler CS. 1990. Ethnographic perspectives on marsh-based cultures in Western Nevada. In: Janetski, JC and Madsen, DB. (editors). Wetland adaptations in the Great Basin. Brigham Young University Museum of Peoples and Cultures, Occasional Papers No. 1, Provo, pp. 17–32.

Fracchia J and Lewontin RC. 1999. Does culture evolve? In: Shaw, DG and Pomper, P (editors). The return of science: evolutionary ideas and history. History and theory, studies in the philosophy of history. Vol. 38, No. 4, Dec 1999. pp. 52-78

French D. 1965. Ethnobotany of the Pacific Northwest Indians. Economic Botany 19: 378–382.

Gadgil M, Hemam NS, Reddy BM. 1998. People, refugia and resilience. In: Berkes F, and Folke C (editors). Linking social and ecological systems. Cambridge University Press, Cambridge, UK. pp. 30–47.

Galloway B. 1982. Upper Sto:lo ethnobotany. Sto:lo Sitel Curriculum, Sardis, British Columbia.

Garibaldi A, and Turner NJ. 2002. Cultural keystone species: implications for ecological conservation and restoration. Symposium: Sustained Use and Conservation of Wild Plants, organized by Nan Vance presented at Society for Conservation Biology, 16th Annual Meeting, July 14-19th, 2002, University of Kent, Canterbury, UK.

Geist C, Galatowitsch SM. 1999. Reciprocal models for meeting ecological and human needs in restoration projects. Conservation Biology 13(5): 970–979.

Gibbs G. 1877. Tribes of Western Washington and Northwestern Oregon. Contributions to North American Ethnology 1, Washington, 1877.

Gilmore MR. 1977. Uses of plants by the Indians of the Missouri River Region. University of Nebraska Press, Lincoln.

Giroux JF, Bedard J. 1987. Factors influencing aboveground production of *Scirpus* marshes in the St. Lawrence estuary, Quebec, Canada. Aquatic Botany 29: 195–204.

Gleason HA, Cronquist A. 1991. Manual of vascular plants of northeastern United States and adjacent Canada. Second Edition. New York Botanical Garden, New York.

Gobster P, Hull B. 1999. The restoration and management of nature. Ecological Restoration 17(1 & 2): 44–51.

Grace JB. 1989. Effects of water depth on *Typha latifolia* and *Typha domingensis*. American Journal of Botany 76(5): 762–768.

Grace JB, Ford MA. 1996. The potential impact of herbivores on the susceptibility of the marsh plant *Sagittaria lancifolia* to saltwater intrusion in coastal wetlands. Estuaries 19(1): 13–20.

Gruenhagen NM, Fredrickson LH. 1990. Food use by migratory female mallards in Northwest Missouri. Journal of Wildlife Management 54(4): 622–626.

Guard J. 1995. Wetland plants of Oregon and Washington. Lone Pine Publishing, Redmond.

Gunther E. 1945. Ethnobotany of Western Washington. University of Washington Publications in Anthropology 10(1): 1–62.

Haeberlin H, Gunther E. 1930. The Indians of Puget Sound. University of Washington Publications in Anthropology 4(1): 1–84.

Haffer J. 1969. Speciation in Amazonian Forest Birds. Science 165(3889): 131–137.

Harris, C. 1997. The resettlement of British Columbia: essays on colonialism and geographical change. UBC Press, Vancouver.

Hart JA, Turner NJ, Morgan LR. 1981. Ethnobotany of the Kootenai Indians of western North America. Unpublished Report to the Kootenay Indian Area Council, Cranbrook, British Columbia.

Hayes P, Matsuda BM, Summers KR. 1993. Critical waterfowl habitats in British Columbia. Technical Report Series No. 184. Environment Canada, Canadian Wildlife Service, Pacific and Yukon Region.

Haynes RR, Hellquist CB. 2000. Alismataceae (Ventenat): Water-plantain or Arrowhead Family. In: Flora of North America Editorial Committee, editor. Flora of North America. Vol. 22. Oxford University Press, New York. pp. 7–25.

Hedrick UP (editor). 1972. Sturtevant's edible plants of the world. Dover Publications, Inc., New York.

Hellson JC, Gadd M. 1974. Ethnobotany of the Blackfoot Indians. Canadian Ethnology Service Paper No. 19. National Museums of Canada, Ottawa, Ontario.

