Gardens on the Edge: Estuarine Root Gardens as Places of Tangible Heritage and Indigenous Futurity

by

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B.A., University of British Columbia, 2014
M.A., University of Toronto, 2016

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We acknowledge and respect the Lək̓ʷəŋən (Sof̣nghees and Xʷsepsəm/Esquimalt) Peoples on whose territory the university stands, and the Lək̓ʷəŋən and W̱SÁNEĆ Peoples whose historical relationships with the land continue to this day.

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Abstract

Estuarine root gardens are Indigenous plant stewardship landscapes on the Pacific northwest coast of North America. The plants that were principally cared for in these coastal sites–Pacific silverweed (*Argentina egedii (Wormsk.)* Rydb.; syn. *Potentilla pacifica* (L.) Howell), springbank clover (*Trifolium wormskioldii* Lehm) and northern rice-root lily, *Fritillaria camschatcensis* (L.) Ker Gawl)– were eaten by Indigenous Peoples from northern California to Alaska. In certain areas, generations of Indigenous Peoples cared for and altered the soils, hydrology, and ecology of high estuarine marshes to maximize the growth and output of these nutritionally, spiritually, and economically important plants. Though stewardship methods and the location of some of these places are still known by Indigenous Knowledge Holders,[1] descendant communities, and researchers (primarily in coastal British Columbia, Canada), the extended dismissal of Indigenous plant stewardship practices by settler ethnographers and archaeologists has resulted in a chronic under-representation of these places in the archaeological record of British Columbia. Furthermore, tangible remnants of Indigenous estuarine stewardship–in the form of legacy ecosystems and cultural soils–is not currently seen as sufficient evidence in categorizing these places as archaeological sites. This has implications for their protection under current provincial Heritage and Conservation (HCA) legislation, as well as the ability of descendant communities to reconnect with these culturally significant places and foods. Finally, identifying estuarine root gardens, and contributing to eco-cultural restoration efforts, is occurring within a context of ongoing and cumulative colonial violence to Indigenous territories, with estuaries particularly at risk. Understanding and addressing these complex factors is key to the successful restoration, renewal, and creation of stewarded places.

Ultimately, this dissertation aims to address the disconnect between the (often limited and fragmented) archaeological study of estuarine root gardens and the importance of these landscapes for Indigenous heritage, food sovereignty and security, and cultural reconnection through the Indigenous-led restoration and renewal of food systems. In doing so, I present and tests a series of novel and interdisciplinary methods to identify estuarine root garden sites and

[1] Thanks, in large part, to Indigenous elders and knowledge holders, late Kwaxsistalla Wathl'thla (Adam Dick) of the Qawadiliqəlla Clan of the Dzawada̲'enux̱w Kwakwa̱ka̱'wakw of Kingcome Inlet, as well as his relatives and friends Mayanilth (Dr. Daisy Sewid-Smith), and Oqwilowgwa (Kim Recalma-Clutesi)

better understand their post-stewardship trajectories, accounting for eco-cultural context, present day ecologies and hydrologies, and cumulative colonial impacts. Combining archaeological excavations, ecological monitoring, and pedological analysis, I examine two estuarine root gardens (and comparative periphery, or control sites) occurring in different eco-cultural contexts. The first, at Tl'chés, is a Lək̓ʷəŋən/Songhees root garden that was no longer known by descent communities and knowledge holders, making it the first of its kind to be formally identified in Coast Salish territories. The second, at the mouth of the Gwa'ni (Nimpkish) River, is a known 'Na̱mgis Kwakwa̱ka̱'wakw estuarine root garden site which has been documented by non-Indigenous researchers since the 19th century, offering a rare glimpse at more than a century of changing use and occupation patterns in the area. A third estuarine root garden at Tsinwilht'as (Anderson) Creek in ʕaaḥuusʔatḥ Nuu-chah-nulth territories was investigated as part of an Archaeological Impact Assessment (AIA) by Stafford (2020). As such, the methods described in this paper could not be replicated there. However, the thoroughness of Stafford's (2020) investigation provides important comparative data, helping illustrate both the similarities and differences of estuarine root gardens located in different eco-cultural areas, as well as an example of best archaeological practice in the field of Cultural Resource Management (CRM).

Overall, the methods applied during this research demonstrated that 1) estuarine root gardens continue to support distinct ecological assemblages shaped by past Indigenous stewardship, though the ecological trajectory of these places vary based on local hydrological, cultural, and climactic factors. 2) Estuarine root garden soils are morphologically and chemically distinct, with heightened levels of organic matter and available soil phosphorous (P). As such, they can best be understood as *cultural* or *Indigenous soils*, developed in situ to increase garden productivity and access to preferred long, straight roots and rhizomes. 3) Archaeological signatures at estuarine root gardens are variable; as such, archaeologists need to expand their arsenal when investigating a potential estuarine root garden site. These considerations, furthermore, should be rooted in engagement with the communities to which these places belong. 4) Finally, estuarine root gardens are *living archaeological sites*. As such, they are places with profound ties to the communities that built and cared for them, a relationship that extends into the future. Developing a better understanding of estuarine root garden formation has implications for the community-driven restoration of these places, often occurring in contexts where coastlines have been altered by ongoing and cumulative settler colonial impacts.

Table of Contents

List of Figures

List of Tables

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Dedication

To the liminal magic of estuaries, and to this coast, which holds my heart.

Chapter 1 – Introduction

1.1. An introduction to estuarine root gardens

For more than half a century–and increasingly since the 1970's–archaeologists and ethnobiologists have seeking to actively collaborate with Indigenous Peoples to document and uphold knowledge relating to the ways in which communities engage with and shape their landscapes over time (e.g., Lewis, 1973; Robbins et al., 1916; Turner et al., 1983). This tending of landscapes–often with the implicit purpose of enhancing their productivity and easing access to culturally, economically, and spiritually important species–encompasses long-term knowledge systems, which contain important information about sustainable practices and other ways of being in the world (Lepofsky & Fowler, 2011). From the successional agroforestry *milpa* system of the ancient Maya (Nigh & Diemont, 2013) to the Hawaiian *loko iʻa* (fishponds) (Innes-Gold et al., 2024) to the Māori stewardship of *kūmara* (sweet potato, *Ipomoea batatas*) and *taewa* (Māori potato, *Solanum tuberosum*) (Barber & Higham, 2021), it is today apparent that cultural landscapes are overwhelming shaped by people, and that this has been taking place for over 12,000 years (Ellis et al., 2021). Indeed, many of these ancient cultural places remain highly productive and biodiverse today compared to untended ecosystems, even when active stewardship no longer occurs (Armstrong et al., 2021).

On the Northwest Coast of North America, similarly shifting understandings of the active roles that Indigenous Peoples have had in shaping their ecosystems has led to better understandings of cultural landscapes and guided ethnobotanical and archaeological investigations.[2] Today, we know that marine, coastal, and terrestrial ecosystems were stewarded by Indigenous Peoples over hundreds and thousands of years, enhancing their productivity and resilience over the long-term in ways that are still observable today (e.g., Armstrong et al., 2021; Mathews & Turner, 2017; Smith et al., 2019; Thornton et al., 2015; Trant et al., 2016). We also

[2] The work of ethnobotanists such as Dr. Nancy J. Turner, and her life-long commitment to building and maintaining relationships with her Indigenous friends and collaborators, has been pivotal to this shift. The same can be said for Dr. Harriet Kuhnlein, a close and long-time collaborator of Dr. Turner's, who helped found and run the The Nuxalk Food and Nutrition Program (1979-86), a model for collaborative and co-created research providing tangible impacts to community (Kuhnlein et al., 2013; Lepofsky & Fowler, 2011).

know that Indigenous Peoples in British Columbia (traditionally, and to this day) harvested and stewarded over 100 plant species (Lepofsky & Lertzman, 2008; Turner, 2020a, 2020b; Turner et al., 2013). The study of estuarine root gardens fits within this broader and still developing understanding of traditionally stewarded landscapes.

Globally, estuaries represent some of the biodiverse ecosystems on earth, supporting vast arrays of plant and animal life and serving key ecosystem functions (Day et al., 2012). These places, located at the confluence of salt and freshwater systems and defined by dynamic organic and sedimentary deposition processes, are nutrient rich and central to the diverse human populations and cultures that have built productive and reciprocal relationships with these places over hundreds and thousands of years, continuing into the present (Erlandson et al., 2019; Mitra & Zaman, 2016). An example of such a relationship can be found on the west coast of British Columbia, Canada, where Indigenous People carefully stewarded estuaries to encourage the growth of specific nutritionally, culturally and economically important plant species–namely, springbank clover (*Trifolium wormskioldii* Lehm), Pacific silverweed (*Argentina egedii* (*Wormsk*.) Rybd.; syn. *Potentilla pacifica* (L.) Howell), riceroot lily (*Fritillaria camschatcensis* (L.) Ker Gawl (Figure 1) (International Plant Names Index, IPNI, 2025). Known as estuarine root gardens, archaeological and cultural evidence for these places exists from Alaska to the southern coast of British Columbia (Deur, 2000, 2002a, 2002b, 2005; Lloyd, 2011; Pukonen, 2008; Maurice-Hammond et al., 2023), though Indigenous Peoples as far south as California were known to eat these foods, suggesting that even more southern gardens existed (Anderson, 2005; Kniffen, 1934).

Figure 1. From left to right, Pacific silverweed (*Argentina egedii* (*Wormsk*.) Rybd.; syn. *Potentilla pacifica* (L.) Howell), springbank clover (*Trifolium wormskioldii* Lehm), and riceroot lily (*Fritillaria camschatcensis* (L.) Ker Gawl) in bloom.

Estuarine root foods stewarded in estuaries were prized for their starchy roots and rhizomes, a nutritionally crucial source of carbohydrates (Turner & Kuhnlein, 1982). Stewardship practices for these low-lying coastal places—characterized by varying tidal and riverine flows, and the associated frequent deposition of organic materials—occurred along a spectrum, as with most traditional Indigenous plant stewardship practices (Deur & Turner, 2005; Lepofsky & Lertzman, 2008; Turner, 2020a; Turner et al., 2013). These practices included weeding out competing species within plots, replanting and transplanting individual plants, and the alteration of entire ecosystems though terracing and soil amendments. Ultimately, and over generations, these practices increased the size of these plant communities, creating a stable food source that also served important economic, ceremonial, and social roles within and between communities (Deur, 2000, 2002a; 2002b; Lloyd, 2011; Pukonen, 2008).

Generally, plant stewardship practices remain under-documented in the ethnographic record, due, in part, to the long-held belief by settler and European academics that Indigenous Peoples of the Northwest Coast were “affluent foragers” and “complex hunter-gatherers,” not plant cultivators (Ames & Maschner, 1999; Douglas & Brown, 1985). Furthermore, entrenched biases by (almost always) male researchers against what was perceived as “women’s work” led to a broad academic discounting of important practices associated with plant and landscape stewardship, a process that has only begun to be corrected in recent decades (Lepofsky, 2004; Moss, 1993; Turner & Berkes, 2006; Spalding, 2022).

Despite some mentions in the early colonial and ethnographic literature about the locations of estuarine root garden sites and associated practices (Boas & Hunt, 1921, Boas, 1934; Menzies, 1923; Sapir, 1914), much of what we know today about these places is due to the generosity of Indigenous Elders and Knowledge Holders such as Kwaxsistalla Wathl'thla (Adam Dick), the late clan chief of the Qawadiliqəlla Clan of Dzawada̲'enux̱w Kwakwa̱ka̱'wakw. Kwaxsistalla was raised traditionally by his grandparents. Hidden from settler colonial systems– that, at the time, actively sought to extinguish Indigenous knowledge, an act of genocide that functioned concurrently with the theft of children and their transfer to residential schools– Kwaxiststalla was trained to hold knowledge aligned with his future chiefly duties, including the care and functioning of specialized stewardship systems (such as clam gardens and estuarine root gardens) (Dick et al., 2022). His training, and the hope that it embodied (hope of a future where Indigenous knowledge systems will no longer be criminalized, freely practiced by Indigenous Peoples once again) is the realisation of Indigenous futurities, the bringing home of relationships to land and foods and community. In his lifetime, Kwasistalla shared his knowledge with collaborators and friends, such as Dr. Nancy Turner, Dr. Douglas Deur, and Abe Lloyd. Carrying forward his teachings, and adding much knowledge of their own, have been his relations Mayanilth (Daisy Sewid-Smith) and Oqwilowgwa (Kim Recalma-Clutesi).[3] Furthermore, knowledge about the traditional stewardship of estuaries lives on in descendant communities who maintain enduring connections, relationships, and responsibilities with these places, leading, in some cases, to their revival (see Pukonen, 2008). This is tied to a wider process of landscape revitalization and reclaiming of traditional Indigenous sovereignty currently taking place in coastal British Columbia and beyond.[4]

[3] Kwaxsistalla also shared his knowledge and expertise on plant stewardship with many others, such as Cullis-Suzuki (2007), Deveau (2010), Grimes (2011), Joseph (2010), Lloyd (2011), Pukonen (2008), Wyllie de Echeverria (2013)– and, of course, Deur (2000).

[4] This reclaiming of sovereignty over traditional territories by Indigenous Peoples in Canada is occurring on a wider scale; for example, the Haida Nation's Canadian Supreme Court victory in 2004, which acknowledged their unceded and ongoing ownership of their homeland of Haida Gwaii, or, more recently, B.C.'s Supreme Court acknowledging the rights of Quw'utsun (Cowichan Tribes) to fish the Fraser River and reclaim stewardship over their ancestral village site of Tl'uqtinus on Lulu Island (as of August 9th, 2025) (Cowichan Tribes v. Canada, 2025). On a smaller scale,

The archaeological study of these food-producing landscapes, however, is limited by current understandings of what constitutes evidence of material culture. Typically, this includes features such as rock walls and artifacts such as digging-stick fragments and other preserved tangible materials (Lepofsky, 2009; Lepofsky & Lertzman, 2008; Schaepe et al., 2020). Though important, this emphasis makes it difficult for archaeologists—increasingly working with community looking to re-connect with their culturally important places—to identify estuarine root gardens that may present more subtle markers of past stewardship. Furthermore, the dynamism of estuaries, resulting in varied ecological and hydrological conditions, would have required an equally dynamic approach to stewardship practices. These heterogenous conditions, combined with local and specific cultural preferences and practices, would have resulted in a broad history of estuarine usage and material correlates. As archaeologists, we do not currently understand the full range of potential identifying indicators of estuarine stewardship—which might include combinations of remnant plant communities, archaeological features, and unique soil characteristics. In order to meet these challenges, I propose that was is needed is an interdisciplinary approach, one which draws from western scientific frameworks to support and uphold Indigenous ways of knowing and caretaking of home territories (Armstong et al., 2021; Turner et al., 2021).

1.2. A note on terminology

In this dissertation, I use the terms “caretaking,” “stewardship,” and, to a lesser degree “management” to discuss the practices employed by Indigenous People in increasing access to, and output of, plant foods. This terminology is understood to encompass “the application of traditional ecological knowledge to maintain or enhance the abundance, diversity and/or availability of natural resources or ecosystems” (Fowler & Lepofsky, 2011, p. 286) by Indigenous Peoples. Indigenous stewardship, and the resulting knowledge of the best methods for enhancing resources under specific environmental conditions, is the expression of cumulative and inter-generational knowledge gained from peoples’ interactions with their local

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though no less important to restoring stewardship practices, are the sea gardens being built and repaired along the Northwest Coast (Augustine, 2025; Tadlock, 2019), the camas prairies being restored and harvested from (Corntassel & Bryce, 2012), and the reclamation and renewed care of estuaries.

environments over centuries. This form of knowledge results from a profound history of intimate place-based relationships with plants, animals and landscapes (Anderson, 2005). This frame—looking at caretaking as reciprocal relationship rather than a series of disturbances or one-sided pressures enacted by humans on their environment—is crucial in any understanding of the relationships between Indigenous Peoples and their homelands. Salmón (2000, p. 1327) described this as "kincentric ecology," an understanding by Indigenous Peoples that "life in any environment is viable only when humans view their surroundings as kin; that their mutual roles are essential for their survival." In the context of stewarded plant communities, this frame allows us to identify and highlight the reciprocal nature of the relationships that exist between plants and peoples, a relationship that is upheld by Indigenous communities through caretaking practices. While peoples benefit from this relationship through their ability to increase the size and reliability of harvests, the plants themselves benefit in return, adjusting to their environments and becoming more adaptable, resilient and productive thanks to the forms of disturbance created by Indigenous stewardship (Anderson, 2005; Geniusz, 2015; Turner & Turner, 2007; Turner, 2020). Indeed, "plants are known to increase their productivity, enhance biodiversity, and benefit overall ecosystem health when growing in culturally managed ecosystems" (Joseph et al., 2022, p. 67).

Additionally, I choose the terms stewardship and caretaking over agriculture, domestication, and cultivation. Cultivation is understood here as a sustained pattern of engagement with specific species and environments. This engagement may involve the purposeful dissemination of plant species (though transplanting, seeding, etc.) or modifications to entire ecosystems through fertilization, the improvement of drainage, terracing, etc. Domestication, which is more closely associated with present-day conceptions of agricultural systems, similarly implies sustained engagement with landscapes and species, though on a more intensive scale, often resulting in distinct morphological and genetic changes to the species in question (Deur, 2002a, 2002b)[5]. Though cultivation has been used convincingly in the past to

[5] Morphological changes in targeted species are not guaranteed. Furthermore, even if these changes are manifest, cultivated species can re-integrate with wild populations after cessation of cultivation, diluting the evidence of these markers. Though it has been speculated that Indigenous stewardship practices on the Northwest Coast might have resulted in morphological changes, further genetic work is needed (Beckwith, 2004; Przelmoska et al., 2020).

describe the suite of practices associated with plant stewardship on the Northwest Coast[6] (see Deur, 2002a, 2002b; Lepofsky & Lertzman, 2008), it implies a pattern of linear and unilateral pressure that is enacted in places and species by humans. This unidirectional influence is not reflective of the broader relational concepts of responsibility and kinship to land and other/more than human kin that define Indigenous Peoples' relationships to territory (Geniusz, 2015; Kimmerer, 2013; Salmón, 2000).