Hewes E. 1973. Indian fisheries productivity in precontact time in the Pacific Salmon area. Northwest Anthropological Research Notes 7: 133–155.

Higgs E. 1993. The ethics of mitigation. Restoration & Management Notes 11(2): 138–143.

Higgs E. 1994. Expanding the scope of restoration ecology. Restoration Ecology 2(3):

137–146.

Higgs E. 2003. Nature by design. MIT Press, Cambridge, Massachusetts.

Hilliard MA. 1971. The effects of regulated livestock grazing on waterfowl production. M.Sc. thesis, Utah State University, Logan.

Hoff TM. 1993. Effects of cattle grazing on waterfowl nesting cover in Arizona montane wetlands. M.S. Thesis. Northern Arizona University, Flagstaff.

Hohman WL, Woolington DW, Devries JH. 1990. Food habits of wintering canvasbacks in Louisiana. Canadian Journal of Zoology 68: 2605–2609.

Holling CS. 1973 Resilience and stability of ecological systems. In: Johnston, RF, Frank, PW, and Michener, CD (editors). Annual Review of Ecology and Systematics, Vol. 4. p. 1-23.

Howard RJ, Mendelssohn IA. 1995. Effect of increased water depth on growth of a common perennial freshwater-intermediate marsh species in Coastal Louisiana. Wetlands 15(1): 82–91.

Hunn ES. 1981. On the relative contribution of men and women to subsistence among hunter-gatherers of the Columbia Plateau: a comparison with *Ethnographic Atlas* summaries. Journal of Ethnobiology 1(1): 124–134.

Hunn ES, Turner NJ, French DH. 1998. Ethnobiology and subsistence. In: Walker Jr.,D (editor). Handbook of the North American Indians: Plateau. Vol. 12. Smithsonian Institution, Washington D.C. p. 525-545.

Hunter ML. 1996. Fundamentals of conservation biology. Blackwell Science, Cambridge, Massachusetts.

Hussey JS. 1974. Some useful plants of early New England. Economic Botany 28:

311–337.

Hutchison M. 2001. Vegetation management guideline: reed canary grass (*Phalaris arundinacea* L.). [http://www.conservation.state.mo.us/nathis/exotic/vegman/twentyon.htm] Accessed: 27 July 2001.

Ignace MB. 1998. Shuswap. In: Walker Jr., D (editor). Handbook of North American Indians: Plateau. Vol. 12. Smithsonian Institution, Washington, D.C., pp. 203–219.

Ignace MB, Turner NJ (forthcoming). Coyote, grouse and trees: Secwepemc lessons about ethnobiological knowledge. In: Bannister, KP, and Turner, NJ (editors). Secwepemc people and plants: research papers in Shuswap ethnobotany. Manuscript in preparation for Advances in Economic Botany. New York Botanical Gardens Press, New York.

Indian Affairs and Northern Development. 2003. Specific claims [http://www.ainc-inac.gc.ca/pr/info/info121_e.html]. Accessed 21 August 2003.

Johnson WB, Sasser CE, Gosselink JG. 1985. Succession of vegetation in an evolving river delta, Atchafalaya Bay, Louisiana. Journal of Ecology 73: 973–986.

Johnston A. 1982. Plants and the Blackfoot. Natural History. Occasional Paper No. 4. Provincial Museum of Alberta, Alberta Culture Historical Resources Division, Edmonton, Alberta.

Johnston A. 1987. Plants and the Blackfoot. Occasional Paper No. 15. Lethbridge Historical Society, Lethbridge, Alberta.

Jordan WR. 1999. Nature and culture. Ecological Restoration 14(4): 187–188.

Joshi NV, Gadgil M. 1991. On the role of refugia in promoting prudent use of biological resources. Theoretical Population Biology 40: 211–229.

Kadlec JA, Smith LM. 1989. The Great Basin marshes. In: Smith, LM, Pederson, RL, and Kaminski, RM (editors). Habitat management for migrating and wintering waterfowl in North America. Texas University Press, Lubbock. pp. 451–474.

Kartesz JT. 1994. A synonymized checklist of the vascular flora of the United States, Canada, and Greenland. 2nd ed. Vol. 1. Timber Press, Portland, Oregon.

Kaul RB. 1978. Morphology of germination and establishment of aquatic seedlings in Alismataceae and Hyrocharitaceae. Aquatic Botany 5: 139–147.

Kaul RB. 1985. Reproductive phenology and biology in annual and perennial Alisamataceae. Aquatic Botany 22: 153–164.

Keddy PA, Constabel P. 1986. Germination of ten shoreline plants in relation to seed size, soil particle size and water level: an experimental study. Journal of Ecology 74: 133–141.

Keddy PA, Ellis T. 1985. Seedling recruitment of 11 wetland plant species along a water level gradient: shared or distinct responses? Canadian Journal of Botany 63:1876-1879

Kimmerer RN. 2000. Native knowledge for native ecosystems. Journal of Forestry 98(8): 4–9.

Kroeber K. 1998. Artistry in Native American myths. University of Nebraska Press, Lincoln.

Kuhnlein HV, Turner NJ. 1991. Traditional plant foods of Canadian Indigenous Peoples: nutrition, botany and use. Gordon and Breach Science Publishers,

Philadelphia, Pennsylvania.

Kuipers AH. 1983. Shuswap-English dictionary. Peeters-Leuven, Belgium.

Kuipers AH. 1989. A report on Shuswap with a Squamish lexical appendix. Peeters/Selaf, Paris.

Laland KN, Kumm J, Feldman MW. 1995. Gene-culture coevolutionary theory: a test case. Current Anthropology 36(1): 131-156. Feb. 1995.

Lancaster J. 2000. Geometric scaling of microhabitat patches and their efficacy as refugia during disturbance. The Journal of Animal Ecology 69(3): 442–457.

Lantz T. 2001. The population ecology and ethnobotany of devil's club (*Oplopanax horridus* (Sm.) Torr. & A. Gray ex. Miq.; Araliaceae). M.Sc. thesis. University of Victoria, Victoria, British Columbia.

Lantz T, Turner NJ. In press 2003. Traditional phenological knowledge (TPK) of Aboriginal Peoples in British Columbia. Journal of Ethnobiology 23(2).

Leck MA. 1996. Germination of macrophytes from a Delaware River tidal freshwater marsh. Bulletin of Torrey Botanical Club 123(1): 48-67.

Li H. 1970. The origin of cultivated plants in Southeast Asia. Economic Botany 24:3-19.

Lieu SM. 1979. Growth form in the Alismatales. I. *Alisma triviale* and species of *Sagittaria* with upright vegetative axes. Canadian Journal of Botany 57: 2325–2352.

Loewen D. 1998. Ecological, ethnobotanical, and nutritional aspects of yellow glacier lily, *Erythronium grandiflorum* Pursh (Liliaceae), in Western Canada. M.Sc. thesis, University of Victoria. Victoria, British Columbia.

Low JB, Bellrose FC, Jr.. 1944. The seed and vegetative yield of waterfowl food plants in

the Illinois River Valley. Journal of Wildlife Management 8: 7–22.

Luna T. 2000. Native Americans and their plants: linking the past with the future. Native Plants Journal 1(2): 95–101.

Lynch JJ, O'Neil T, Lay DW. 1947. Management significance of damage by geese and muskrats to Gulf Coast marshes. Journal of Wildlife Management 11: 50–76.

Mabberley DJ (editor). 1997. The plant-book. Cambridge University Press, Cambridge, UK.

MacArthur RH, Wilson EO. 1967. The theory of island biogeography. Princeton University Press, Princeton, New Jersey.

McIntosh EN. 2003. The Lewis and Clark expedition: food, nutrition, and health. The Center for Western Studies, Augustana College, Sioux Falls, South Dakota.

McNaughton SJ. 1983. Compensatory plant growth as a response to herbivory. Oikos 40: 329–336.

Marburger JE. 1993. Biology and management of *Sagittaria latifolia* Willd. (broad-leaf arrow-head) for wetland restoration and creation. Restoration Ecology December: 248-255.

Martin AC, Zim HS, Nelson AL. 1951. American wildlife and plants: a guide to wildlife food habits. Dover Publications Inc., New York, New York.

Martin G. 1995. Ethnobotany: a methods manual. Chapman and Hall, London, UK.

McPhee M, Gebauer M, Holman G, Runka G, Wallis M. 1996. The Salmon River watershed: an overview of conditions, trends and issues. Technical Report prepared for the Salmon River Watershed Roundtable by Quadra Planning Consultants Ltd. West Vancouver, British Columbia.

Meurk CD, Swaffield SR. 2000. A landscape ecological framework for indigenous regeneration in rural New Zealand. Landscape and Urban Planning 50(1-3): 129–144.