Finally, weaved throughout this dissertation is the concept of Indigenous futurity(ies). Drawing from Dillon's (2012) understanding of Indigenous futurisms (itself related to Afrofuturism[7]), this framework acknowledges the ruptures (past and present) caused by colonialism while also asserting a vision of the future in which Indigenous Peoples can live and thrive, free from colonial cycles of violence and loss. In doing so, Dillon (2012) identifies, and challenges, seminal frameworks for settler colonial understandings of self in relation to land and Indigenous Peoples (contact, science, slipstream and apocalypse), all leading to the inevitable disappearance of Indigenous Peoples and the actualization of settler colonial fantasies of belonging on/to stolen land. By disrupting (and turning away) from these narratives, Dillon (2012), instead, moves towards a return to community and self, focused on the recovery of ancestral traditions, places and knowledge systems in order to build better futures. Drawing from these concepts, Montgomery & Pezzarossi (2026, p. 6) emphasize that Indigenous futurities affirm "the dynamic pasts, present, and future of Indigenous [P]eoples," making them powerful, future-oriented interventions that can help dismantle "disciplinary practices grounded in colonial power structures and narratives."[8]

[6] Indeed, Lyons et al. (2021) made the argument that ancient Coast Salish Peoples could best be understood as farmers. In the words of Daisy Sewid-Smith: "to get more harvest, and a bigger…berry, they did these things. Same thing…a farmer does" (quoted in Turner et al., 2013, p. 107. See also Turner & Deur, 2024).

[7] Afrofuturism was originally articulated by Mark Derry (1994), who observed that "being Black in America is a science fiction experience" (p. 208). Drawing from this formative text, as well as other key contributors (see Nelson, 2002; Womack, 2013), Larkin (2022, p. 3) defines Afrofuturism as "an artistic and intellectual movement of the African diaspora that draws from a range of speculative techniques in order to articulate complex counter-narratives of past, present, and future and to enable the creation of a more just world."

[8] For more on the theorizing and application of Indigenous futurisms, see Baldwin (2012), Goodyear-Kaʻōpua (2017), Hickey (2019), Liboiron (2023), Rifkin (2017), Simpson (2017), TallBear (2023), and Tuck & Gaztambide-Fernández (2013), amongst many others.

1.3. Plant stewardship practices on the Northwest Coast

Stewardship, when considered as a series of practices occurring over the long-term resulting from profound and ongoing reciprocal relationships with ecologies and species, is a departure from previous understandings of the relationships between people and their food-producing landscapes. The prevalent anthropological thinking of the 19th century (which had begun to by the middle of the 20th century) emphasized the existence of an inherent dichotomy between agriculturalists—peoples who enact pressure on ecosystems, animals and plants species in specific ways to increase their output—and hunter-gatherer/foragers, who incidentally benefit from their ability to procure a wide range of resources that they do not in any material way engage with otherwise (Benedict, 1934; Drucker, 1951; Kroeber, 1939; Sauer & Kenzer, 1984; Spinden, 1917). Shaped by this same dichotomous thinking, Northwest Coast archaeology historically framed Indigenous peoples as “complex hunter-gatherers” (Ames & Maschner, 1999; Price & Brown, 1985), with access to naturally productive marine resources, such as salmon. Consequently, they were understood as an anthropological anomaly, in that they challenged the ideas of plant domestication and agriculture as key precursors to “cultural complexity” (Morgan, 1877; Chick, 1997). Indigenous Peoples of the Northwest Coast, with their large, permanent winter villages, intricate art forms, and social hierarchies, fell within this colonial and Euro-centric understanding of “complex societies.” These peoples, according to Kroeber (1962, p. 61) were a “a wholly non-planting and non-breeding culture—perhaps the most elaborate such culture in the world.” Later archaeological thinking, however, recognized the role of people in intentionally manipulating ecosystems as a hallmark of this cultural complexity (e.g., Ames, 1991) and the resulting “domesticated environments” (Yen, 1989). This shift in the archaeological recognition of Indigenous Peoples role in shaping ecosystems was influenced directly by the ethnoecological work of Dr. Nancy Turner and colleagues (Ames, 1991, p. 942), including their formative papers on *T. wormskioldii*, *A. egedii*, and *F. camschatcensis* stewardship (Turner & Kuhnlein, 1982, 1983). This work was later expanded upon and contextualized within traditional stewardship frameworks, emphasizing the role of Indigenous Peoples in amending and shaping landscape to increase their productivity and ease of access to key, culturally important plants (e.g., Turner & Berkes, 2003; Turner & Peacock, 2005; Deur & Turner, 2005).

Today, we know that the relationships between Indigenous Peoples and their landscapes and foods is complex, occurring in deep time and on a variety of scales, from lighter amendments (e.g., the pruning of individual trees or shrubs) to the creation of large-scale anthropogenic landscapes dedicated to increasing access to and output of specific foods. On the Northwest Coast of North American, these anthropogenic landscapes include clam gardens (Lepofsky et al., 2015; Neudorf et al., 2017; Toniello et al., 2019; Smith et al., 2019), forest gardens and managed forests (Armstrong et al., 2021; Armstrong et al., 2023; Earnshaw, 2019), stewarded blue camas (*Camassia quamash*) prairies (Beckwith, 2004; Lyons & Ritchie, 2017; Lyons et al., 2021), fish trap complexes (Caldwell et al., 2012; Letham et al., 2023; Moss, 2013; White, 2006), and estuarine root gardens (Deur, 2000, 2002a, 2002b, 2005; Joseph, 2012; Lloyd, 2011; Pukonen, 2008; Maurice-Hammond et al., 2023). Within this framework, Indigenous Peoples are understood as being deeply engaged in shaping and "sustainably managing plant and animal communities of various scales and at different stages of their life cycles to enhance their productivity" (Lyons et al., 2021, p. 505). These practices, and many of the landscapes associated with them, are ancient, displaying both the ongoing and intergenerational relationship occurring between Peoples and their homelands and the importance of these species on which they depend, the maintenance and care of which often necessitated large engagements of labour and materials through time. However, the concept of scale is important here, with stewardship also occurring at locations that did not require significant alterations, or which could be stewarded by smaller numbers of individuals (Deur, 2000).

1.4. The ecological and cultural importance of wetlands and estuaries

Estuaries occur at the confluence of freshwater sources and the marine environment. They are characterized by tidal brackish inundations and sedimentary deposition, the degree of which influence the development and size of estuarine habitats (MacKenzie & Moran, 2004). Plant species occurring on these sites tend to be salt-tolerant vascular hydrophytes, growing along defined gradients away from the waterline based on their tolerance to waterlogged conditions and saltwater inundation. Unsurprisingly, these places are also nexuses of human use and caretaking, both historically and into the present day (Day et al., 2012; Kennett & Kennett, 2006; Stanley & Warne, 1997).

Estuarine root gardens on the Northwest Coast of North America were built and maintained by Indigenous Peoples over generations to ensure access to culturally and nutritionally important plant foods (Deur, 2000). This is concurrent with global patterns of human-estuarine relationships occurring in deep time. In Central and South America, culturally altered and stewarded wetlands were (and remain) central to life ways and food systems, from the Chinampas raised fields of the Aztec capital of Tenochtitlan (today's Mexico City) (Beach & Luzzader-Beach, 2012; Beach et al., 2015) to the wetland plant cultivation systems of the Amazon rainforest (Krause et al., 2019). In parts of Asia, peoples learned to shift the hydrological processes of wetlands to develop large, terraced rice cultivation complexes which remain key to food systems into the present (Zong et al., 2007; Yunfei et al., 2009). Similarly, in Europe, the "reclamation" of coastlines and estuaries through extensive diking networks and the building of seawalls allowed for early arable land expansion which accelerated in the 15th and 16th centuries alongside population growth (Bazelmans et al., 2012; Nabarte et al., 2022; Oosthuizen, 2017). These wetland plant caretaking systems, furthermore, served a multiplicity of purposes. In the Amazon, for example, raised fields were coupled with complexes of fish traps that served as penning areas for future harvests (Blatrix et al., 2018), representing a node in a vast system of land tenure and management that extended over the entirety of a peoples' territory. On the Northwest Coast of North America, similarly, estuaries were places where Indigenous Peoples would trap fish, harvest shellfish, hunt waterfowl, and grow culturally and nutritionally important plant foods (Mathews & Turner, 2017). Increasing our understanding of locally specific estuarine gardening practices, and the inter-relation of various land-tenure and harvesting activities, not only deepens our understanding of culturally and geographically specific practices but contributes to a broader understanding of the importance of the relationships between Indigenous Peoples and estuaries—past, present, and future.

1.5. Synthesizing the estuarine root garden stewardship literature

As mentioned previously, and aligning with other food stewardship systems on the Northwest Coast of North America, estuarine root gardens building and maintenance occurred on a spectrum, which varied in size, intensity, and specific practices based on local ecologies, resource availability, cultural traditions and the nutritional needs for these root foods. Deur (2000, 2005) produced a detailed review of the evidence for estuarine root gardening in preexisting ethnographic and historical sources pertaining to the BC coast; here, I revisit some of those same facts augmented by references to other literatures – especially those that have emerged in the intervening years (e.g., Lloyd, 2011; Pukonen, 2008). Six main themes regarding estuarine stewardship practices and their cultural and economic importance emerge. These themes, which include specific pedological and ecological manipulations to estuaries, contribution of estuarine root foods to diets, the ceremonial and economic importance of root foods, and ownership patterns governing harvest and consumption, are fundamentally inter-related. Stewardship practices (such as weeding and transplanting), for example, also encompass ceremony, spirituality and social responsibility to human and non/more than human kin (Salmón, 2000; Geniusz, 2015, Kimmerer, 2013). Similarly, ceremonial and economic obligations, such as the potlatch and winter ceremonies, serve a multiplicity of purposes (such as asserting ownership and responsibility over certain food producing areas) that cannot be disentangled from the materiality of caretaking practices.

1.5.1. Building an estuarine root garden

1.5.1.1. Terracing and changes to hydrology in estuarine root garden construction

Stewardship of estuarine root gardens exist on a spectrum, from intensive geo-engineering through terracing and soil mounding to more subtle caretaking practices, such as weeding out competing species, transplanting and replanting propagules, and the removal of rocks and debris in the sediment (Deur, 2000). In places where more intensive alterations were needed to sustain a sufficient quantity of the targeted species, the hydrology of the coastal landscapes was modified through the construction of terracing, which retained mounded sediment at the ideal coastal gradient favoured by the targeted plant foods. These terraces could be constructed out of piled rocks or shaped cedar planks, which were placed on edge into the ground and held up between short posts or pegs, serving the dual purpose of delineating individual plots (Boas, 1934; Deur, 2005). Whether or not retaining walls were present, soil mounding was often employed to extend the growing area for estuarine root foods. In some tidal flats, such as Kingcome Inlet, rockwork was not required to increase the growing area for root foods; rather, churned soils were delineated by more compacted sediments and cedar pegs marking individual plots. As Kwaxsistalla noted, rockwork was necessary to “make flat ground” (i.e., terracing) in places where this was not already naturally occurring (quoted in Deur, 2000, p. 87). Mayanilth, similarly, suggested that soil mounding and rockwork would expand growing areas in places where it was otherwise limited. My recent work in Coast Salish territory suggests that naturally occurring waterlogged coastal sediment, which is dense and resistant to erosion, may have been employed by Indigenous Peoples as a retaining barrier in their root gardens, removing the need for rockwork construction (Maurice-Hammond et al., 2023).

1.5.1.2. *t’aki’lakw* – Making the soil

Soil churning, which occurred as a by-product of harvesting and as its own separate act, was known to both increase porosity and mix in recently deposited tidal or riverine debris, creating “texturally diverse and structurally amorphous soils” (Deur, 2000, p. 89), which were furthermore enhanced by the regular mixing in of organic matter. According to Kwaxsistalla wathl’a (quoted in Deur, 2000, p. 88):

> You’ve got to keep that earth soft...soften it up! You’d ...’’plow” it, I guess... And then you continue on that, digging the soft ground... so it will grow better every year... “fertilizing?” I guess that's... the word for it.

This textural porosity, created through regular soil churning (which homogenized the otherwise distinct depositional strata that otherwise tends to define estuarine sediments) and the addition of organic matter, created loose, uncompacted and organically rich sediments, encouraging the growth of root foods and facilitating their removal during harvest (McIlwraith, 1948). Furthermore, the addition of marine inputs, such as fish carcasses, was a key contributor to the development of organic materials and soil porosity, while also contributing to nutrient inputs. Soil phosphorous (P), specifically, is a key nutrient for plant growth, directly impacting the development of healthy, robust roots and rhizomatic–an area of particular significance for estuarine root foods (Bosman, 2019; Raghothama, 2005). Increases in P within an archaeological context (and in the study of food stewardship places) are primarely related to the addition of bones and other animal parts to the soil, though other organic sources (such as vegetation, e.g. seaweed) were also contributors (Miller & Gleason, 1994).

For the Kwakwa̲ka̲'wakw, estuarine root gardens were known as *t'aki'lakw* or "[places of] human-manufactured soil." "*t'aki'lakw*," because you made that soil. That's what it means, *t'aki'lakw*. It's yours!" (Kwaxsistalla as quoted in Deur, 2000, p. 90). Similarly, Bouchard & Kennedy (1990, p. 464) recorded at least one Nuu-chah-nulth estuarine garden site, with remnant rockwork, as *ts'isakis*, or "place with soil." In both cases, the terminology associated with these stewarded garden grounds is etymologically distinct from naturally occurring root grounds. Additionally, the concept of *t'aki'lakw* fits within a broader understanding of anthropogenic soils, or soils that have altered by peoples through intentional or unintentional action. More specifically, these soils are cultural soils, or soils that reflect the legacies of past actions made by peoples to steward and enhance their landscapes and ecosystems while safeguarding against potential degradations. Alternatively, these could also be described as Anthrosols, which are often associated with past agricultural activities, such as long-term gardening activities (e.g., hortic, plaggic and pretic Anthrosols) and alterations to hydrological regimes (e.g., hydragic or irragic Anthrosols) (FAO, 2015; Lowther, 2022). Describing these as cultural soils aligns with broader ideas of "cultural landscapes," which, in some cases, are associated with comparatively high numbers of culturally important plant species, cultural sites, and higher-nutrient soils (Lepofsky et al., 2017; Trant et al., 2016). These landscapes are the result of long-term relationships with lands, which are rooted in mutual cooperation with other than human kin (Salmón, 2001).

1.5.1.3. Ecological caretaking in estuaries

While some gardens occurred in areas where the targeted plant foods already grew naturally, other areas could be enhanced (and, potentially, created) by "transplanting clover roots from elsewhere" (Edwards 1979, p. 6). Indeed, plant translocation and human-assisted range extension of culturally important species into anthropogenically enhanced habitats is known to have occurred on a wide scale on the Pacific Northwest Coast (Turner et al., 2021). Boas (1934) describes the complete removal of vegetation during the construction of new garden sites, which would then need to be actively revegetated. Other forms of caretaking occurring in estuarine root gardens included weeding out competing and non-edible species. While harvest would occur in the early fall, springtime would mark the time for *siixa* or weeding in Kwak´wala. Kwaxsistalla described it this way: "They sure left it ... just nice and clean. If you see something else coming up [weeds or grasses] you pick it up, root and all, so you don't want it there" (Deur et al., 2013, p. 1). While long, straight roots would be harvested, not all would be removed, thus ensuring the following years' harvest (Edwards, 1979). As Kwaxsistalla explained: "You don't take those little pieces [of root]. You leave them here. They come back. You put them back in the ground 'cause that's going to be your *texwsus* [*Trifolium*] and *tliksem* [*Potentilla*] next year" (Deur, 2000, p. 93). During harvest, soils would be turned over using specialized digging sticks carved out of yew wood, which would loosen the soil and pry out the roots without breaking them (Lloyd, 2011). Mayanilth, in talking about her grandmother's estuarine root plot near the village of Haada, described peoples using digging sticks to push marsh soil together to "extend it…to make their gardens bigger" (quoted in Deur, 2000, p.84).

1.5.3. Contributions of root foods to traditional diets

Today, we know that plant foods played a large role in traditional diets in British Columbia (Turner, 2020b; Turner & Turner, 2008). Estuarine root gardens, which could provide large and stable outputs of root foods (Figure 2), were a particularly valued part of these systems. *A. egedii* and *T. wormskioldii* rhizomes were an important source of carbohydrates, an often-limiting factor in an otherwise protein rich diet (Boas & Hunt, 1921; Edwards, 1979; Turner & Kuhnlein, 1982). Furthermore, these gardens contributed to nutritional risk reduction, providing a relatively stable source of food in times where other resources were less reliable. Edwards (1979), for example, talks of Nuxalk Peoples surviving a famine[9] by travelling from marsh to marsh in search of *T. wormskioldii* rhizomes. Additionally, estuarine root gardens often served an important nutritional dual purpose as waterfowl hunting grounds. Waterfowl, who also rely on *A. egedii* and *T. wormskioldii* roots and rhizomes as a food source, were attracted to the gardens, where they would then be captured by hunters who had set up traps to protect their root grounds from predation (Edwards, 1979; Turner & Kuhnlein, 1982). According to Deur (2000, p. 97),

[9] The exact cause of the famine was unspecified, though the knowledge holder, Margaret Siwallace, specified that it occurred in the winter and in a time before contact. According to Margaret, people lived in a raft or float house (*awanaaxkw*) that could be moved to different tidal flats. A fire would be lit on the side, on rocks, which would thaw the ground enough to be able to dig for clover roots. "From the little they dig from there, that's what kept them alive– the clover roots." (Edwards, 1979, p. 11).

many garden sites continued to be used as waterfowl hunting grounds into the 20th century, long after active plant stewardship practices in these places had ceased, paralleling Armstrong et al. (2021)'s findings on the ongoing use of traditionally stewarded forest gardens and village sites by community for ungulate hunting.

Figure 2. Springbank clover rhizomes (*Trifolium wormskioldii* Lehm) (left) and Pacific silverweed rhizomes (*Argentina egedii* (*Wormsk*.) Rybd.; syn. *Potentilla pacifica* (L.) Howell) (right) removed from a 1m x 2m unit at the Tl'chés estuarine root garden in 2023. This volume of food shows how productive these gardens still are, even though more than a century has passed since active stewardship occurred at the site.