Miles M. 1995. Salmon River Channel Stability Analysis. Fraser River Action Plan, Department of Fisheries and Oceans, Fisheries and Aquatic Sciences No. 2309.

Morris K, Raymond AW. 1993. People of the marsh: a cultural and natural history Stillwater National Wildlife Refuge. U.S. Department of the Interior, Fish and Wildlife Service, Fallon, Nevada.

Muenchow GE. 1985. The evolution of dioecy: patterns and pollination. Ph.D. dissertation, University of Colorado, Boulder.

Muenchow GE. 1998. Subandrodioecy and male fitness in *Sagittaria lancifolia* subsp. *lancifolia* (Alismataceae). American Journal of Botany 85(4): 513–520.

Muenchow GE, Delesalle VA. 1992. Patterns of weevil herbivory on male, monoecious and female inflorescences of *Sagittaria latifolia*. American Midland Naturalist 127: 355–367.

Muenchow GE, Delesalle VA. 1994. Pollinator response to male floral display size in two *Sagittaria* (Alismataceae) species. American Journal of Botany 81(5): 568–573.

Murphy PJ, Nicholas GP, and Ignace, M. 1999. Coyote U: stories and teachings from the Secwepemc Education Institute. Theytus Books Ltd., Penticton, British Columbia.

Nabhan, GP. 1991. Restoring and re-storying the landscape. Restoration & Management Notes 9(1): 3–4.

Nabhan, GP. 1997. Cultures of habitat: on nature, culture and story. Counterpoint, Washington, D.C.

National Resources Conservation Service (NRCS). 2000. Plant fact sheet. USDA, NRCS, Plant Materials Program. [http://plants.usda.gov/plants/cgi_bin/topics.cgi?earl=fact_sheet.cgi]. Accessed 1 June 2003.

Naveh Z. 1998. Ecological and cultural landscape restoration and the cultural evolution towards a post-industrial symbiosis between human society and nature. Restoration Ecology 6(2): 135–143.

Nicholas GP. 1998. Wetlands and hunter-gatherer land use in North America. In: Bernick, K (editor). Hidden dimensions: the cultural significance of wetland archaeology. UBC Press, Vancouver, pp. 31–46.

Ortner DJ. 1983. Biocultural interaction in human adaptation. In: Ortner, DJ (editor). How humans adapt: a biocultural odyssey. Smithsonian Institution Press, Washington, D.C. p. 127-161.

Paige KN, Whitham, TG. 1987. Overcompensation in response to mammalian herbivory: the advantage of being eaten. The American Naturalist 129(3): 407–416.

Palmer G. 1975a. Cultural ecology in the Canadian Plateau: pre-contact to the early contact period in the territory of the southern Shuswap Indians of British Columbia. Northwest Anthropological Research Notes 9(2): 199–245.

Palmer G. 1975b. Shuswap Indian ethnobotany. Syesis 8: 29–81.

Palmer MA, Arensburger P, Botts PS. 1995. Disturbance and the community structure of stream invertebrates: patch-specific effects and the role of refugia. Freshwater Biology 34: 343–356.

Peacock S. 1998. Putting down roots: the emergence of wild plant food production on the Canadian Plateau. Ph.D. dissertation. University of Victoria, Victoria, British Columbia.

Peacock S, Turner NJ. 2000. Just like a garden: traditional resource management and biodiversity conservation on the Interior Plateau of British Columbia. In: Minnis, P, and Elisens, W (editors). Biodiversity and Native America. University of Oklahoma Press, Norman. pp. 133-179.

Phillips F. 1998. The 'Ahakhav Tribal Preserve: Colorado River Indian Tribes initiate a major riparian restoration program. Restoration & Management Notes 16(2): 140–148.

Plowman T, Gyllenhaal LO, Lindgren JE. 1971. *Latua publiflora*: magic plant form southern Chile. Botancial Museum Leaflet, Harvard University 23 (1971): 61-92.

Pojar J, MacKinnon A (editors). 1994. Plants of Coastal British Columbia. Lone Pine Publishing, Edmonton, Alberta.

Pojar J, Meidinger D. 1991. British Columbia: The Environmental Setting. In: Meidinger, D and Pojar, J (compilers and editors). Ecosystems of British Columbia. Special Report Series 6, BC Ministry of Forests, Province of British Columbia, Victoria.