Though estuarine root foods could be eaten raw or steamed, they could also be dried, bundled and stored to provide ongoing sustenance over the leaner winter months (Boas, 1908, 1910b). Amongst the Kwakwa̱ka̱'wakw, rhizomes storage areas were commonly located under the seating areas of household or clan chiefs (Boas, 1888, 1909). In Nuxalk territories, rhizomes could be kept fresh in cedar bentwood boxes filled with marsh soil, mimicking the processing of harvesting directly from the garden (Edward, 1979). Bentwood boxes were often also used for cooking estuarine root foods, which could also be steamed in underground pits, a practice known as pit cooking (Boas & Hunt, 1921; Curtis, 1915), which is seeing a revival and is still used today to prepare culturally important foods (Joseph & Turner, 2020). Notably, though the ethnographic and archaeological literature on the Northwest Coast has long focused on the importance of storing marine foods and its role in increasing cultural complexity and stability (for more, see Ames, 1991; Matson & Coupland, 1995), accounts of plant storage remain relatively rare.

1.5.4. Estuarine roots foods as locus for ceremonial life

Accounts in the ethnographic literature, as well as information shared by Indigenous Elders and Knowledge Keepers, highlight the importance of estuarine root foods in peoples' cosmological, cultural, and economic lives. Haskins (1934, p. 28) noted that *T. wormskioldii* rhizomes held a "prominent…place in the tales in myths of Coast Indians from Oregon to British Columbia." Amongst the Kwakwaka'wakw Peoples, rhizomes were described as an important source of sustenance for ancestral beings in the time before the transformers, when the world was still dark and chaotic. They were also the preferred foods eaten by ancestral and supernatural beings inhabiting the spirit world (Boas, 1934; Boas & Hunt, 1902; Deur, 2000; Haskins, 1934). Estuarine root crops were also the focus of feasts, winter dances, and potlatches. In Kwakwaka'wakw and Nuu-chah-nulth territories, entire feasts were dedicated to the consumption of either *A. egedii* or *T. wormskioldii* (Boas & Hunt, 1921; Drucker, 1951). Drucker (1951, p. 62), in his work with the Nuu-chah-nulth, notes his collaborators' pride at the scale of their ancestor's rhizome production and feasts, describing piles of rhizomes so tall that young men would have to climb onto the roof of longhouses to pour water down to steam them. The preparation and serving of these root foods would be accompanied by the owners of the plots from which these roots had been harvested recounting the lineage through which they were inherited (Deur, 2000).

1.5.5. Ownership patterns of estuarine root gardens and status implications

Like with other plant stewardship areas on the Northwest Coast[10], many estuarine root garden plots were cared for inter-generationally, with certain prized root grounds under the caretaking of

[10] Examples of plant ownership systems include the governance of blue camas (*Camassia quamash*) amongst Salish Peoples, where an individual family's plot would be clearly delineated within a wider area that was owned and stewarded by the village or clan. These plots were often inherited along the matrilineal line, and unauthorized harvesting from another's plot was strictly prohibited (Jenness, 1934-35; Suttles, 1974). Similar ownership patterns

a household or clan chief, while smaller plots were owned and cared for by family groups (Boas, 1934; Deur, 2000). Though root foods would often be redistributed amongst the community by chiefs, with the families stewarding the plots retaining some portion of their harvest, it was understood that these places were not to be trespassed without invitation. “[P]eople didn’t just go pick anywhere; they had those [cedar] markers. If they weren’t yours, you don’t pick there” (Kwaxsistalla, quoted in Deur, 2000, p. 54). This concept of ownership over root grounds or plots came with the inherent responsibility of caring for and enhancing these places for future generations, fitting within the broader framework of caretaking as an act of reciprocity towards human and non/more than human kin (Deur, 2000; Salmón, 2000). Additionally, accounts indicate that ownership of prime root garden sites was strictly enforced, dictating both who had access to and was responsible for the plant communities. In Nuu-chah-nulth territory, for example, Turner et al. (1983) describe a chief using several slaves to defend his garden from unauthorized harvesting.

Long, straight *A. egedii* and *T. wormskioldii* roots and rhizomes were highly prized and associated with high status (Boas & Hunt, 1921). Amongst the Kwakwa̱ka̱'wakw, it was considered essential that roots not be broken during harvest, with broken roots being a source of shame amongst harvesters (Deur, 2000). The longest and straightest roots of every harvest would then be set aside for the chief’s use and consumption (Boas & Hunt, 1921). Indeed, a term for chief in Kwak´wala, which was often used in ceremonial contexts while discussing lineages and ancestors, could roughly be translated to “the thick root of the tribe” (Boas, 1940, p. 235). Significantly, places capable of producing these long straight roots would have been characterized by deep and uncompacted soils, markers of a well-tended and productive garden governed through chiefly tenure systems. Comparatively, small, broken or gnarled roots would be associated with more compacted digging conditions, making it challenging for harvesters to fulfill both nutritional needs and ceremonial obligations, with social status implications (Boas, 1940; Deur, 2000). Indeed, small, gnarled rhizomes, the places that produced them, and the people that encountered them, were associated with supernatural misfortune (McIlwraith, 1948, p. 537).

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are noted for wapato (*Sagittaria latifolia*) plots amongst the Katzie Peoples (and other Salish Peoples) (Darby, 1996; Suttles, 1974; Suttles et al., 1956) and Haida tobacco (*Nicotiana quadrivalvis*) gardens (Deur, 2000).

1.5.6. Estuarine root foods in the fulfilment of trade and ceremonial obligations

As noted above, economic and ceremonial activities often cannot be separated on the Northwest Coast. Important ceremonial events, such as potlatches, were also economically and politically important events, where chiefly peoples put their wealth and prestige on display and formed important alliances with neighbours and guests. The ownership of highly productive garden sites, a symbol of wealth and responsibility to the many human and more-than-human kin relating to these plants and foods, could also be translated to the accumulation of wealth through trade. Some Kwakwaka'wakw peoples travelled hundreds of kilometers by canoe to trade surplus root foods in kin-based trade networks (Turner & Bell, 1971). Kwakwaka'wakw elder Mayanilth, for example, described how her ancestors in the village of Haada "used to plant enough [*Trifolium*, *Potentilla* and *Fritillaria*] to trade with the northern people…the northern people would come and trade with them…[the Heiltsuk and the Nuxalk]" (quoted in Deur, 2000, p. 17). Boxes of rhizomes could also be traded to fulfill ceremonial obligations, such as helping pay for a bride price, or in exchange for a high prestige item, such as a copper shield (Boas & Hunt, 1921; Boas, 1910).

1.6. Colonial perceptions of plant harvesting practices and impacts on Indigenous land rights

1.6.1. Colonial and ethnographic perceptions of plant caretaking practices on the Northwest Coast

The written observations of plant caretaking sites and practices on the Northwest Coast by early colonists and anthropologists are, today, an important source of information regarding specific stewarded sites and practices (e.g., Boas, 1934; Boas & Hunt, 1921; Menzies, 1923). Paradoxically, however, these observations often came coupled with strenuous denials that Indigenous Peoples managed or significantly altered their environments for the purposes of plant stewardship. For example, Archibald Menzies, the chief botanist aboard Captain Vancouver's expedition on the coast, noted in his journal on September 4, 1792, that:

> In the evening our curiosity was excited in observing a number of Females busily occupied in digging up a part of the Meadow close to us with Sticks, with as much care and assiduity as if

> it had been a Potato field, in search of a small creeping root ... of a new species of *Trifolium* which they always dig up at this time of year for food. Wherever this *Trifolium* abounds the ground is regularly turned over in quest of its Roots every year." (Menzies, 1923, p. 116).

Menzies, here, was describing Nuu-chah-nulth women stewarding a *T. wormskioldii* garden, ensuring the yearly return of a key food crop by utilizing methods that would have been familiar to the observing Europeans: tilling soils, removing stones and woody debris, and replanting propagules. Despite this, Captain Vancouver made sure to note in his accounts that he had "no reason" to believe that the landscapes that he encountered on his travels had been influence by "the hand of man" (quoted in Haig-Brown, 1967, p. 227). Less than a century after Menzies observed estuarine root gardening on Nuu-chah-nulth territories, Indian land commissioner Gilbert Sproat (1868, p. 8), when speaking of that Nation, declared that:

> Any right in the soils which these natives had as occupiers was partial and imperfect as, with the exception of hunting animals in the forest, plucking wild fruits, and cutting a few trees…*the natives did not in any civilized sense, occupy the land* [emphasis my own].

This pattern – observing and describing plant caretaking practices while simultaneously denying their existence – was, until recently, a key element of anthropological narratives on the Northwest Coast. Franz Boas (1934), for example, similarly described plant caretaking practices in detail (for example, he wrote about the Gwa'ni[11] (Nimpkish) River estuarine root garden and drew a map delineating individual named plots) while also insisting that Indigenous Peoples on the Northwest Coast were a fully "non-agricultural" people (Deur, 2002a). For Boas, Indigenous Peoples on the Pacific Northwest Coast could best be understood as "complex hunter-gatherers," who flaunted the dominant cultural evolution models of the time which presupposed that agriculture was the key precursor to social complexity, as it was then understood within European academic circles. Believed to rely primarily on abundant salmon runs, it was declared that they "did not rely heavily on plant foods" (Huelsbeck, 1988, p. 166).

[11] Gwa'ni is the 'Na̲mgis name for the Nimpkish River in Kwak'wala, the language of the Kwakwa̲ka̲'wakw Peoples. The name Nimpkish, which was ascribed by settlers, is an anglicized derivation of 'Na̲mgis. Gwa'ni comes from Gwa'nalalis, a man who was transformed into the river by the supernatural being K̲´aniki̲'lakw̲ (Boas, 1934).

1.6.2. The perennial paradox, *terra nullius,* and land theft

This tension – observing and describing plant stewardship practices while simultaneously denying their existence – can partly be explained by the inability of early colonists and settlers to identify practices of plant stewardship that did not mimic the linear, seed-based, mono-cropped fields of their native Europe. This is what Turner & Peacock (2005) termed the "perennial paradox" – the long-standing inability of European colonizers (and, later, academics) to recognize practices of plant stewardship centered around the tending of perennials instead of annual, seed-grown plants. Furthermore, the dominant academic beliefs at the time dictated that plant cultivation in the Americas has had emerged from Mesoamerican seed crops (Deur & Turner, 2005), which was then dispersed through pre- and post-colonial trading networks. Today, we know that plant stewardship systems in the Americas (and globally) have multiple distinct origins (Larson et al., 2014; Piperno, 2011; Wallace et al., 2019). This reluctance, or resistance, to recognizing Indigenous productivity, ecological knowledge, and economy is rooted in the foundations of colonialism.

The colonial categorizing of Indigenous Peoples as non-cultivators, specifically, placed them under the doctrine of *terra nullius*.[12] If these lands were truly "empty," then expropriating them for settler use could hardly be categorized as theft. However, for this concept to apply, a mechanism was needed to justify this apparent "emptiness." These metrics for dispossession and theft of lands–already prevalent within European Nation States and in relationships to their colonies–were best articulated (and justified) by 17th century colonial philosopher John Locke (1698), who argued that possession and the "taming of nature" functioned in lockstep (Blomley, 1998, p. 573). Within this ideological framework, land that was "uncultivated" could not truly be said to belong to anyone, and certainly not to Indigenous Peoples who were so evidently misusing it (Locke, 1968). According to Armitage (2012), this idea was most succinctly taken up by Swiss jurist Emer de Vattel (1759, p. 81), who argued that peoples who:

[12] The Latin term *terra nullius*, which translates the "empty land," is borrowed from Roman law and describes land that does not have a sovereign. This term was incorporated into British Law and used to assert sovereignty onto Indigenous territory through the Doctrine of Discovery, which would allow settlers to acquire land that was seen as "empty" (i.e., un-stewarded) (for more on this see Armitage, 2012; Spalding, 2022).

> to avoid labour, chuse to live only by hunting, and their flocks' pursued an 'idle mode of life, usurp more extensive territories than … they would have occasion for, and have therefore no reason to complain, if other nations, more industrious, and too closely confined, come to take possession of a part of those lands.

"Uncultivated" lands, in other words, did not truly belong to the peoples inhabiting them. Indeed, land theft by settlers who would "better" it through agriculture was not only appropriate – it was morally justifiable (Armitage, 2012). Within the context of accelerating imperialism, Indigenous stewardship practices, which left traces on the landscape that settlers either could not or were unwilling to recognize, became synonymous with "vacant possession, tactic invitations to colonial possession and appropriation" (Gregory, 2001, p. 95). In British Columbia, these beliefs crystalized during the McKenna-McBride Royal Commission (1913-16), which was largely responsible for the allocation of reserve lands for Indigenous communities. Colonial and racist biases, and a desire to acquire territories for colonial expansion, resulted in a decision declaring that the majority of traditional territories were not "reasonably required" for the survival of Indigenous communities, who were allotted small reserves, usually at the site of villages or camps. The rest of traditional territories were claimed by the Crown, who then divided up the land and leased it out to industries (such as logging companies), a process that continues to this day (Dick et al., 2022). Despite testimony from Indigenous chiefs describing the importance of plant caretaking and harvesting sites, most of these key places were put down as "proposed" or "potential" cultivation areas, discounting long-standing Indigenous land tenure systems and undermining Indigenous food sovereignty and security (McKenna-McBride, 1913-16). This included many known and actively stewarded estuarine root gardens. Additionally, in this period, many important plant stewardship places were specifically targeted for destruction by colonial authorities to undermine Indigenous sovereignty and land claims. Deur et al., (2013), for example, describe a retaliatory attack by two British gunboats against ʕaaḥuusʔatḥ Nuu-chah-nulth Peoples in Clayoquot Sound, where oil was poured over estuarine root gardens before setting them ablaze, destroying the year's harvest and damaging garden structures and soil health (see also Fisher, 1994, p. 168). Other accounts suggest settlers attacking and burning down digging houses associated with estuarine root gardens, further challenging Indigenous Peoples' abilities to claim these places as part of allocated reserve lands (Deur et al., 2013).

Tidal flats–rare areas of open, productive, and flat land on the mountainous coast–were often amongst the first to be appropriated by settlers for livestock grazing or diked for orchards (Dick et al., 2022). Kwaxsistalla (quoted in (Dick et al., 2022, p. 556), when talking about the vast estuarine gardens of his home in Kingcome Inlet, discussed the settler processes of expropriation which resulted in his community no longer having access to their ancestral plots:

> "where the Halliday farm is now, took all over…They claimed that, and that's what happened. And after that, it disappeared. They quit doing that [tending their root gardens] when the Halliday's went up there and cleaned up that whole flat."

Loss of access to these important landscapes was compounded by a rapid nutrition transition within Indigenous communities in North America and on the Northwest Coast. Demographic collapse and contraction in early contact periods–and the loss of knowledge, labour, and chiefly rights associated with this–forced the abandonment of key stewarded places (Boyd, 1990; Deur, 2000). Residential schools were a key component in this process, separating children from traditional teaching and foods and exposing them to a nutritionally poor environment, often creating dysfunctional relationships with food in the process. Additionally, the forced transition of Indigenous Peoples into wage economies lessened opportunities to harvest and care for (already contracted) stewarded landscapes, contributing to the cessation of active caretaking and the adoption of imported and refined marketed foods, often with negative health implications (Joseph, 2012; Joseph & Turner, 2020; Kuhnlein et al., 2013). Even in cases where direct loss of access to estuaries wasn't a compounding factor, the rapid adoption of productive introduced foods such as the potato (*Solarium tuberosum*) rapidly eclipsed traditional estuarine root crops. Indeed, potato stewardship, in many cases, was described as almost identical to estuarine root food management, with traditional estuarine root gardens being adapted to this new crop (Deur, 2000; Suttles, 1951).

1.6.3. Cumulative losses and habitat disruptions

Over the last almost two centuries since colonization began on the Pacific coast of North America, the rights of Indigenous Peoples to access and steward their culturally important species and landscapes have been impacted by multiple factors, the harms of which are cumulative, ongoing, and difficult to quantify. These includes, for example, the forced removal of Indigenous Peoples from traditional territories and the theft of lands that occurred through the reserve system and accelerated with the imposition of the residential school system, profoundly affecting family and community dynamics. Furthermore, the denigration and prohibition of traditional food systems, the imposition of extractive industries like fisheries and forestry onto territories and communities, and the pressures put onto communities to fold into an increasingly dominant capitalist labour system and cash economies furthermore limited peoples' time and abilities to access, steward and harvest traditional foods as they had previously (Joseph & Turner, 2020; Kuhnlein & Receveur, 1996). This, in turn, has impacted Indigenous Peoples' health, food security, and food sovereignty, leading to a nutritional transition and the decline of stewarded systems that required human caretaking to flourish (Dick et al., 2022; Joseph, 2020; Joseph & Turner, 2020). In estuaries, as elsewhere, these impacts were significant. Beyond land theft and expropriation by settlers, which affected Indigenous Peoples' abilities to return to their traditionally stewarded estuaries, modifications to the estuaries themselves since colonization began have led to significant sedimentation and hydrological changes, impacting the long-term survival of culturally important plant communities and legacy ecosystems (Dick et al., 2013; Maurice-Hammond et al., 2023; Vanier et al., 2025).

The research in this dissertation is, in large part, a direct result of concerns surrounding these ingoing colonial impacts to estuaries. Today, the harvest of important foods, such as *A. egedii*, *T. wormskioldii* and *F. camschatcensis* is not less intensive merely because of cultural changes; rather, the ability of people to harvest these plants has been altered by the elimination of "the anthropogenic habitats necessary to provide safe, viable subsistence quantities of these food products" (Dick et al., 2022, p. 559). Impacts to estuarine sites, which have led in the gradual decrease of their productivity over time (or, in some cases, their complete alteration), are ongoing, cumulative, and have been accelerated by the rapid urbanization of the southern coast of British Columbia, resource extraction practices (e.g., logging and log dragging through estuaries, dredging to create deep water harbours), and industry (e.g., the building of pulp mills and effluent processing facilities) (Staveren et al., 2006). These pressures are only increasing under anthropogenic climate change, where rising sea levels and increased storm surges are threatening to make our estuaries unrecognizable over the next century (Cruz et al., 2018; Thorne et al., 2018). This research, then, is both timely and urgent.