Parbhu R, Colfer C, Venkateswarlu P, Tan L, Soekmadi R, Wollenbery E. 1996. Testing

criteria and indicators for the sustainable management of forests: Phase 1. Final Report. CIFOR Special Publication, Centre for International Forestry Research, Jakarta, Indonesia.

Provincial Agricultural Land Commission. 2003. Agricultural land capability in Agricultural Land Reserve. [http://www.alc.gov.bc.ca/alr/Ag_Capability.htm] Accessed 06 August 2003.

Radcliffe G, Bancroft B, Butt G. 1990. Salmon Arm Bay wildlife viewing plan. Prepared by Madrone Consultants Ltd., Duncan, British Columbia.

Ray VF. 1939. Cultural relations in the Plateau of Western America. Publications of the Frederick Webb Hodge Anniversary Publication Fund, Vol. 3.

Robertson M, Nicholas P, Horwitz P, Bradby K, MacKintosh D. 2000. Environmental narratives and the need for multiple perspectives to restore degraded landscapes in Australia. Ecosystem Health 6(2): 119–133.

Salmon River Watershed Roundtable (SRWR) (1995). Verbal history of the Salmon River watershed. Unpublished literature. On file with the Salmon River Watershed Roundtable, Salmon Arm, British Columbia. Also available online at [http://www.scrn.org/srwr/srwr/srwr_verbal.HTM]

Sarkissian T, Barrett S, Harder L. 2001. Gender variation in *Sagittaria latifolia* (Alismataceae): Is size all that matters? Ecology 82(2): 360–373.

Schultes RE. 1976. Hallucinogenic plants. Golden Press, New York, New York.

Schultes RE, Hoffman A. 1992. Plants of the Gods: their sacred, healing and hallucinogenic powers. Healing Arts Press, Rochester, Vermont.

Schultz BD. 1987. Biotic responses of *Typha*-monodominant semipermanent wetlands to

cattle grazing. M.S. thesis, South Dakota State University, Brookings.

Schussler EE, Longstreth DJ. 1996. Aerenchyma develops by cell lysis in roots and cell separation in leaf petioles in *Sagittaria lancifolia* (Alismataceae). American Journal of Botany 83(10): 1266–1273.

Secwepemc Cultural Education Society (SCES) (in prep. 1). Plants of the Secwepemc (Shuswap) People. In: Turner, NJ, Ignace, M, and Loewen, D (editors). Unpublished manuscript of the Secwepemc Ethnobotany Project, 1993-1997. On file with Dr. Nancy Turner, University of Victoria, Victoria, British Columbia.

Secwepemc Cultural Education Society (SCES) (in prep. 2). Secwepemc People and plants: research papers in Shuswap ethnobotany. Bannister, KP, Turner, NJ, and Ignace, M (editors). Manuscript in preparation for Advances in Economic Botany. New York Botanical Gardens Press, New York.

Seixas CS. 2002. Social-ecological dynamics in management systems: investigating a coastal lagoon fishery in Southern Brazil. Ph.D. dissertation, University of Manitoba, Winnepeg.

Sewid-Smith D. 1998. Incorporating traditional knowledge, interests and values of Aboriginal Peoples into restoration of natural systems projects. In: Brian Egan (compiler and editor). Helping the land heal, ecological restoration in British Columbia. Conference Proceedings form the BC Environmental Network Educational Foundation. pp. 39-40.

Sheldon JW, Balick MJ. 1995. Ethnobotany and the search for balance between use and conservation. In: Swanson, T (editor). Intellectual property rights and

biodiversity conservation: an interdisciplinary analysis of the values of medicinal plants. Cambridge University Press, Cambridge, UK. p. 45–64.

Shuswap Nation Tribal Council (SNTC). 1989. The Shuswap: one people with on mind, one heart and one spirit. Shuswap Nation Tribal Council, Kamloops, British Columbia.

Smith T, Lundholm J, Simser L. 2001. Wetland vegetation monitoring in Cootes Paradise. Ecological Restoration 19(3): 145–154.

Society for Ecological Restoration (SER). 2003. [http://www.ser.org/ser.php?pg=mission] Accessed 13 July 2003.

Spurgeon T. 2001. Wapato (*Sagittaria latifolia*) in Katzie traditional territory, Pitt Meadows, British Columbia. M.Sc. thesis. Simon Fraser University, Burnaby, British Columbia.