1.6.4. Resurgence and the renewal of Indigenous stewardship practices

This work exists in a colonial context of cumulative harm and ongoing loss. However, it also exists in a context of renewal, with Indigenous communities working hard to re-connect and renew governance and stewardship over their landscapes and important food sources (Joseph, 2020; Joseph & Turner, 2020). This is the work of Indigenous resurgence, which is “about reconnecting with homelands, cultural practices, and communities, and is centered on reclaiming, restoring, and regenerating homeland relationships” (Corntassel & Bryce, 2012, p. 153). Renewing stewardship and harvesting practices is an “act of radical resurgence, and thereby also a means of resistance” (Joseph, 2020, p. 173). Relationships to land are re-affirmed and community bonds are strengthened through protocol, ceremony, inter-generational sharing, and time spent together on the land. It is within this context that many communities are working to restore relationships to land and to important food sources. Examples of this abound, exemplified in collaborative or Indigenous-led restoration and renewal of traditional clam gardens (Augustine, 2025; Horwedel et al., 2025; Larson, 2023) and the continuation and restoration of camas harvesting practices in Lək̓ʷəŋən and many other Indigenous territories (Corntassel & Bryce, 2012; Proctor, 2013). Cumulatively, these practices represent a continuation of care for traditional territories, and an assertion that this care will continue to grow and extend into the future. In many of these instances, the work is led by communities but done in collaboration with interdisciplinary research partners, showcasing how western scientific research that is committed to upholding Indigenous knowledge systems and centering Indigenous decision making can be used to uphold:

> “an Indigenous land care ethic that is embedded in specific Indigenous territories, languages, and ways of relating to land and embodies principles of respect, reciprocity, and responsibility” (Dickson-Hoyle et al., 2022, p.4).

1.7. Impetus for this research project/what don’t we know about estuarine root gardens

Today, knowledge about the specific location of certain estuarine root gardens and associated caretaking practices remains in some descendant communities and with certain knowledgeable individuals (such as Kwaxsistalla). This knowledge, however, has been impacted by colonialism and its ongoing effects on Indigenous communities and cultural landscapes. As such, specific root grounds may no longer be known in communities, especially when pertaining to smaller sites, areas more peripheral within traditional territories and seasonal rounds, and places where estuarine root gardens perhaps represented a smaller, though no less culturally important, element of traditional food systems (Maurice-Hammond et al., 2023). In Coast Salish territories, for example, comparatively little information exists about the specific locations of estuarine root gardens or practices associated with them. However, we do know that the foods grown in these places were prized and culturally important. SENĆOŦEN, the language of the W̱SÁNEĆ Peoples, has specific words for both *A. egedii* and *T. wormskioldii*, with associated knowledge of harvesting sites, which appeared to have been most plentiful on some of smaller offshore islands (Gunter, 1945; Suttles, 1974). The late Christopher Paul of W̱JOȽEȽP (Tsartlip First Nation) recalled his father digging *A. egedii* roots at SELEꝀTEȽ (the Goldstream estuary), one of the few relatively intact ecosystems of its kind in W̱SÁNEĆ territories (Turner & Bell, 1971, p. 87). In Lək̓ʷəŋən territories (today's Songhees and Xʷsepsəm First Nations, on whose territories Victoria, British Columbia's capital city, was built), a spit of land still bears the name of Clover Point, so named for the "large area of ground […] covered with a species of red clover, growing most luxuriantly" (James Douglas quoted in Walbran, 1909, p. 96), though the native *T. wormskioldii* that he was referring to has since been extirpated (Turner, 1999a). Despite the culturally, economically and ceremonially importance of *kwetlal* (the Lək̓ʷəŋən word for blue camas, *Camassia quamash* and *Camassia leichtlinii*) in Coast Salish territories[13], trade and familial ties with other communities whose territories, cultures and ecosystems supported the presence of larger estuarine root gardens would have insured the presence of these foods in stewarded places and traditional diets (Turner & Bell, 1971).

However, and despite the information listed above, knowledge about specific estuarine root garden sites in the Coast Salish remains elusive. This gap can be attributed, in part, to early and persistent colonial pressure on the southern coast of British Columbia and the Northwestern United States, driving early waves of deadly epidemics and other large-scale disruptions in and

[13] For more the importance of *kwetlal*, and the processes associated with its stewardship, see Beckwith, 2004; Corntassel, 2024; Lyons & Ritchie, 2017; Proctor, 2013; Suttles, 1974, 1997.

between communities (Boyd, 1994; Lutz, 2008, 2010). The severe impacts of these epidemics, which resulted in dramatic demographic contractions and population relocations (sometimes resulting in communities amalgamating), affected knowledge transmission systems (i.e., estuarine root garden locations, rights and responsibilities to plots, and specific stewardship techniques) and, in many cases, led to the partial or complete abandonment of these gardens. Estuarine plots located in more peripheral areas within territories (and/or less productive areas) would likely have been abandoned earlier, while productive plots closer to population cores might have continued being cared for and harvested from at lower intensities into the 20th century (Deur et al., 2013; Dick et al., 2022)[14]. In the Coast Salish, large settler populations, high rates of urbanization, and the associated destruction of important food harvesting sites are an ongoing legacy of this early colonial pressure, with estuaries being disproportionally impacted. Today, roughly 85% of estuaries on the British Columbia coast have been significant altered or destroyed altogether due to industry and so-called "development" (Janousek, 2024). These compounding and cumulative effects make it challenging for descendant communities to locate and re-connect with these ancient food producing landscapes. It is highly significant, therefore, that an estuarine root garden site was positively identified in Ləkʷ̓əŋən territories as part of this doctoral work (Maurice-Hammond et al., 2023), a first in Coast Salish territories (more on this in Chapter 3).

Comparatively, more information exists about the specific locations of estuarine root gardens on the west and north-eastern coasts of Vancouver Island and the adjacent mainland. Accounts from Pacheedaht territories (Turner et al., 1983), Tseshaht and Hupačasath territories (Sapir, 1914) and ʕaaḥuusʔatḥ (Ahousaht) territories (Pukonen 2008) (amongst other examples found in Nuu-chah-nulth territories) describe the location of garden sites, as well as practices associated with their stewardship and ownership (Bouchard & Kennedy, 1990; Deur, 2000).

[14] At the Gwa'ni (Nimpkish) River estuarine root garden in 'Na̱mgis First Nations territories, for example, the continued use of the anthropogenically elevated and terraced tidal island, and its associated village, 'Kagis, represented an adaptation to shifting demographic changes and the amalgamation of 'Na̱mgis Peoples to 'Ya̱lis (Alert Bay on Cormorant Island) in the 1860's and 1870's. At that time, occupation of 'Kagis became primarily associated with salmon fishing, despite it having been built previously as a place shifted for stewarding and harvesting estuarine root foods (i.e., digging houses, as identified by Kwakwa̱ka̱'wakw elder Mayanilth) (Deur, 2000; Ham & Howe, 1983). Though occupation of 'Kagis would likely have been associated with some level of estuarine root foods harvest, it was likely minimal, ceasing when occupation of the village ended (though this exact timelines is unknown, arial imagery of the island taken in 1930 show what appear to be intact houses at 'Kagis; as such, I would tentatively place the date for abandonment at 1940-50's and onward) (National Air Photo Library, A7239).

Similarly, in Kwakwaka'wakw territories, limited ethnographic information about estuarine root garden locations (e.g., Boas, 1941) has been significantly enhanced by the knowledge of key Elders and Knowledge Holders, such as Kwaxsistalla, who shared information and memories about his family's gardens in Dzawada'enuxw territories with key friends and collaborators (Deur, 2000, 2005; Deur et al., 2015; Dick et al., 2022; Lloyd, 2011). However, ecological changes resulting from a century of colonially-driven impacts, with associated disruptions to traditional diets and harvesting practices, is making it more difficult for descendant communities to reconnect with the estuarine root grounds of their ancestors, especially ones that might have been smaller or more peripheral within traditional territories (Dick et al., 2022; Joseph & Turner, 2020; Turner & Turner, 2008).

In British Columbia, archaeological sites and cultural heritage are governed under the Heritage and Conservation Act (HCA), which offers limited protection to sites shown to pre-date 1846, when the province was officially established as part of the British colonial empire. Designation of places as archaeological sites, however, relies on the recovery of specific forms of material culture, which can be described as the physical expressions of Indigenous Cultural Heritage (ICH). However, "physical expression of ICH may be less important than their intangible aspects" for communities (Schaepe, et al. 2020, p. 14). In other words, the importance of a place for Indigenous Peoples is not necessarily tied to its recognition as an archaeological site within the HCA, which tends to discount places of intangible heritage (Schaepe et al., 2020; Nicholas, 2022). Furthermore, amongst archaeologists and cultural heritage practitioners in coastal British Columbia, broader difficulties surrounding the identification of ancient plant stewardship landscapes play out in the identification of estuarine root gardens.[15] The focus on material culture means that their recognitions depends on the presence of physical and enduring markers of stewardship, such as rock walls–which, as discussed previously, were not always present or, indeed, desirable (Deur, 2000; Maurice-Hammond et al., 2023).[16] More subtle

[15] Lepofsky & Lertzman (2008, p. 130) suggested that biases against the presence of significant plant stewardship practices on the Northwest Coast, combined with their overall "light footprints," has resulted in their under-representation within archaeological research and literature.

[16] The presence of "clear" markers of estuarine root garden stewardship, such as rockwork, has not always been enough to ensure the identification of these places as estuarine root gardens. Deur (2000, p. 184) notes that, in his review of recorded rock wall features, most had been categorized as "fish traps," despite their position in the high intertidal making them completely unsuitable for this purpose. Furthermore, the dynamic depositional and ecological nature of estuaries means that even when intact rockwork is present, locating it can be a challenge. Ham & Howe (1983, p. 40),

markers of stewardship, such as changes to sediment structures or plant communities, are rarely considered, leading to the under-identification of these places and a lack of protection under the HCA, a particularly grievous fact considering how at-risk estuaries are in Coastal British Columbia (Kennish, 2021; Olivares-Aguilar et al., 2022; Reeder et al., 2013). Beyond impacting the protection of these places, challenges in identifying the precise locations of estuarine gardens within traditional territories may have legal implications, with archaeological and cultural knowledge being a cornerstone of supreme court cases arguing for Indigenous Rights and Title over their traditional territories (see Delgamuukw v. British Columbia, 1997; Tsilhqot'in Nation v. British Columbia, 2014; Nuchatlaht v. British Columbia, 2024). As such, providing observable material evidence for practitioners and community members seeking to identify estuarine root gardens within traditional territories can have an impact on land rights, the renewal of traditional food systems and environmental stewardship, and the protection of these places in a climactically uncertain future (Joseph, 2020; Reeder et al., 2013).

1.8. Research questions

Taking into consideration these knowledge gaps, the priorities of Indigenous communities to reconnect with traditional foods and harvesting areas, and the significant and ongoing vulnerabilities of coastal and estuarine landscapes, this research proposes a novel methodology to aid in the identification of estuarine root gardens, especially in areas where locations and specific practices are no longer known by communities. Crucially, this involves developing my understanding of post-stewardship ecological, pedological and archaeological site histories, allowing me to pick up on enduring indicators of estuarine root garden stewardship. I begin with the supposition that there will be both similarities and variability among root gardens across both time and space. Gardens may be as variable as the peoples and landscapes in which they were made and used, based on local culture practices, as well as physical, biological, and ecological factors. Anticipating this variability, I also expect that commonalities in estuarine root garden stewardship practices across regions (such as weeding, soil amendments, terracing, etc.) will leave lasting and tangible markers on landscapes, persistent ecological, archaeological, and

in their archaeological study of the Gwa'ni (Nimpkish) estuarine root garden in 'Namgis territories, were "unable to locate any distinct boundaries between garden plots," though such boundaries were further excavated in 2023 as part of this doctoral research (for more on this, see Chapter 4).

pedological signatures that thread through all estuarine root garden sites (Trant et al., 2016; Armstrong et al., 2021; Hoffman et al., 2016). As such, my research questions are as follow:

1. *Estuarine root gardens are the result of long-term and intentional processes of building, maintaining, and expanding physical garden structure, which included soil amendments and terracing. As such, are there archaeologically and ecologically detectable soil and structural characteristics that define estuarine root gardens?*
2. *Traditional plant management practices, such as weeding competing species and transplanting/replanting rhizomes, had the intention of promoting the abundance and density of key plant species. As such, do estuarine root gardens still maintain distinct ecological characteristics, as compared to ecologically/hydrologically similar places that were under different management regimes?*
3. *Recognizing the likely impacts of local cultural and ecological variability on estuarine root garden composition and stewardship, what are the ecological, pedological and archaeological post-stewardship trajectories of estuarine root gardens, and how may they differ in varying ethnolinguistic and biogeoclimatic estuarine root garden settings?*

1.9. Three Vancouver Island research sites

To answer these questions, three comparative estuarine root gardens were chosen for investigation. These root gardens occur in different cultural, environmental, and hydrological contexts, and vary furthermore in both scale and existing knowledge about past management practices (Figure 5). The first, on the coastal archipelago of Tl'chés (Chatham and Discovery Islands) in Lək̓ʷəŋən Coast Salish territories, is small in scale and no longer known as a food stewardship place by descendant communities, despite still supporting a small but dense community of *T. wormskioldii* and *A. egedii*. The estuarine root garden at Tl'chés is located off a low-energy tidal bay and fed by a perennial stream that drains from an adjacent shallow pond (Figure 3). The archipelago of Tl'chés is one of the southernmost places in British Columbia, extending out into the Strait of Juan de Fuca. It is also a Cultural Keystone Place (CKP), or a place:

> with high cultural salience for one or more groups of people and which plays, or has played in the past, an exceptional role in a people's cultural identity, as reflected in their day to day living,

> food production and other resource- based activities, land and resource management, language, stories, history, and social and ceremonial practices (Cuerrier et al., 2015, p. 431).

Figure 3. Aerial drone image taken in 2021 of the estuarine root garden on the archipelago of Tl’chés (Chatham and Discovery Islands), Lək̓ʷəŋən Coast Salish territories (Credit: D. Mathews).

The second estuarine root garden investigated as part of this doctoral research is located on a tidal island at the mouth of the vast and salmon-bearing Gwa’ni (Nimpkish) River in ‘Na̲mg̲is Kwakwa̲ka̲'wakw territories, north-eastern Vancouver Island (Figure 4). Unlike the garden at Tl’chés, the Gwa’ni estuarine root garden is still known today by the descendant ‘Na̲mg̲is community. Its rock walls and distinct, named garden plots were recorded by Boas (1941) and, later, re-visited by Ham and Howe (1983) and Deur (2000). These successive visits make it possible to trace how this landscape has changed in the last century, aiding in our understanding of the post-active caretaking ecological, pedological, hydrological, and archaeological processes affecting these sites.

Figure 4. Aerial drone image of the estuarine root garden tidal island at the mouth of the Gwa’ni (Nimpkish) River taken in 2022 by D. Mathews.

The third estuarine root garden site considered in this doctoral research is located on Tsinwilht’as (Anderson) Creek in ʕaaḥuusʔatḥ Nuu-chah-nulth territory on the west coast of Vancouver Island. Significantly, this site was not included in the fieldwork of this dissertation; rather, inclusion is based off the archaeological impact assessment (AIA) led by Jim Stafford (2020), and the subsequent discovery of a multi-tiered and walled estuarine root garden site. Though the methods described below (Table 1) could not be equally deployed at this garden site, it does provide an important point of comparison in a culturally and ecologically distinct area, contributing to our wider understanding of estuarine root garden site formation processes.

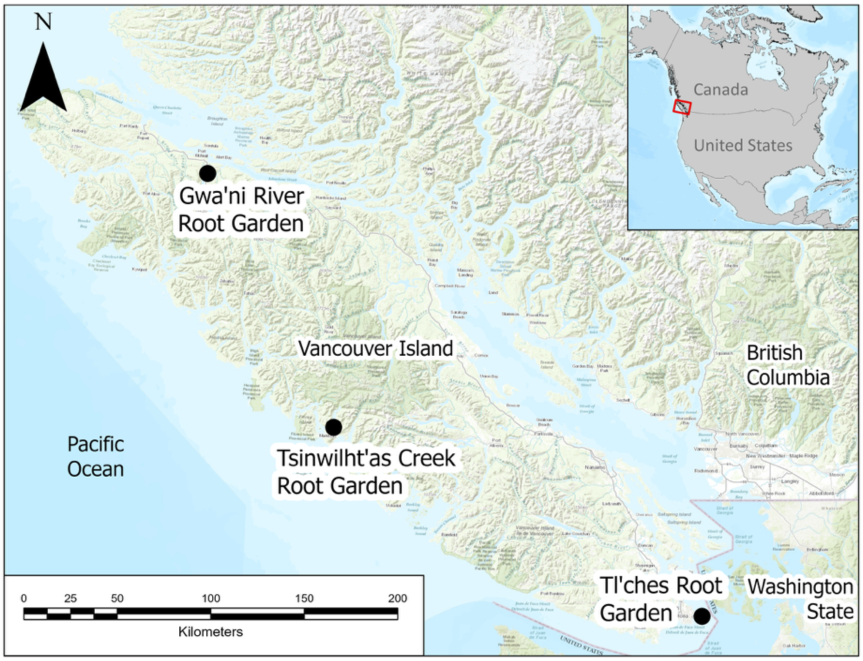

Figure 5. Map showing the three estuarine root gardens discussed in this dissertation on Vancouver Island, British Columbia, Canada. From north to south: The Gwa'ni (Nimpkish) River estuarine root garden in 'Namgis Kwakwaka'wakw First Nation territories; the Tsinwilht'as (Anderson) Creek estuarine root garden in ʕaaḥuusʔatḥ Nuu-chah-nulth territories; and the Tl'chés estuarine root garden in (Chatham and Discovery Islands) in Ləkʷəŋən (Songhees) First Nation territories (Credit: D. Mathews).

1.10. Methodological approach

1.10.1. Guiding framework

The methods used to draw data from the root garden sites and the periphery sites are grounded in existing knowledge about estuarine root garden stewardship, which is itself drawn largely from knowledge shared by Elders and knowledge keepers. This methodological approach is outlined in the table below (Table 1). Methods and expected outcomes will be discussed in more detail in the following chapter.

Table 1. Guiding framework

Ethnographic estuarine root garden stewardship practices	Potential observable or measurable impacts	Methods of data collection and analysis
Anthropogenic inputs to soil: Fertilization or addition of soil organic matter– the addition of fish	Increase in certain key nutrients – especially phosphorous, nitrogen, carbon, calcium,	Multi-element soil analysis (ICP-AES, ICP-MS, XRF)

remains and organic remains brought with the tides. Humans associated with increased phosphorous and nitrogen.	potassium, magnesium, and sulphur	
Tillage – the regular turning and mounding of soil.	Lowered levels of compaction	Soil penetrometer
	Less defined stratigraphy/stratigraphic indicators in the upper 30-40 cm	Visual in-field observation of soil profile
Use of tools to work/maintain the gardens.	Remnants of broken or discarded tools (e.g., digging stick tips)	Archaeological recovery of artifacts related to garden management.
Terracing	Little to no shoreline slope, heightened soil retention, archaeological evidence (e.g., rock walls)	Archaeological excavation of terracing features
	Changes in ecological gradation, succession. Species found in different zones than expected.	Shore-perpendicular line transects/Measuring slope gradation (laser range finder)
Selective weeding and transplanting	Heightened relative abundance of culturally important species, changes in overall species richness on the landscape	Shore-perpendicular line transects and quadrat sampling

1.10.2. Use of periphery sites

When conducting fieldwork, a minimum of two periphery sites were chosen for every field site to test the methods used and minimize the risk of pseudoreplication (Krebs, 1989). In calling these sites periphery instead of control, I echo the work of Armstrong et al. (2021), who make the point that the concept of a control site–a neutral place situated outside of the realm of human influence–is poorly suited to the study of cultural landscapes on the Northwest Coast. As such, I want to emphasize that the areas that I designate as periphery are *also cultural*. These “periphery” places would have served as seed banks and transplant donor ground for the main gardens, or places from which to harvest in times of scarcity or by peoples who did not have rights to the more productively and intensively stewarded garden grounds. As such, these “periphery” places should not be understood as unmanaged, or existing outside of Indigenous land tenure systems; rather, they are just representative of a different form or intensity of stewardship.

1.11. Dissertation outline

In **Chapter 1**, I introduce estuarine root gardens as an important component of traditional Indigenous food systems in British Columbia, Canada. I summarize what we know about these places (such as specific stewardship practices, their nutritional importance, etc.) as well as the cumulative and post-settler impacts that have altered estuaries and the ability of communities to access and care for their ancestral foods. I link this to present-day challenges that descendant Indigenous communities and archaeological practitioners face in identifying and categorizing these places within the context of ongoing and colonial impacts to peoples and lands, impacting both their level of protection under current provincial Heritage and Conservation legislation and the ability of descendant communities to reconnect with these landscapes. I also use this chapter to broadly outline my research questions, my research sites, and my methodological framework.

Main findings: Estuarine root gardens are ancestral food stewardship places, cared for by generations of Indigenous Peoples to increase their access to key nutritionally, culturally and economically important roots and rhizomes. However, ongoing colonial violence has impacted the ability of descendant communities to continue to care for these places or identify them in cases where exact locations are no longer known. By developing and utilizing a novel, interdisciplinary set of methods, which combines archaeology, ecology, and pedology, it may become possible to identify these places, making this information accessible to descendant Indigenous communities and within conceptions of archaeological and cultural heritage in British Columbia.

In **Chapter 2**, I detail my methodological frameworks in engaging with this work, beginning with an acknowledgement of my own positionality. I then expand on the significance of estuarine root gardens, the gaps that exist in our understanding of these places, and how these gaps continue to affect the level of protection awarded to these cultural places under current legislative frameworks. I then couch this work within an anti-colonial research lens, arguing for the importance of engaging with this work through the lens of historical ecology, while considering cumulative impacts and the potentials for community-led eco-cultural restoration and revitalization of these places.

Main findings: The ongoing focus on materials culture within archaeological and cultural heritage investigations in British Columbia does not accurately reflect the breadth and depth of the relationships that Indigenous Peoples have with their territories. A methodological framework that centers Indigenous knowledge systems/futurities and engages with cumulative impacts and historical ecology is needed to both increase our understandings of these places and re-insert them within Indigenous food systems and eco-cultural restoration.

In **Chapter 3**, I test my methods at a suspected estuarine root garden site in Lək̓ʷəŋən/Songhees First Nation territory on the islands of Tl'chés (Chatham and Discovery Islands) in southwestern British Columbia, Canada. This work emerged out of a multi-year collaboration effort between the ethnoecology lab at the University of Victoria and the Lək̓ʷəŋən Peoples, driven by a desire to better understand past landscape caretaking practices and reconnect with traditional foods. This chapter touches on the specific eco-cultural context of Tl'chés, and how this help inform our understandings of the findings from the estuarine root garden site.

Main findings: The Tl'chés estuarine root garden site presents many of the markers associated with an estuarine root garden site, such as the presence of both *T. wormskioldii* and *A. egedii* as indicator species (when compared to three other tested periphery sites) and the presence of chemically and texturally distinct cultural soils. Heightened levels of available soil phosphorous (P), specifically, indicate that the area was an anthropologically stewarded area. Despite a non-diagnostic assemblage of material artifacts recovered during excavation, the balance of evidence indicates that this was a stewarded root garden site.

In **Chapter 4**, I test my methods at the Gwa'ni (Nimpkish) estuarine root garden in 'Na̱mg̱is Kwakwa̱ka̱'wakw First Nation territory. Unlike the Tl'chés root garden, the Gwa'ni garden is known by descendant communities and was relatively well documented within the ethnographic, archaeological and ethnoecological literature, offering a rare opportunity to examine the post-stewardship trajectory of an estuarine garden site. After highlighting the specific eco-cultural context of the site, I discuss the outcomes of my methodological approach, and the implications of my findings on our ability to identify these sites.

Main findings: The estuarine root garden site at the Gwa'ni River still contains many of the "classic" material features associated with these places (e.g., intact rock wall fragments). The soils at the garden site, furthermore, are texturally and chemically distinct, with elevated levels of available P. Present-day plant communities at the garden site, however, indicate that the cessation of active human stewardship has led to a process of replacement through succession, with food plants shifting to higher elevation and less salt tolerant species.

In **Chapter 5**, I expand my analysis by comparing my findings from the Tl'chés and Gwa'ni River estuarine root garden sites. I also bring in archaeological data from a third estuarine root garden site in ʕaaḥuusʔatḥ First Nation territories, excavated as part of an Archaeological Impact Assessment (AIA) (Stafford, 2020). Though the methods detailed in Chapters 3 and 4 could not be replicated in at this final site, the data present in the report allows for a comparison of site-specific characteristic, helping to contextualize estuarine root garden formation processes and post-stewardship trajectories. Basing myself off of this compiled information, I offer a methodological pathway for archaeologists looking to do this work in the future.

Main findings: Though archaeological and ecological indicators associated with past estuarine root garden stewardship are variable and closely associated with local ecologies, hydrology, and cultural practices, the presence of enduring cultural soils (deep, uncompacted, and organically rich) is a primary indicator for the presence of estuarine root gardens. Archaeologists and cultural heritage practitioners looking to better understand estuarine root garden sites need to engage with multiple stewardship indicators and comparative (periphery) sites to gain a clear understanding of site formation and stewardship practices.

In **Chapter 6**, I go over my findings and offer my recommendations for those wanting to study estuarine root gardens in the future.

Main findings: Increasingly, this work is occurring in the context of community-led eco-cultural restoration and Indigenous resurgence. As such, understanding these systems is as much about the past as it is about the future, and the ability of archaeologists and cultural heritage practitioners to support this work.

Chapter 2 - Building a methodological framework for the study of estuarine root gardens

2.1. Abstract

Estuarine root gardens are places that hold significant knowledge about the ways in which Indigenous Peoples engaged with, cared for, and stewarded coastal landscapes and specific culturally and nutritionally important plant species. As such, these are places of Indigenous heritage, both tangible and intangible, connecting them to broader considerations of Indigenous futurity in the reclaiming of, and reconnecting with, traditional territories and ancestral food systems. However, the protection of these places, in the context of cumulative colonial impacts and present-day legislative frameworks, continues to fall short while sidelining true engagement with Indigenous communities. In this paper, I draw a conceptual framework for the research of estuarine root gardens, one which draws on the interdisciplinary methodology of historical ecology and centers Indigenous knowledge as a path forward to a more ethical (and effective) engagement with these ecologically, hydrologically and culturally complex places. Ultimately, I argue that the present and future of estuarine root garden research, which exists in the context of Indigenous heritage and futurity, requires a fulsome engagement with the limitations of current provincial and federal heritage legislations, as well as a broadening of understandings of tangible heritage in British Columbia to include landscape-level ecological and pedological markers.

2.2. Introduction

Estuarine root gardens are places of ancestral food stewardship by Indigenous Peoples on the Northwest Coast of North America. These dynamic and variable ecosystems, which were cared for by generations of Indigenous People to ensure a steady access to culturally, nutritionally and economically important plant foods (specifically, Pacific silverweed (*Argentina egedii (Wormsk.)* Rydb.; syn. *Potentilla pacifica* (L.) Howell), springbank clover (*Trifolium wormskioldii* Lehm) and northern rice-root lily, *Fritillaria camschatcensis* (L.) Ker Gawl), are places of Indigenous heritage, connecting descendant communities to the labour and gifts of their ancestors (Deur, 2000, 2002a, 2002b, 2005; Lloyd, 2011; Maurice-Hammond et al., 2023; Pukonen, 2008). As such, they are also places of Indigenous futurity, with important implications for territorial reclamation, Aboriginal rights and title, and the restoration of traditional food systems (Lepofsky et al., 2017; Letham et al., 2023). Currently, however, this process is stymied by the ways in which heritage legislation in British Columbia (such as the Heritage and Conservation Act, or HCA) and heritage practitioners understand, and approach, the study of estuarine root gardens specifically, and places of ancestral plant stewardship more broadly.

In recent decades, archaeologists and ethnobotanists, attempting to grapple with the colonial roots and legacies of harm of their disciplines, have sought to collaborate with Indigenous Peoples on projects that enhance understandings of the processes and long-term effects of territorial stewardship (e.g., Kelly et al., 2024; Lepofsky & Lertzman, 2018; Lepofsky et al., 2017; Lepofsky et al., 2020; Letham et al., 2023; Vanier et al., 2025). Often, this engagement has been framed through the lens of historical ecology, an interdisciplinary methodological approach that considers the entire breadth of relationships that exist between peoples and their landscapes, as well as the ways in which this knowledge can be applied to contemporary environmental and social issues (Armstrong & Veteo, 2015; Groesbeck et al., 2014; Lepofsky et al., 2017; Letham et al., 2023). This represents an important shift towards an archeological and ethnoecological practice that better allies itself with the goals and priorities of Indigenous communities. However, despite these important collaborative shifts, Indigenous Peoples continue to be sidelined when it comes to decisions about the futures of their territories and cultural heritage (Kelly et al., 2024; Nicholas, 2017a, 2022). This is particularly apparent when it comes to Indigenous plant caretaking landscapes, which, despite being places of profound and long-standing engagement with land and non/more than human relatives, rarely receive any recognition or protection under currently settler legislative frameworks (Armstrong et al., 2021; Lepofsky et al., 2013; Lepofsky et al., 2017; Schaepe et al., 2020). This is a significant issue, especially in a context where Indigenous Peoples and descendant communities are seeking to reconnect with traditional foods and culturally important landscapes as a way of strengthening cultural practices, well-being, and inter-generational knowledge transfers (Joseph, 2021; Joseph & Turner, 2020).

In this paper, I consider these pressing issues to highlight the need for a broader methodology of practices, one which centers Indigenous knowledge systems and argues for the reform of institutions that serve the settler state and industries to the detriment of Indigenous communities. I make the case that broader issues at play within our understandings, and legislating, of heritage in British Columbia not only directly impacts the ability of practitioners to correctly identify estuarine root garden sites in the field but puts the very survival of these places at risk, impacting their potential for Indigenous eco-cultural restoration and reclamation. Ultimately, this is methodologically complex work, which requires not only a multidisciplinary engagement (hence the advantages of historical ecology), but an engagement with decolonial praxis that disrupts settler institutions and phenomenology (Tuck & Yang, 2012). Estuarine root gardens, as places of both tangible and intangible Indigenous heritage, are as much about the past as they are about the future; as such, their study cannot happen without considering how these places have been impacted by colonial violence over time, and how this may be redressed to ensure their future within Indigenous concepts of sovereignty and stewardship.

2.3. Positionality and critical context of research

2.3.1. Positionality

I am a white settler of French, Scottish, and British descent, born on the traditional territories of the Wendat (Huron), Haudenosaunee and Anishinaabeg Peoples in southern Ontario, though I was not raised in these territories (or in North America more broadly). I became a settler and uninvited guest again at the age of 19 to attend university in what is today known as the city of Vancouver, on the homelands of the Coast Salish xʷməθkʷəy̓əm, Sḵwx̱wú7mesh and səlilwətaɬ Peoples, and then later west again, to Lək̓ʷəŋən (Songhees and Xʷsepsəm) and W̱SÁNEĆ territories in Victoria, south Vancouver Island. What I have found in Coast Salish territories is a profound love for these lands, which comes with a responsibility of care and reciprocity for both the land and its Peoples (hooks, 2001). My ability to choose to live on these territories, my whiteness and the privileges it entails, exist because of the ongoing genocide of Indigenous Peoples and the profound loss of expulsion and displacement from and within their own home territories. To ignore these legacies and this positionality is its own form of violence.

This work represents an imperfect attempt at allyship with Indigenous Peoples by engaging in work that seeks to support Indigenous sovereignty and the restitution/restoration of traditional territories and food systems. This is an ongoing project and process, which extends beyond this doctoral research and has/will continue to shape my life and career.

2.3.2. Community engagement

As a settler with no pre-existing ties to communities, I wanted to conduct this work in a community-centered way, working as a response to stated needs and centering the voices of descendant communities. However, the bulk of this research was conducted within the context of a global pandemic (COVID-19). Though I was fortunate enough to still be able to conduct fieldwork, this context necessarily limited my contacts with communities, at their request. As such, I do not feel comfortable calling this research "community engaged." Though this work did occur with the knowledge and by invitation of the Lək̓ʷəŋən Songhees and the ‘Na̱mg̱is Nations, my ability to meet with community, work with local knowledge holders, meet with governing councils in person, and spend time with community out on the land was severely curtailed, especially with work occurring on ‘Na̱mg̱is territories, which mainly took place in the spring and summer of 2022. Fortunately, the bulk of my fieldwork in Lək̓ʷəŋən territories occurred either just before the start of the pandemic or during periods of temporary relax, which allowed me to spend time on the land with community members. This occurred in the context of the existing Tl'chés collaborative research and learning program, established by Dr. Darcy Mathews, which is predicated on learning from the land and from each other. Here, I am greatly indebted to Səłłəmah, a *sʔéləxʷ* (elder) of the Lək̓ʷəŋən Peoples of the Songhees Nation. Tl'chés is her home, where she was raised by her great-grandparents, who were Lək̓ʷəŋən healers, who upheld the values that culture, traditional foods, human and other-than-human relations, and *tə́ŋəxʷ*/the land are all integral to wellbeing. My work on Tl'chés could not have occurred without her invitation and support. Overall, however, this chapter constitutes, in part, a discussion of what I could have done differently, and how my approach to this work would be different if I were to embark in it today.

2.4. Why do estuarine root gardens matter?

2.4.1. Estuarine root gardens are places of Indigenous heritage

Estuarine root gardens, as traditionally stewarded places, are places of Indigenous heritage, both tangible and intangible. Dominant, colonial forms of heritage management in British Columbia (and beyond) have long operated under the misconception that tangible and intangible heritage are distinct, and, as such, require differing management approaches. As a result, places of tangible heritage (e.g., places containing material artifacts) receive more consideration and protection than places of intangible heritage (e.g., spiritual locations). This approach is poorly suited to Indigenous understandings of relationships with landscapes and the non/more than human beings that inhabit them (Salmón, 2000; Schaepe et al., 2020). Within Indigenous knowledge systems, tangible heritage, which relates to objects, specific places, and the built, material world, is inseparable from intangible meaning, situating the tangible within webs of stories, relationships, and knowledge systems. In other words, it is the intangible context of an object (i.e., an "artifact") that gives it cultural value (Nicholas, 2017a, 2017b, 2022; Nicholas & Smith, 2020; Schaepe et al., 2020).

Conceptually, places of Indigenous plant stewardship have often been categorized by archaeologists and heritage practitioners as places of intangible heritage. The lineage to this idea can be traced back to colonial perceptions about Indigenous Peoples on the Northwest Coast being primarily hunter-gatherers, as well as more pervasive beliefs about the "light footprint" that plant stewardship practices leave on the landscape (Lepofsky & Lertzman, 2008; Wyndham, 2009). This has led to a discounting of plant stewardship places in the archaeological record, a vicious cycle that reinforces beliefs that practices associated with these places did not leave tangible markers on the landscape. However, in more recent years, community driven work on plant stewardship practices on the Northwest Coast is countering these assumptions, leading to a re-calibration on how these places are understood and studied within the context of archaeology and historical ecology. Significantly, this shift advocates that present-day plant communities and sediments (often seen as "the context" in archaeological research) should be considered as tangible makers of Indigenous stewardship, putting them in the realm of archaeological inventory work and cultural heritage resource management (e.g., Armstong et al., 2021;

Earnshaw, 2016; Groesbeck et al., 2014; Hoffman et al., 2016; Lepofsky et al., 2020; Lyons & Ritchie, 2017; Trant et al., 2016; Vanier et al., 2025).

2.4.2. Estuarine root gardens inform better understandings of cultural landscapes and Indigenous food systems

Within this context of disputed and shifting understandings of heritage in British Columbia, estuarine root gardens can be understood as containing both the tangible markers of past stewardship (in recoverable archaeological materials, in soils, in present-day plant communities) and the intangible context tying these markers to the communities to which they belong (in stewardship practices, in stories and songs and ceremonies, in inter-generation knowledge sharing). As such, they are important nodes within wider networks of relationships that exist between Indigenous Peoples and their home territories, informing our understandings of how communities interacted with specific places, species, and broader cultural landscapes. Cultural landscapes, which are shaped by the profound and reciprocal relationships between peoples and their homeland, are inherently tied to a peoples' sense of self and well-being (Basso, 1996; Ingold, 2000; Janowski & Ingold, 2012).