Squires L, Van der Valk AG. 1992. Water-depth tolerances of the dominant emergent macrophytes of the Delta Marsh, Manitoba. Canadian Journal of Botany 70: 1860–1867.

Suttles WP. 1955. Katzie Ethnographic Notes. Anthropology in British Columbia, Memoir No. 2. British Columbia Provincial Museum, Victoria.

Suttles WP. 1987. The early diffusion of the potato among the Coast Salish. In: Suttles, WP (editor). Coast Salish essays. Talonbooks, Vancouver, British Columbia, p. 137–151.

Suttles WP. 1990. Central Coast Salish. In: Suttles,WP (editor). Handbook of North American Indians: Northwest Coast. Vol. 7. Smithsonian Institution, Washington, D.C. p. 453–475.

Teit J. 1909. The Shuswap. In: Boas, F (editor). The Jesup North Pacific Expedition. Memoir of the American Museum of Natural History, New York. Vol. II. EJ Brill Ltd., Leiden. p. 443–813.

Thomas, M. 2001. Personal communication to Ann Garibaldi and Nancy Turner in Victoria, British Columbia. February 15.

Thomas, M. 2001. Personal communication to Ann Garibaldi in Victoria, British Columbia. February 25.

Thomas, M. 2001 Personal communication to Ann Garibaldi in Salmon Arm, British Columbia. April 16.

Thomas, M. 2001 Personal communication to Ann Garibaldi driving from Salmon Arm to Three Valley Gap, British Columbia. July 4.

Thomas M. 2002. The wisdom of Dr. Mary Thomas. Turner, N, Hood, RJ, Infanti, J and Peacock, D (compilers). On file with Dr. Nancy Turner, University of Victoria, Victoria, British Columbia.

Thomas, M. 2003. Personal communication to Ann Garibaldi, telephone interview. June 22.

Thomas M, Turner NJ, Garibaldi AC. In prep. "Everything is deteriorating": environmental and cultural loss in Secwepemc territory. In: Bannister, KP and Turner, NJ (editors). In prep. Secwepemc people and plants: research papers in Shuswap ethnobotany. Secwepemc Cultural Education Society (SCES). Manuscript in preparation for Advances in Economic Botany. New York Botanical Gardens Press, New York.

Toews DAA, Moore MK. 1982. The effects of streamside logging on large organic debris

in Carnation Creek. Land Management Report Number 11. Habitat Protection Division, Department of Fisheries and Oceans, Vancouver, British Columbia.

Turner NJ. 1978. Food plants of British Columbia Indians. Part II - Interior Peoples. British Columbia Provincial Museum Handbook No. 36, Victoria.

Turner NJ. 1995. Food Plants of coastal First Peoples. UBC Press, Vancouver.

Turner NJ. 1997. Food Plants of interior First Peoples. UBC Press, Vancouver.

Turner NJ, Bell MAM. 1971. The ethnobotany of the Coast Salish Indians of Vancouver Island. Economic Botany 25: 63–104.

Turner NJ, Brown CH. In press, 2003. Grass, Hay, Low Growth and Weeds: Utility and Semantics of Interior Salish Botanical Terms. Festshrift for M. Dale Kinkade, edited by Donna Gertz. University of Montana publications in Linguistics, Monograph series.

Turner NJ, Davidson-Hunt I, O'Flaherty J. 2003. Ecological edges and cultural edges: diversity and resilience of traditional knowledge systems. Human Ecology 31(3).

Turner NJ, Ignace MB, Compton BD. 1998. Secwepemc (Shuswap) tree names: key to the past? In: Czaykowska-Higgins, E, Kinkade, MD (editors). Salish languages and linguistics: theoretical and descriptive perspectives. Mouton de Gruyter, Berlin p. 387–417.

Turner NJ, Loewen DC. 1998. The original "free trade": exchange of botanical products and associated plant knowledge in Northwestern North America. Anthropologica XL: 49–70.

Turner NJ, Thompson LC, Thompson MT, York AZ. 1990. Thompson ethnobotany:

knowledge and usage of plants by the Thompson Indians of British Columbia, Memoir No. 3. Royal British Columbia Museum, Victoria.

Turner RD. 2003. West of the Great Divide: an illustrated history of the Canadian Pacific Railway in British Columbia, 1880-1986. Second Edition. Sono Nis Press, Winlaw.

Van der Valk AG. 1989. Northern prairie wetlands. Iowa State University Press, Ames, Iowa.