Engaging with estuarine root gardens as a constitutive element of a cultural landscape means understanding them not as isolated and spatially/temporally bounded *sites* but as part of an inter-related network of relationships with land, with peoples, and with non/other-than-human beings. Cultural landscapes, in other words, are the context, materially influencing the ways in which people live, which, in turn, materially influences the land (Basso, 1996; Sauer, 1968). Constitutive to these cultural landscapes are Indigenous food systems, networks of "interdependent relationships between all species, air, water, and soil, the health of which is inseparable from Indigenous Peoples foods which are actively cultivated and cared for with respect and through reciprocating acts" (Grenz & Armstrong, 2023, p.3). As such, the ability of Indigenous Peoples to re-engage with cultural landscapes and places of food stewardship has profound implications for Indigenous resilience and resistance to colonial violence (Joseph & Turner, 2020). As Lək̓ʷəŋən ethnobotanist and Knowledge Holder Cheryl Bryce puts it:

> It's not just about creating a plan, or conserving and protecting. It's many other things: it's the people, it's the connections, it's the stories, it's the songs, it's the trading of *kwetlal*[17], as well. To me, it's a food system, and it really encompasses more than 'sustaining the land' so-to-speak, (quoted in Corntassel, 2024, p. 39).

2.4.3. Estuarine root gardens are living archaeological sites

Estuarine root gardens, like other plant stewardship landscapes, are living archaeological sites (Vanier et al., 2025) (Figure 6).These are places where living ecological heritage (is profoundly intertwined with archaeological features and site, blurring boundaries between cultural and "natural" processes (Vanier et al., 2025). Furthermore, as Lepofsky et al. (2017, p. 459) describes it, these are

> places that have never stopped working. Stone fish traps catch and release fish daily, clam gardens persist as favorable bivalve habitats, and estuarine root gardens continue to produce rhizomes. These places and features are intentional products of ecological management as well as enduring and visible constructions that speak to emergent and changing economic, social, and spiritual practices through time.

The resilience of these food-producing systems situates them as places of Indigenous futurity, or places where the recovery of Indigenous traditions and ways of being can occur through a reclamation of land and stewardship practices. By (re)engaging with these practices and caring for non/other than human relatives, Indigenous Peoples uphold long-standing relationships with their homelands, redressing colonial harms to landscapes while supporting Indigenous resurgence (Corntassel & Bryce, 2012; Grenz & Armstrong, 2023). Furthermore, as Vanier et al., (2025, p. 505) put it, engaging with these landscapes as living heritage, and centering the role of Indigenous communities in creating and maintaining them, created opportunities to "enrich archaeological interpretations, engage broader publics, and contribute to powerful conservation goals."

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[17] *Kwetlal* is the Ləkʷəŋən word for blue camas (*Camassia quamash*)

Figure 6. Undated estuarine root garden rock wall in Huu-ay-aht Nuu-chah-nulth First Nation territory (west coast of Vancouver Island), still preserving the soil from erosion and supporting a large community of estuarine root foods.

2.4.4. Estuarine root gardens have rights and title implications

Increasing understandings of estuarine root garden stewardship is tied to Indigenous resilience and resistance to colonial violence (Joseph & Turner, 2020). However, it also has important implications for Aboriginal rights and title. Differing from the broader Canadian context, many First Nations in British Columbia were never engaged with through a formal treaty process. Instead, colonial governments in the province presumed *terra nullius*, or that "the lands [in this region] were empty and, therefore, free for the taking" (Spalding, 2022, p. 153). In practice, this means that Aboriginal rights and title to land and resources in British Columbia was never extinguished, even within the western legal frameworks that sought to subsume them.[18] In recent years, court challenges by Indigenous Peoples, seeking to assert their rights over their territories, have utilized archaeological evidence to prove continuous, exclusive, and sufficient occupation

[18] I would argue, however, that the treaty process should not be understood as an extinguishment of Indigenous claim to lands. Rather, this process, which often took advantage of individuals and communities (due to language barriers, being lied to/manipulated, differences in legal and cultural frameworks, material difficulties caused by colonialism, etc.) is steeped in settler colonial genocidal ideology and the desire to steal land from Indigenous Peoples. As such, and with the possible exception of modern-day treaties, it cannot be understood as a good faith process. Indeed, many of the lands that were "granted" to Indigenous communities in treaties were subsequently taken back by settler governments (Canada, 2015; Spalding, 2022.

of territory (Hogg & Welch, 2020. See also Delgamuukw*,* 1997; Tsilhqot'in*,* 2014; Nuchatlaht*,* 2023). According to the Supreme Court of Canada:

> Archaeology may seem to be the most concrete form of evidence available to prehistoric times. Extracting tangible objects from archaeological survey sites can produce information about many aspects of the society that occupied the lands from which the objects are uncovered. (*Lax Kw'alaams*, 2008, para. 17)

As such, the tangible recognition of places of Indigenous plant stewardship, and the ways that these fit within broader traditional territories, can provide furthermore evidence of Indigenous rights and title over an area. Significantly, the under-representation of places of plant stewardship in the archaeological context has limited understanding of the breadth of engagement with territories, impacting the success of Nations seeking to re-claim their territories (e.g., Nuchatlaht, 2023).

2.5. What isn't working: Historic and ongoing issues in the archaeological study of estuarine root gardens.

As noted above (and discussed in more detail in Chapter 1), places of Indigenous plant stewardship have, historically, been discounted or under-reported within British Columbia's archaeological and ethnographic literature. An over-emphasis on specific forms of tangible heritage, such as stone and bone tools, limits the delineation of archaeological sites to places where these elements are recovered, to the detriment of more subtle markers of stewardship and landscape alterations (Fowler & Lepofsky, 2011; Letham et al., 2023; Lepofsky & Lertzman, 2008). This is a self-reinforcing system; if plant stewardship places remain under-studied by archaeologists, tangible heritage (subtle or otherwise) is unlikely to be recovered, reinforcing already existing beliefs that these places do not contain archaeological materials and, as such, cannot be categorized as archaeological sites. In the case of estuarine root gardens, built features that might have allowed for their designation as archaeological sites (such as rock walls) may no longer be present due to the high dynamism of these places, or may have disintegrated in-situ due to changes in hydrology and soil moisture regimes (e.g., preserved organic materials). Even when obvious terracing remains, protection would only occur if the feature can be shown to pre-date 1846 (Letham et al., 2023). To date, and to my knowledge, only two radiocarbon dates have ever been recovered at estuarine root gardens, neither of which cover breadth and continuity of use. Both are discussed furthermore in this dissertation (see Chapter 4 and Chapter 5).

2.5.1. Legislative issues in the governance of Indigenous landscapes in British Columbia

Archaeology and heritage legislation in British Columbia is, in many ways, a blunt instrument, one which fails to capture the myriad ways that Indigenous Peoples engaged with and cared for their traditional landscapes. As such places of Indigenous heritage more broadly, and plant harvesting places specifically, remain under-protected under the current iteration of the HCA (Table 2).

Table 2. Issues with archaeological and cultural heritage management in British Columbia, Canada.

Issues with archaeological and cultural heritage management in British Columbia (BC)	
Sites versus landscapes	Archaeological sites are recorded as spatially bounded (i.e., the site). This fits poorly within Indigenous understandings of connectivity between places and cultural landscapes (Lepofsky et al., 2023).
Tangible and intangible heritage	Cultural heritage is both tangible and intangible. However, current practices focus primarily on tangible heritage. For Indigenous Peoples, this distinction may not exist and impacts to places of intangible heritage may lead to significant harms (Nicholas, 2017a, 2022).
The limitations of archaeological "evidence"	The requirements for tangible evidence for site recognition is furthermore restricted by the nature of this evidence. Culturally managed soils, for example, are often not recognized, despite long-term associations with Indigenous Peoples (e.g., Lək̓ʷəŋən camas prairies) (Lowther, 2022). Estuarine root gardens, similarly, would not be considered as sites without remnant physical built structures, such as retaining rock walls (Lepofsky et al., 2023).
1846 as a cut-off	In British Columbia, the cut-off for automatic archaeological protection is AD 1846. Sites post-dating 1846 or unregistered sites "only requires between 5%-10% systemic data recovery of archaeological deposits, depending on the assessed significance of deposits" (Kelly et al., 2024, p. 4). However, the history of use, and kinds of uses of cultural landscapes often predate and post-date AD 1846.
Mitigation and management	Even when sites can be shown to fall under HCA protection, they are not granted automatic protection. Following a site permit alteration process (which is administered by the archaeology branch), up to 95% of the site may be altered or destroyed (Kelly et al., 2024).

Indigenous archaeology v. settler heritage	While evidence of Indigenously built structures (e.g., shell middens) falls under the purview of archaeology and the HCA, settler "heritage" (e.g., a 100-year-old house, which cannot be altered in a way that would detract from its character) is managed through the *Local Government Act* at the municipal level. This creates an inherent double standard, which privileges settler histories over Indigenous heritage (Kelly et al., 2024).
Compliance failures with international law: UNDRIP and DRIPA	Despite being signatories of the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP), furthermore enshrined in BC with the passing the Declaration on the Rights of Indigenous Peoples Act (DRIPA) into law in 2019, BC Heritage legislation continues to fall short. One of the pledges made by DRIPA, specifically, stated in section 4.35 that the province would "work with First Nations to reform the Heritage and Conservation Act to align with the UN Declaration, including shared decision-making and the protection of First Nations cultural, spiritual, and heritage sites and object" (DRIPA, p. 27).

2.5.3. Recent changes in the study of plant stewardship places

As stated previously, recent decades have seen a surge in ethnoecologically minded archaeologists thinking about alternative forms of tangible evidence present in places of plant stewardship (e.g., Armstrong et al., 2021; Lepofsky et al., 2017; Letham et al., 2023; Turner et al., 2021). Furthermore, there has been a shift towards centering Indigenous knowledge and the desires of descendant communities in shaping research programs and determining deliverables, engaging with Indigenous Peoples as leaders and co-investigators instead of research subjects (e.g., Dick et al., 2022; Ignace et al., 2016; Joseph et al., 2022). Often, this shift has occurred within the inclusion of a historical ecology research framework, recognizing both the diversity of breadth of Peoples-landscape relationships and the many ways in which these relationships become inscribed onto the land (e.g., Armstrong et al., 2021; Currier et al., 2017; Groesbeck et al., 2014; Letham et al., 2023; Lightfoot et al., 2021; Vanier et al., 2025). These collaborative investigative methods help provide answers about specific kinds of stewardship practices, which can then help in decision-making processes concerning ecological restoration and the revitalization or cultural practices (Lightfoot et al., 2021; Vanier et al., 2025). To date, however, most of this work has occurred in the context of academic and research relationships with

Indigenous Peoples and communities.[19] Professional heritage resource management in British Columbia–mostly consisting of contractors working on industrial and extractive projects–has yet to catch up (Lepofsky et al., 2017).

2.6. Specific considerations in the archaeological study of estuarine root gardens

2.6.1. Estuarine variability and dynamism on the Pacific Northwest Coast

Located at the intersection of marine and freshwater systems, estuaries are some of the most productive systems on the planet (Call & Bauman, 2021). Unsurprisingly, and resulting from this dynamism and productivity, estuaries globally have a profound history of human use and occupation spanning centuries (Erlandson et al., 2019; Letham et al., 2021). Estuaries, furthermore, are highly morphologically and hydrologically variable, impacting local ecological compositions and the intensity of use that can occur in these places (Call & Bauman, 2021). Estuarine marshes, which develop due to sedimentary accretion caused by frequent depositional events, remain subject to the hydrological influences of both fresh and salt water. As such, plant species occurring on these sites tend to be salt-tolerant vascular hydrophytes, occurring along defined gradients away from the water line (MacKenzie & Moran, 2004). Highly localized ecological, environmental, hydrological, and cultural contexts impact both historical relationships with estuaries (which plants were cared for, and to what intensity), the scale and form of landscape alterations required (whether people were building and maintaining rock walls and terraces), and continuity of use in the face of profound changes and colonial pressures (Deur, 2000; Deur et al., 2013; Dick et al., 2022). Furthermore, surrounding topographies and their impacts on watershed play a role in both sedimentary accretion in estuaries and the ability for estuarine marshlands to develop and expand horizontally over time, determining whether anthropogenic modifications were needed to expand growing areas (Rosencranz et al., 2017; Thorne et al., 2018). This differentiation is, in part, regional, with the large tidal flood lands of

[19] This, however, is starting to shift, with communities leading their own research and resurgence projects. Examples for this can be seen in the Clam Garden Network, which brought together community knowledge, western science, and collaborative research methodologies to inform and inspire the renewal of clam garden and sea garden stewardship on the Pacific Northwest Coast. This, in part, led to the creation of other endeavours, such as the Cross-Pacific Indigenous Aquaculture Collective (2021), which relies on cross-community solidarity to help revitalize important coastal stewarded landscapes. This has led to the revitalization of Indigenous Hawaiian *loko i'a* fishponds and Coast Salish sea gardens in recent years.

the south Salish Sea (e.g., the Fraser River estuary) differing from the steep costal fjords more common in the more northern coastal regions of British Columbia.[20]

2.6.2 Ecological composition resulting from anthropogenic caretaking

Long-term engagements between humans and stewarded plant communities are recognized as an "important driver of contemporary plant community structure and function" (Armstrong et al., 2021, p. 6). Specific and long-term caretaking practices, such as transplanting (sometimes over long distances), replanting propagules, selective harvesting, coppicing, and weeding (to name a few), have resulted in places supported conspicuously distinct species assemblages even 150 years post cessation of active caretaking (Armstrong et al., 2021; Freschet et al., 2014; Letham et al., 2023; Przelomska et al., 2020; Turner et al., 2013; Turner et al., 2021). These ecological assemblages, shaped by peoples, often still support dense concentrations of culturally important species, and, as such, represent an important element of living Indigenous heritage.

However, the inclusion of ecological assemblages remains far from common practice in heritage work in British Columbia, with the focus remaining on "more dramatic signatures of ecosystem changes" rather than "less so or more subtle ecological changes" (Turner et al., 2021, p. 880). Furthermore, research to date has tended to focus on longer-lived terrestrial species, such as trees (like *Malus fusca*, the Pacific crab-apple) and shrubs (specifically berry-bearing shrubs, like salmonberry, *Rubus spectabilis*, and huckleberry species, *Vaccinium spp*.) (e.g., Armstrong et al., 2021; Benner et al., 2019; Fisher, 2015; Trant et al., 2016). Herbaceous and shorter-lived species, such as those growing in estuarine root gardens, are likely to display more subtle and ephemeral evidence of human-assisted alterations to ecosystems (Przelomska et al., 2020). To date, they have not received equal consideration (with some exceptions – see Lyons et al., 2021),

[20] According to MacCready & Geyer (2024), the entirety of the Salish Sea is an estuary, the meeting point for multiple large freshwater systems (e.g., the Fraser and Nooksack Rivers) and innumerable tributaries with the Pacific Ocean. At a more localized scale, estuaries in the Salish Sea eco-region vary greatly in size and significance, with many of the larger historical estuaries having been significantly altered by industrialization and land reclamation projects. In the more northern reaches of the Salish Sea (southern British Columbia and the American San Juan Islands), which are characterized by a mild, Mediterranean climate and lower relative rainfall, streams and rivers are often smaller in size and/or seasonal, making for smaller and more scattered estuaries. This is a marked contrast to the rest of coastal British Columbia, where a mild climate, combined with large amounts of rainfall and resulting larger river systems produce larger estuaries, which also tend to be less impacted by urbanization (Pojar et al., 1991).

though parallels can be drawn with traditionally stewarded prairie environments and the growth of traditional herbaceous plant foods such as camas. Weiser (2006), for example, was able to use archaeobotanical evidence to evidence the location of historic camas prairies, despite the area having gone through significant ecological changes with the banning of traditional burning practices (see also: Lepofsky et al., 2003; Lowther, 2022; Weiser & Lepofsky, 2009).

2.6.3. Cultural soils and Indigenous soils

Cultural soils occur globally, with some better-known examples being the *terra preta* of the Amazon basin (Amazonian Dark Earth, or ADE) and the European Dark Earths of northern Europe (Acksel et al., 2019; Asare et al., 2021; Schmidt et al., 2014). Other examples can be found in China, West Africa, Puerto Rico, and south and north America (Frausin et al., 2014; Rivera-Collazo & Sánchez-Morales, 2018; Sandor and Homburg, 2017; Solomon et al., 2016; Zhang et al., 2003). However, the Northwest Coast of North America, and its association with cultural soils, remains under-studied, despite some pioneering work occurring in the last few years (e.g., Lowther, 2022). Similar to the distinct ecological assemblages mentioned above, cultural soils derive from long-term engagements with landscapes in the form of targeted amendments and/or as a by-product of human presence (Acksel et al., 2019; Holliday, 2004; Lowther, 2022; Sandor & Homburg, 2017; Schmidt et al., 2014). On the Pacific Northwest Coast, a shift towards considering and recognizing cultural soils entails a re-evaluation in our understandings of anthropogenic deposits as intentional and targeted, rather than the incidental outcome of long-term use and habitation (Lowther, 2022; Cook-Patton et al., 2014; Erlandson, 2013; Sawbridge & Bell, 1972; Trant et al., 2016; Vanderplank et al., 2014). In practice, this entails shifting away from seeing pedological assemblages (e.g., shell midden) as incidental deposits towards an understanding of soils and sediments as an important element of material culture and tangible heritage. Currently, we are just beginning to understand and correctly categorize these soils and their formation processes (Suttles, 1974; Turner, 1999b; Lowther, 2022). However, it is clear that estuarine root garden soils—soils which have been altered through tilling, fertilizing, and terracing, changing their textural qualities so that they have a "little bit of everything" (Kwaxsistalla, quoted in Deur, 2005, p. 314)—are cultural soils, significantly altered by human activity over time to increase their fertility and productivity, while also altering their basic characteristics.

Deur (2000, 2005), under the guidance of Kwaxsistalla, explored the idea of cultural soils in estuarine root gardens, testing soils from seven root gardens and noting “a nutrient balance approaching that of a contemporary, fertilized greenhouse potting soil” (Deur, 2000, p. 176). The soils, taken at rooting depth, were found to high in phosphorous, nitrogen, calcium, and other trace minerals. Furthermore, these organically-rich and porous soils were easy to work and weed, easing the growth, and extraction, of root foods (Deur, 2000).

2.7. Building a model for a more comprehensive study of estuarine root gardens

Ultimately, the factors discussed above have profound impacts on Indigenous Peoples land rights, as well as our understandings of cultural landscapes of plant stewardship. This has both shaped and limited our understandings of what constitutes archaeological evidence and site delineation in British Columbia, affecting which places receive protection under the HCA and can be considered as evidentiary during Aboriginal right and title litigations. Engaging with these issues through a framework of historical ecology and relational research with Indigenous communities presents a path forward, one that considers the cumulative impacts that estuaries are subjected to without discounting their importance as place of Indigenous futurity and eco-cultural restoration. However, this engagement, and the associated use of Western scientific tools, has the potential of being both generative (i.e., in support of Indigenous stewardship, rights and title, and future/current stewardship–the context in which estuarine root gardens exist) or harmful, replicating and enacting colonial violence through knowledge extraction/integration. Ultimately, these processes strengthen Western science while consolidating knowledge within Western institutions and away from Indigenous communities (Reid et al. 2021).[21] Engaging in relational and grounded research represents a way forward, using Western scientific tools to uphold and supporting Indigenous knowledge, cultural landscapes, and community goals for the future of these places. This process, and its many interactions, are illustrated below (Figure 7) and explained further in the following sections.

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[21] For more on this, see Castleden et al., 2012; Nicholas, 2017a; Nicholas, 2022; Simpson, 2004; Zank et al., 2025).

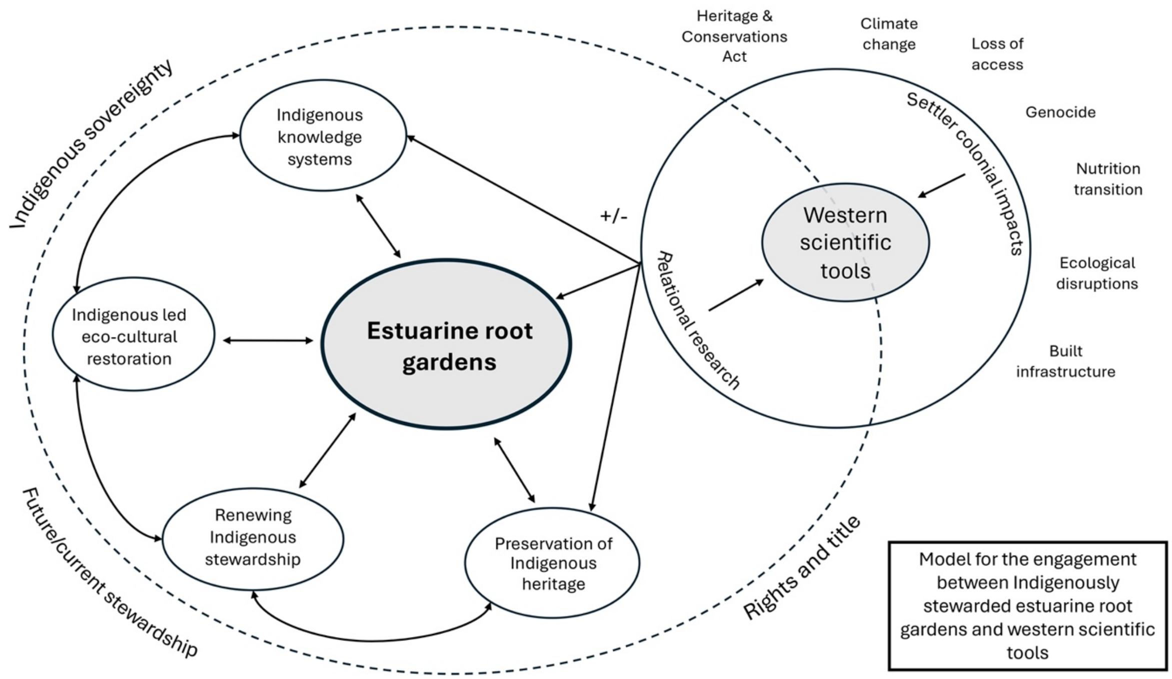

Figure 7. Model for a novel, multidisciplinary approach to the study of estuarine root gardens in British Columbia, Canada.

2.7.1. Historical ecology and multidisciplinary approaches

Historical ecology is a research methodology that focuses on the reciprocal and integrated relationships that humans have with their landscapes, recognizing physical relationships to land without dismissing the social, spiritual, cognitive and emotional experiences of its peoples (Anderson, 1996; Balée, 1998, 2006; Basso, 1996; Crumley, 2015; Crumley et al., 2018; Eriksson et al., 2018; Hayashida, 2005). This more holistic approach to the study of human-landscape relationships better aligns with Indigenous conceptions of relationality and reciprocity with land and the non/more-than-human world (Basso, 1996; Salmón, 2000). Furthermore, this approach, which incorporates multiple lines of evidence (e.g., archaeology, ecology, geography, history, geology, Indigenous knowledge, and cultural anthropology), provides a framework for exploring the long-term cultural-natural processes and relationships that shape landscapes over time, including a range of caretaking practices that have increased the productivity and ecological diversity of key landscapes of high eco-cultural salience (Cuerrier et al., 2015; Lepofsky et al., 2017). Specifically, the interdisciplinary nature of historical ecology is key to gaining a more complete picture of human-environmental interactions that may be “light” or otherwise difficult to document (Armstrong & Veteo, 2015; Wyndham, 2009).

In recent years, historical ecology has increasingly been used in coastal British Columbia to develop a better understanding of the ancient and ongoing relationships between Indigenous Peoples and their homelands (e.g., Armstrong et al., 2021; Earnshaw, 2016; Groesbeck et al., 2014; Lepofsky et al., 2017; McCune et al., 2013; Toniello et al., 2019; Vanier et al., 2025; Wickham et al., 2022). This has had a significant impact on “our understanding of the range and complexity of Indigenous management, and on Indigenous assertions of their rights to continue age-old interactions with their biological worlds” (Lepofsky et al., 2017, p. 449). Building on this body of research, centering a multidisciplinary approach in the study of estuarine root gardens allows for a better understanding of stewardship practices occurring in highly variable and dynamic places, as well as an expansion in current understandings of tangible evidence of human use of these landscapes. Furthermore, the interest of historical ecology in understanding landscape changes over time can help determine pre-site formation processes (i.e., specific climactic/geomorphological/hydrological causes affecting local ecological productivity) and post-stewardship trajectories (i.e., how these places have changes since active stewardship stopped), with implications for identification and the community-led recovery/ongoing and future stewardship of these places. Finally, a central emphasis on Indigenous and community knowledge systems challenges the limitations inherent in the application of the HCA in British Columbia by underlining both the depth and breadth of human-Indigenous landscape relationships, relationships that extend into (and will continue to shape) the future of these places.

2.7.2. Incorporating a cumulative impacts framework

Incorporating a cumulative impacts framework to this work allows for a holistic understanding of colonial influences to estuaries, and the cascading effects these have had on local ecologies, hydrological and sedimentation regimes, and relationships with place (Dick et al., 2023). Often deployed in the context of industrial and resource extraction projects, the cumulative effects framework is used to qualitatively and quantitively evaluate “changes to environmental, social and economic values caused by the combined effects of past, present and potential future human activities and natural processes" (British Columbia Natural Resource Board, 2016). However, historic impacts to landscapes and species have often gone unrecorded, making it challenging to monitor their effects over time. This is of particular concern to Indigenous communities, confronted with myriad historic and ongoing colonial changes to their territories which impact their environments, cultural systems, and ability to exercise their rights (Arnold et al., 2024).

Today, even estuaries that may appear "natural" or "pristine" are likely to have weathered some level of colonial impact, either purposeful or as a side effect of "development" in BC. Deur et al. (2013), for example, describe purposeful attacks on estuarine root gardens by colonial gunboats in the late 19th and early 20th century, which, in some cases, led to the forced abandonment of garden sites. Dietary changes associated with colonialism (e.g., residential schools, the introduction of processed foods, the imposition of wage labour, etc.) further contributed to a nutrition transition away from traditional foods and towards foods made more easily available by settlers (Joseph & Turner, 2020). Other impacts can be traced to industry on or near estuaries[22] and pressures caused by increasing settler populations on coastlines, leading to the constriction of estuarine habitats and/or their destruction through land reclamation processes (Freeman et al., 2019; Kennish, 2021)[23]. Ultimately, these impacts have created conditions where estuaries may no longer be accessible to communities, or able to support enough root foods to allow for harvest. This is compounded by very real concerns over the safety of these foods for consumption (Dick et al., 2023). Therefore, not only does the identification of ancestral root growing landscapes require a deep-time and methodologically varied approach, but it also requires a consideration of the range of colonial impacts to these places over time. This will aid both in the identification of these places and in helping develop robust eco-cultural restoration processes to support them into the future.

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[22] E.g., pulp mills and effluent treatment facilities, which leach pollutants into waters and sediments, as well as the impacts of logging on sedimentation rates and water flow (Dick et al., 2023; Gerwing et al., 2018; Wenger et al., 2018)

[23] For an excellent, comprehensive breakdown of settler-driven impacts to Indigenous food systems, see Dick et al., p. 552-554.

2.7.3. Relational accountability and centering Indigenous epistemologies

This work exists in the context of Indigenous heritage and knowledge systems. As such, it requires a fulsome engagement with Indigenous epistemologies and a commitment to building ethical and robust relationships with the peoples to whom these places belong. Paralleling ideas of kincentric ecology (Salmón, 2000), relational accountability situates the researcher as a node within a broader system of relations with the human and more than human world. Countering extractive and colonial forms of research, this approach advocates for the building and maintenance of respectful and reciprocal relationships with collaborators and friends (Smith, 2013). It is a slow process that takes a lifetime, not one that can be quickly and easily folded into the length of a graduate program or a grant timeline. As articulated by Reo (2019, p. 66):

> As a researcher, I am not only responsible for nurturing and maintaining relationships with my specific community collaborators, but I am also accountable to entire communities where I work. This potentially includes my collaborators' non-human network of relations.

Carrying on relationships of respect and care also presents us with the most ethically sounds approach to research, with the important caveat that the ethics ascribed to need to also be seen as such from the perspective of the Indigenous Peoples with whom we engage in this work, not simply the ethics of western science (Reo, 2019). As stated above, not only does this involve engaging in the long-term process of building and maintaining relationships with human community, a similar process of accountability and care needs to be extended to the plants, animals, landscapes, and more/other than human beings encountered as part of this process. (Kimmerer, 2013). In practice, this may mean avoiding fieldwork during certain times of year to minimize damage to plant communities or aligning research methodologies with Indigenous Knowledges about the best ways to enhance and care for landscapes[24]. It may also require researchers to "take a back seat" and release the mantle of expertise (something that often runs counter to our training) (Castelden et al., 2017, p. 1).

[24] For example, as part of my own fieldwork in estuaries, Pacific silverweed (*Argentina egedii* (*Wormsk.*) Rybd.; syn. *Potentilla pacifica* (L.) Howell), springbank clover (*Trifolium wormskioldii* Lehm) and riceroot lily (*Fritillaria camschatcensis* (L.) Ker Gawl) rhizomes and roots were identified and set aside during excavation before being re-buried (with associated watering, based on environmental and hydrological conditions). Not only did this help preserve and important Indigenous food resource, it enhanced the productivity of these plants, resulting in more plentiful returns in the following year (see Maurice-Hammond et al., 2023).

Relational accountability, furthermore, helps counter the totalizing pull of western scientific methods, which seeks universality through the integration and subsummation of local and situated knowledge, thus separating it from its grounded positionality and relationships with the surrounding world (Simpson, 2004). This "knowledge integration" is an inherently extractive process, strengthening western science while consolidating knowledge away from Indigenous communities (Reid et al., 2021). However, engaging in relational networks of care and consent building with community allows us to develop research projects that 1) are of interest to the Peoples on whose land the knowledge is getting gathered and 2) support the recovery of traditional knowledge by resisting the replacement of Indigenous ways of knowing with western ways (Corntassel & Bryce, 2012). In other words, critical research can be used to support place-based work, supporting efforts by Indigenous peoples to "revitalize title, language, environmental stewardship, and well-being" (Lepofsky et al. 2017, p. 450).

2.7.4. Indigenous futurities in the context of eco-cultural restoration

Estuarine root gardens, as deeply situated eco-cultural systems with long histories of human-landscape relationships, exist in the context of Indigenous histories *and* Indigenous futures, which can express itself in the reclamation of land, food systems, and the relationships that these processes encapsulate. As such, reconnecting with estuarine root gardens is an important facet in the restoration of Indigenous food systems, a process that simultaneously works towards the renewal of inter-generational relationships with land (Dick et al., 2022; Lloyd, 2011; Pukonen, 2008). This process of renewal means engaging with ecological restoration, both as an ontology and a set of practices. Like ethnoecology and archaeology, ecological restoration has been shaped by colonial understandings of human-environmental relationships, situating human activity as anachronistic to ecological well-being and implying that human influence needs be removed to ensure the recovery of ecosystems (Zank et al., 2025). This presupposes the existence of ecosystems that pre-date human influence, which does not account for the profound relationships between Indigenous Peoples and the ecosystems that they have fostered and cared for over millennia (Turner & Mathews, 2020; Wehi & Lord, 2017). To the contrary, the removal of Indigenous Peoples' influence on their landscapes is now known to be a precipitating factor in ecosystem degradation (Corntassel, 2024; Dickson-Hoyle et al., 2022; Grenz & Armstrong, 2023; Hoffman et al., 2022; Wehi & Lord, 2017; Wickham et al., 2022), while the presence of Indigenous stewardship is associated with higher levels of biodiversity and productivity at the landscape level (Armstrong et al., 2021; Schuster et al., 2019; Trant et al., 2016). This presents both a material and ethical challenge to the restoration of ecosystems which have been degraded by colonial and capitalistic ways of engaging with the land—ones that focuses on extraction and the monetization of "natural resources" and ecosystems services.[25]

A relational approach to restoration, one which engages with historical ecology to understand the depths of human-landscape relationships and the ways that Indigenous People have shaped ecosystems over time, provides an example of Indigenous futurity in action. For Grenz (2024, p. 138), this is best understood as

> relationally guided healing of our lands, waters, and relations through intentional shaping of ecosystems by humans to bring a desired balance that meets the fluid needs of communities while respecting and honouring our mutual dependence through reciprocity.

Relational land healing, which prioritizes community goals the sustaining of existing relations with landscapes, can succeed at putting western scientific methods in service of Indigenous futures while sustaining ecosystem functions (e.g., Moreira et al., 2016; Weinstein, 2007). For this to be successful, however, deep-time relationships between Indigenous Peoples and landscapes need to upheld and centered. Grenz & Armstrong (2023, p. 3) highlight the importance of this paradigm in the context of Indigenous food systems, which "centers humans' coexistence with other living beings and prioritizes a cultural-ecological equilibrium over exploitation or fixed restoration goals" (see also Kuhnlein, 2020).

[25] The concept of "ecosystem services," articulated by the United Nations (2005), attempted to account for the ways ecosystems benefit humans by looking at the ways in which ecosystems support, provision, regulate, and provide cultural values. In this model, ecosystems are the provider, and humans are the beneficiaries. Furthermore, the health of ecosystems is considered within a capitalist framework, which monetizes and commodifies the health of landscapes in relation to what they can provide peoples. Though this framework does attempt to highlight the reliance of peoples on healthy ecosystems, it does not encapsulate the element of relationship and reciprocity that is core to Indigenous Peoples' relationships to their territories. When ecosystems and the beings that inhabit them are considered as kin, the responsibility of human beings is to "give back" and provide for the need of all relations (Turner & Mathews, 2020).

2.8. Conclusion

Estuarine root gardens are complex places, shaped by both natural and cultural processes and impacted by a variety of cumulative factors that have altered their composition and habitat suitability over time. This complexity presents both a challenge in the ability of researchers to identify these places as stewarded landscapes and an opportunity to do this work well by engaging deeply with place, and the relationships that Indigenous Peoples have with place. The inherently multidisciplinary approach of historical ecology, with its emphasis on the breadth, depth and futurity of peoples-landscape relationships, allows for an understanding of plant stewardship that is both tailored to the specific ecologies of these places and accounts for cultural influence and impacts–that is, the ways in which Indigenous Peoples engaged with these places in the past, how this engagement have shaped post stewardship processes, and how peoples might engage with these places in the future. However, this engagement with Indigenous landscapes and Indigenous futures cannot come without a commitment to anti-colonial praxis, one which requires the profound alteration (and dismantling) of colonial institutions and a dedication towards supporting the return of lands to Indigenous Peoples. This is especially salient for settler researchers who work with Indigenous knowledge systems, which comes with the inherent and institutionally grounded risk of replicating colonial power dynamics and perpetuating harm towards Indigenous communities. As such, good archaeological research is as much about developing better methodological practices as it is about being good collaborators and allies towards Indigenous Peoples. We will never be able to redress all the wrongs that colonialism and extractive research practices have subjected Indigenous Peoples to, but it must be our collective goal to try.

One way for settler researchers to engage in harm reduction in this field (with the understanding that harm elimination is a life-long process that involve both personal work and the dismantling of institutions) is to center Indigenous futurities. In other words, trying to understand past relationships between peoples and place, though an important first step in renewing relationships between communities, landscapes and importance species, cannot be the entirety of this project. Rather, there needs to be an engagement with renewing Indigenous stewardship—that is, the return of land as a material, not just symbolic, process (Tuck & Yang, 2012). This, however, cannot occur without considering the present-day and cumulative material conditions of these places, the ways in which these present conditions will shape reclamation and eco-cultural restoration processes, and the existing institutional frameworks that will impact the ability of peoples to renew these relationships to place. As such, engagement with the study of estuarine root gardens (or places of Indigenous caretaking and stewardship more generally, which extends to the entirety of traditional territories) must center community knowledge of the past and community desires for the future. By doing so, researchers can harness western knowledge frameworks to materially support community goals, centering Indigenous knowledge systems and contributing to the renewal of relationships/stewardship to place by bringing this knowledge home.