Vescio LS. 1979. Germination characterisitics of two *Sagittaria* species. M.S. thesis. University of Nebraska, Lincoln.

Visser JM. 1989. The impact of vertebrate herbivores on primary production of *Sagittaria* marshes in the Wax Lake Delta, Atchafalaya Bay, Louisiana. Ph.D. dissertation. The University of Amsterdam, The Netherlands

Watson A, Alessa L, Glaspell B (authors), Folke C (editor). 2003. The relationship between traditional ecological knowledge, evolving cultures, and wilderness protection in the circumpolar north. The Journal of Conservation Ecology. Special Edition: Traditional Knowledge in Social-Ecological Systems. Online journal [http://www.consecol.org/vol8/iss1/index.html] Accessed 3 August 2003.

Weller MW. 1990. Waterfowl management techniques for wetland enhancement, restoration, and creation useful in mitigation procedures. In: Kusler, JA, Kentula, ME (editors). Wetland Creation and Restoration. Island Press, Washington, D.C. p. 517–528.

Whittey JR, Bassett B, Dillard JG, Haefner RA (authors), Dryden B (editor). 1990. Water

plants for Missouri ponds. Missouri Department of Conservation, Jefferson City.

Whittey A. 1997. Ways of seeing: restoration and the perception of landscape. Restoration & Management Notes 15(1): 67–73.

Wilken GC. 1970. The ecology of gathering in a Mexican Farming Region. Economic Botany 24: 286–296.

Windmiller B, Dobberteen R. 1989. Control of Purple Loosestrife Through Competitive Planting (Massachusetts). Restoration & Management Notes 7:2

Wooten JW. 1971. The monoecious and dioecious conditions of *Sagittaria latifolia* (Alismataceae). Evolution 25: 549–553.

Wooten JW. 1973. Edaphic factors in species and ecotype differentiation of *Sagittaria*. Journal of Ecology 61: 151–156.

Wooten JW. 1986. Variations in leaf characteristics of six species of *Sagittaria* (Alismataceae) caused by various water levels. Aquatic Botany 23: 321–327.

Yamazawa K, Koji K, Yamauchi R, Ueno Y. 1986. Bitter principles of tubers of *Sagittaria trifolia* (Kuwai). Agricultural Biological Chemistry 50(12): 3179.

Yeo RR. 1966. Yields of propagules of certain aquatic plants. Weeds 14: 110–113.

Zepeda C, Lot A. 1999. Acuitlacpalli or *Sagittaria macrophylla* (Alismataceae): a Mexican endemic hydrophyte and a threatened food resource. Economic Botany 53(2): 221–223.

Appendix 1. Data form for *Sagittaria latifolia* replanting study in Salmon Arm British Columbia 2002.

Ann Garibaldi ____ Trudi Smith____ Date ____________ Transect No. _____ Site No. ____

Photo Roll No.	Photo Frame No.	Plant No.	No. of leaves	Height of tallest lf. (cm)	Foraging sign (y/n)

N

(write plant numbers on map)

Plant No.	Leaf No.	Width (cm)	Height (cm)

Other Comments (signs of distress, foraging notes, plant mortality, etc.):

Appendix 2. Site data for 2001 *Sagittaria* spp. survey in interior British Columbia

Site Name	Latitude	Longitude	Altitude (m)
Adams Lake 1	50 56 46	119 39 26	406
Adams Lake 2	50 59 14	119 43 37	412
Black Lake1	50 29 29	210 07 56	1168
Black Lake 2	50 29 23	120 06 49	1162
Bog Lake	50 29 32	120 06 37	1177
Canoe 1	50 45 18	119 13 32	364
Canoe 2	50 45 20	119 13 12	347
Chapperon Lake	50 13 08	120 03 29	902
Douglas Lake 1	50 08 23	120 16 47	795
Douglas Lake 2	50 09 29	120 13 41	797
Glimpse Lake 1	50 14 48	120 17 16	1173
Glimpse Lake 2	50 14 41	120 17 04	1177
Glimpse Lake 3	50 14 39	120 16 48	1177
Goose Lake	50 18 40	119 17 04	494
John Frank Lake	50 28 15	120 08 06	1141
Kawkawa Lake	49 23.129	121 24.786	58
Kawkawa Lake	49 23.123	121 24.849	58
Mara Lake	50 45 30	119 01 56	338
Napier Lake Ranch	50 26 05	120 18 12	733
Nicola Lake 1	50 09.692	120 37.292	625
Nicola Lake 2	50 09.430	120 37.757	617
No Name Lake	50 29 29	120 09 52	1109
Paul Lake 1	50 44 42	120 06 19	771
Paul Lake 2	50 44 42	120 06 24	780
Pennaska Lake	50 43 43	120 01 23	825
Rush Lake	50 15 07	120 02 29	951
Salmon Lake	50 15 48	120 01 12	930
Salmon Arm Wharf	50 42 46	119 16 10	338
Shumway Lake	50 30 42	120 15 46	707
Swan Lake 1	50 50 13	118 59 18	360
Swan Lake 2	50 18 56	119 14 59	404
Swan Lake 3	50 17 57	119 15 18	413
Tappen (Sunnybrae)	50 46 55	119 19 01	334
Tranquille/Kamloops Lake	50 43 18	120 30 37	341
Tulip Lake	50 29 29	120 90 36	1126

VITA

Garibaldi, Ann Catherine

Education
B.S. Environmental Plant Biology, Ohio University, Athens.1993.

Awards and Honours

Ohio University

Outstanding Graduating Senior, College of Arts and Sciences, Ohio University, 1993

Young Botanist Award, Botanical Society of America, 1993

University of Victoria

Dean's Interdisciplinary Scholarship. September, 2001
Global Forest Grant. March, 2001
Vancouver Port Authority Scholarship. November, 2001, 2002

Conference Presentations

Oral Presentations

March 2001: Society of Ethnobiology Conference, Durango, Colorado. *Valuing those soggy, boggy places: the cultural significance of wetlands in British Columbia* (with N. Turner and G. Nicholas).

March 2001: Society of Ethnobiology Conference, Durango, Colorado. *Beyond myth, beyond sky: teaching & taboo in the Star Husband Tale* (with S. Peacock).

July 2002: Society of Conservation Biology, Canterbury, UK. *Cultural keystone species: implications for ecological conservation and restoration* (with N. Turner)

August 2002: Joint Conference for the Society for Ecological Restoration and the Ecological Association of America. *In search of cultural refugia: the role of cultural knowledge in ecological restoration* (with B. Beckwith).

March 2003: Society of Ethnobiology Conference, Seattle, Washington. *Bridging culture, restoration, and Ethnobotany: the study of wapato (*Sagittaria latifolia *Willd.) in interior B.C.*

Poster Presentations

February 2001: University of Victoria, Department of Biology graduate symposium, Victoria *Feast from the swamp: ecological and cultural significance of wetland plants.*

March 2001: Society of Ethnobiology Conference, Durango, Colorado. *Feast from the swamp: ecological and cultural significance of wetland plants.*

Other presentations

University of Victoria Speaker's Bureau. 2001, 2002.

Publications

Thomas, M, Turner, NJ, and Garibaldi, AC. In prep. "Everything is deteriorating": environmental and cultural loss in Secwepemc territory. In: Bannister, KP and Turner, NJ (editors). In prep. Secwepemc people and plants: research papers in Shuswap ethnobotany. Secwepemc Cultural Education Society (SCES). Manuscript in preparation for Advances in Economic Botany. New York Botanical Gardens Press, New York.

Garibaldi, A. 1999. Medicinal flora of the Alaska Natives. Alaska Natural Heritage Program, University of Alaska, Anchorage, 200p.

Smith, WP, Stotts, MJ, Andres, BA, Melton, JM, Garibaldi, A, and Boggs, K. 2001. Bird, mammal, and vegetation community surveys of Research Natural Areas in the Tongass National Forest. USDA Forest Service. Pacific Northwest Research Station Research Paper PNW-RP-535.

Boggs, K, Garibaldi, A, and Helt, T. 1999. Landcover map for the Gates of the Arctic National Park and Preserve. Alaska Natural Heritage Program. University of Alaska, Anchorage.

Garibaldi, A. and R. Lipkin. 1995. Summary of rare species and critical habitats in the Alaska Army National Guard southwestern Alaska training sites. Report to Alaska Army National Guard. Alaska Natural Heritage Program, University of Alaska, Anchorage.

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Title of Thesis:

Bridging Ethnobotany, Autecology and Restoration: The Study of Wapato (*Sagittaria latifolia* Willd.; Alismataceae) in Interior British Columbia

Author

Ann Garibaldi

July 15, 2003