Chapter 3 – A Lək̓ʷəŋən estuarine root garden: The case of Tl'chés

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3.1 Abstract

Archaeologists and others have long overlooked ecosystems stewarded by Indigenous Peoples on the Northwest Coast of North America due to colonial perspectives on food-procurement strategies. As a result, these places remain largely overlooked and unprotected in present-day conservation and cultural resource management. Furthermore, identifying, understanding, and revitalizing these systems are key to supporting the food security, cultural identity, and inter-generational knowledge transfer of Indigenous Peoples. This is the case with the Lək̓ʷəŋən speaking Songhees First Nation (Coast Salish/southern Vancouver Island, British Columbia), where colonialism has severely impacted traditional knowledge about estuarine root gardens. To address this issue, and the desire of the Lək̓ʷəŋən to revitalize these sites, this study employs a novel interdisciplinary methodology to evaluate a potential garden on the archipelago of Tl'chés. By combining archaeology, ecology, and pedology, and conducting ecological surveys, soil analysis, and archaeological excavations, we found that past cultivation practices have left measurable impacts at the site more than 100 years after management ceased. We conclude that evidence of estuarine root garden management is present in the Coast Salish, and that it is possible to identify sites in areas where they are no longer known by the community, re-integrating them within traditional food systems and re-defining archaeological approaches to their study

3.2 Introduction

Globally, wetlands are a nexus of human caretaking and use (Beach & Luzzadder-Beach, 2012; Krause et al., 2019; Yunfei et al., 2009). On the Pacific Northwest Coast of North America, this caretaking of near-shore and coastal ecosystems has taken on many forms, from the building and maintenance of clam gardens (Lepofsky et al., 2015; Smith et al., 2019) to estuarine root gardens (Deur, 2000, 2005; Lloyd, 2011; Pukonen, 2008). Estuarine root gardens are areas of coastal marshland where edible and culturally important plants, such as Pacific silverweed (*Argentina egedii ssp. Pacifica*) and springbank clover (*Trifolium wormskioldii*) were cultivated alongside other root foods, such as northern rice-root lily (*Fritillaria camschatcensis*) and Nootka lupine (*Lupus nootkatensis*). These plants were consumed by Indigenous Peoples from Alaska to northern California, though most evidence for intensive estuarine root garden management is currently found in coastal British Columbia, Canada. Management practices for these gardens included weeding out competing species, working and fertilizing soils and modifying the gradient and the hydrology of coastal marshlands (Deur, 2000, 2005). These practices significantly increased access to and output of these plants (Turner & Kuhnlein, 1982). Their edible roots and bulbs were some of the most important sources of carbohydrates available on the Northwest Coast in pre-colonial times, giving these plants a position of great importance in the economic, cosmological, and cultural lives of many coastal First Nations. They occupied a central position within potlatches, winter dances and feasts, while surplus was traded between Nations (Deur, 2005).

Today, most information about estuarine root gardens comes from two coastal ethnolinguistic areas: the Nuu-chah-nulth of western Vancouver Island and the Kwakwa̱ka̱'wakw of northeastern Vancouver Island and the adjacent mainland. Root foots in these areas were grown in large estuaries characterized by cool climates incapable of supporting other starchy foods grown farther south such as camas (*Camassia quamash* and *Camassia leichtlinii*). Though we know that *T. wormskioldii* and *A. egedii* were eaten in the Coast Salish territories of the Lək̓ʷəŋən Peoples on southern Vancouver Island (Gunter, 1945; Suttles, 1974; Turner & Bell, 1971), very little is known about estuarine root garden management in this area, representing a significant data gap and an impediment for communities keen to reconnect with traditional foods and harvesting areas (Bryce & Corntassel, 2012; Joseph, 2020). Traditional knowledge of these gardens in Coast Salish territory has been impacted by settler colonialism. Lək̓ʷəŋən Peoples have been at the epicenter of colonialism in British Columbia, and dispossession from land in conjunction with other colonial policies have had profound and inter-generational effects on the knowledge and wellbeing of Indigenous Peoples. In urban and built environments, such as Victoria, loss of access to traditional places of food stewardship and harvesting, and places of cultural teaching, has been particularly grievous (Lutz, 2008). Furthermore, colonizers misrecognized both the kinds and scale of Indigenous Peoples plant food stewardship systems (Mathews & Turner, 2017; Turner, 2020); consequently, stewarded sites remain largely overlooked and unprotected in present-day conservation and cultural resource management (Lepofsky et al., 2020).

In support of the Lək̓ʷəŋən People's desire to reconnect with their traditional food systems, we present the first systematic archaeological, ecological and pedological study of a suspected estuarine root garden in Coast Salish territory. Tl'chés is an archipelago off the southern tip of Victoria (Figure 8 and Figure 9), and it is the only non-urban reserve land of the Lək̓ʷəŋən Peoples and the present-day Songhees Nation. The Songhees have always maintained their relationship with and responsibility to Tl'chés, although the islands have been unoccupied for 70 years.

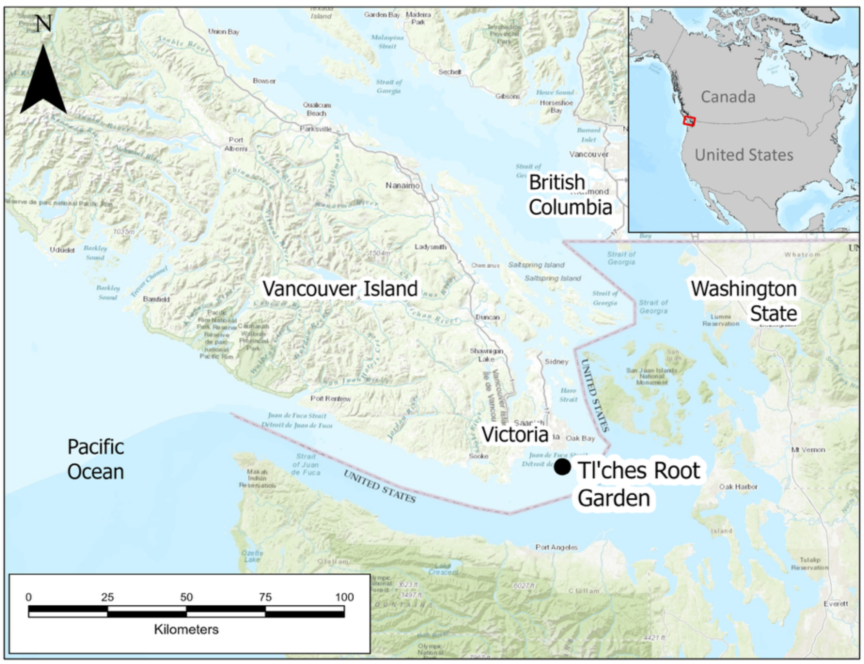

Figure 8. Location of Tl'chés and Lək̓ʷəŋən territories in southern British Columbia, Canada (Credit: D. Mathews)**.**

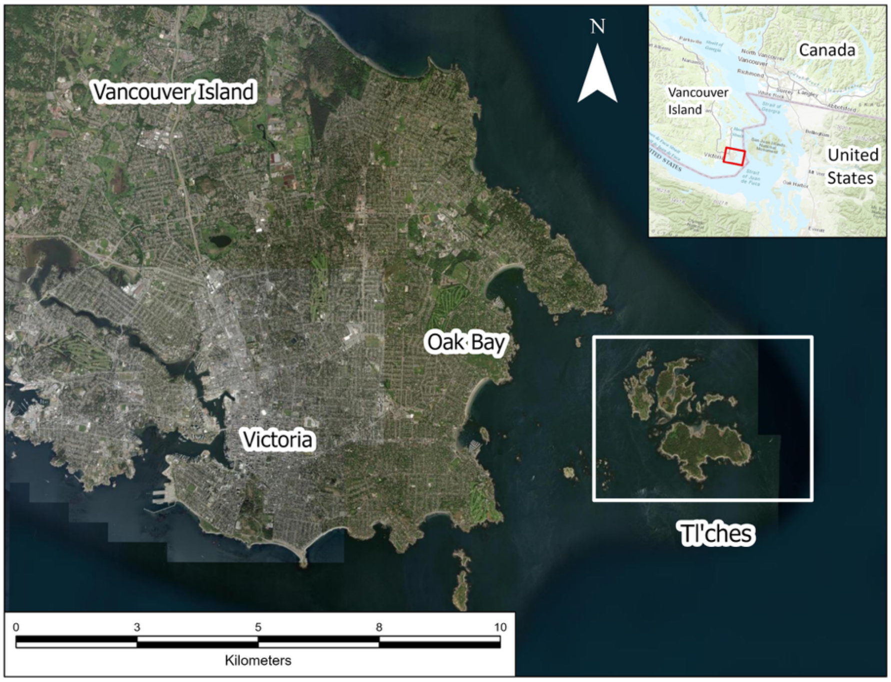

Figure 9. Image of Tl'chés and in relation to the city of Victoria, British Columbia, Canada (Credit: D. Mathews).

This work is part of larger land-based collaborative research and learning program at Tl'chés, focused on traditional plant and intertidal food and medicine sites, ancient villages, and sacred sites. This has been a multi-stage process, building on the promising results of Bosman's (2019) earlier work at the suspected estuarine root garden and the knowledge of archaeologists and Songhees community members such as Wilfred George. Tl'chés is also the home of Səłłəmah, a *sʔéləxʷ* (elder) of the Lək̓ʷəŋən peoples of the Songhees Nation, and our work there occurred at her invitation and with her support. Səłłəmah was raised at Tl'chés by her great grandparents. They were Lək̓ʷəŋən healers, who upheld the values that culture, traditional foods, human and other-than-human relations, and *tə́ŋəxʷ*/the land are all integral to wellbeing. Səłłəmah summarizes the core value of our collaboration: "now, more than ever, we need to get the youth back to the land. Tl'chés has always been a place of healing, one of our last places, and it must be protected."

Significantly, the site in which this study took place is not a *known* estuarine root garden site. Because of the processes of colonial dispossession we introduced above, there is no Lək̓ʷəŋən community knowledge about specific management practices at the site and estuarine root garden management more broadly. However, the site (which we will refer as the "study site" in this paper) has many of the ecological and pedological characteristics associated with known estuarine root gardens. Additionally, the location of the site in a protected, low energy estuary, and its association with a network of other archaeological sites and places that Səłəmah associates with healing and well-being, strongly indicate that this was a previously cultivated estuarine root garden – likely one of many such sites in Lək̓ʷəŋən territories. As such, the purpose of this study is twofold: 1) determine, using a novel interdisciplinary methodology, whether the study site is a cultivated root garden in the absence of surviving cultural information and 2) highlight possible Lək̓ʷəŋən/Coast Salish variations in the management and caretaking of estuaries. In many significant ways, the Coast Salish peoples are culturally distinct from their northern neighbors, in terms of their artistic, technological, and food traditions. Furthermore, the Salish Sea region is ecologically and environmentally distinct from the northern and west coast of Vancouver Island and the expansive estuaries to the north. This leads us to posit that these sites present different characteristics that might make them challenging to identify if our only baseline cultural and archaeological data is derived from these northern gardens.

3.3 Materials and methods

Based on a wider literature review on traditional estuarine root garden management and the lasting ecological, pedological and archaeological impacts of human management systems on landscapes, this research was guided by three principal assumptions:

1) The continuing presence of culturally important plants at the site are the result of past human management.

2) Human amendments to soils have lasting effects on soil structure and chemistry.

3) Archaeological investigations reveal legacies of human management.

This wider literature review included research on anthrosols, or anthropogenically made soils (Eidt, 1984; Fisher, 2015; Grossman et al., 2010; Holliday, 2004; Holliday & Gartner, 2007; Leguedois et al., 2016; Miller & Gleason, 1994; Stein, 1992) as well as research highlighting the long-term effects of Indigenous Peoples' land use legacies on plant community composition and land use function (Armstrong et al., 2021; Trant et al., 2016). This work fits within a global academic shift towards a more comprehensive understanding of traditional methods of environmental stewardship (Balée et al., 2020; Eduardo & Heckenberger, 2019; Lyons et al., 2021) and a call for the conceptualization of resource management practices that includes hunting and foraging activities without dismissing the importance of plant food caretaking practices occurring at a variety of scales (Lepofsky & Lertzman, 2008; Lyons et al., 2021).

3.3.1. Study site

The name Tl'chés means "island" or "the island" in Lək̓ʷəŋən (Duff, 1969). The archipelago is comprised of two large islands, Skingeenis (Discovery) and Stsnaang (Chatham). Skingeenis, the larger island at roughly 320 acres, is now divided between reserve land and marine park. Stsnaang is furthermore divided into two smaller islands, known as East Chatham and West Chatham. The study site is situated at the north end of West Chatham. Tl'chés sustains a high ecosystem diversity, including woodlands, rocky outcrops, coastal bluffs, oak savanna, anthropogenic prairies (Weiser & Leposky, 2009), tidal salt marsh wetlands, intertidal mudflats, and ephemeral freshwater wetlands (Gomes, 2012; Nicholas, 2017c). West Chatham Island has two large habitation sites (with archaeological deposits dating before and after European contact), anthropogenic camas and chocolate lily (*Fritillaria affinis*) prairies (Lowther, 2022), culturally managed Douglas-fir trees (*Pseudotsuga menziesii*), and ancestral sites. These places are overlaid with more contemporary evidence of Lək̓ʷəŋən inhabitation, such as apples and plum orchards. Tl'chés is an archetypal example of a cultural keystone place (CKP), as defined by Cuerrier et al. (2015, p. 431), as a location with:

> high cultural salience for one or more groups of people and which plays, or has played in the past, an exceptional role in a people's cultural identity, as reflected in their day-to-day living, food production and other resource- based activities, land and resource management, language, stories, history, and social and ceremonial practices.

One of these important food producing places at Tl'chés is an estuarine root garden on the northern end of West Chatham. This is a very small and low energy estuary characterized by a flat, open east facing estuarine meadow, fronted by a small tidal lagoon bounded by bedrock on two sides and a mixed silt-cobble shoreline. MacKenzie & Moran (2004, p. 9) define estuaries as "coastal sites […] found at the confluence of a freshwater source and the marine environment and affected by occasional and diurnal tidal inundations." Estuaries in the Coast Salish regions, affected by warm, dry summers with low freshwater flows, differ significantly from the large, river-fed estuaries furthermore north. Because of its location, the garden is protected by the prevailing winter southwesterly winds, making tidal inundations infrequent. Saltwater inputs occur primarily through winter high tidal inundations and salt spray. Winter storms would also lead to tidal flushing of the lagoon, affecting nutrient input (Bosman, 2019). Fresh water input, key to these estuarine sites, is drawn from what were originally small ponds or large vernal pools a short distance to the south-west. However, in the last 50 years, these pools, that Səƚƚəmah remembers her grandparent bathing in, have all but dried up (Nicholas, 2017c). Though stream bed features in the estuary indicated that, at some time, water flowed through the site, several of the authors (Maurice-Hammond, Mathews and Bosman) have not observed this over the past seven years. If this does occur, it is likely reserved to short periods with high precipitation.

The study site is roughly 20 meters wide on its N-S axis, facing the tidal pool to the east (Figure 10). It is fronted by a 1.5 m wide band of waterlogged, highly compacted, and biotically active sediment with similar characteristics to coastal peat, though the component of organic materials does not meet the threshold of peat. These natural peat-like sediment occurs elsewhere at Tl'chés, but at the study site, they transition abruptly and conspicuously about 1.5 m inland, into the organic and uncompacted soil that characterizes the rest of the site. All other areas surveyed at Tl'chés with similar ecological and hydrological characteristics had deep shelves with only narrow bands of soil, transitioning rapidly into the treeline.

Figure 10. Aerial view of the estuarine root garden (study site) at Tl'chés, British Columbia, Canada, looking south towards the vernal pool (Credit: D. Mathews).

As noted above, most of the site is characterized by organically rich, dark, uncompacted soil, supporting diverse plants communities. In a roaming survey conducted in 2018, Bosman (2019) noted 42 species present at the site, 33 of which were native. These included Baltic rush (*Juncus balticus*), dune wild rye (*Elymus mollis*) cleavers (*Galium aparine*) and fringed willowherb (*Epilobium ciliatum*). Of the invasive species, a proportional majority were grasses, such as creeping bent grass (*Agrostis stolonifera*) sweet vernal grass (*Anthoxanthum odoratum*) and quackgrass (*Agropyron repens*). Significantly, it is the only places on Tl'chés with a dense concentration of *T. wormskioldii*, growing in a patchy distribution on the meadow. The study site is situated a short distance from the village site where Səƚƚəmah grew up with, as well as the sacred pools, culturally managed Douglas-fir trees, and a small adjacent shell midden.

3.3.2. Research design

This research employs an eco-archaeological interdisciplinary approach to test for evidence of estuarine root garden management practice at Tl'chés through a combination of archaeology, ecology, and pedology. In doing so, we also attempt to establish an understanding of site history and use. To accomplish this, we develop a model, outlined in Table 3, employing known Indigenous estuarine root garden management practices. Although some ethnographic data concerning the consumption of estuarine root foods in Coast Salish territories exists (Gunther, 1945; Suttles, 1974; Turner & Bell, 1971), we rely primarily on information from Kwakwa̲ka̲'wakw (Deur, 2000, 2002a, 2002b, 2005; Lloyd, 2011) and Nuu-chah-nulth territories (Pukonen, 2008) concerning stewardship practices. Furthermore, we employ archaeological data concerning known anthropogenic signatures in cultural soils globally, such as elevated levels of soil phosphate (Herz & Garrison, 1998).

In Table 3, we hypothesize what these practices can be expected to look like in the present-day ecological, pedological, and archaeological records, and then list the methods of data collection and analysis used to test these hypothetical lines of evidence for stewardship. The Tl'chés research represents the first archaeological investigation of this site type in the region.

Table 3. Estuarine root garden components

Ethnographic estuarine root garden stewardship practices	Potential observable or measurable impacts	Methods of data collection and analysis
Anthropogenic inputs to soil: Fertilization or addition of soil organic matter (SOM)– the addition of fish remains and organic remains brought with the tides. Humans associated with increased phosphorous and nitrogen.	Increase in certain key nutrients – especially phosphorous (P), nitrogen (N), carbon, calcium (C), potassium, magnesium and sulphur	Multi-element soil analysis (ICP-AES, ICP-MS, XRF)
Tillage – the regular turning and mounding of soil.	Lowered levels of compaction	Soil penetrometer
	Less defined stratigraphy/stratigraphic indicators in the upper 30-40 cm	Visual in-field observation of soil profile
	Changes in ecological gradation, succession. Species found in different zones than expected.	Shore-perpendicular line transects/Measuring slope gradation (laser range finder)
Use of tools to work/maintain the gardens.	Remnants of broken or discarded tools (e.g., digging stick tips)	Archaeological recovery of artifacts related to garden management.

Terracing	Little to no shoreline slope, heightened soil retention, archaeological evidence (e.g., rock walls)	Archaeological excavation of terracing features
Selective weeding and transplanting	Heightened relative abundance of culturally important species, changes in overall species richness on the landscape	Shore-perpendicular line transects and quadrat sampling

3.3.3 Limitations of the study.

We acknowledge that we are relying upon a Direct Historical Approach to the archaeology and applying ethnographic data from one ethnolinguistic region to another. Furthermore, there has been no known stewardship of traditional foods at Tl'chés in at least 70 years. As such, we anticipated some potential variability in the kinds of observable and measurable evidence of stewardship and use. We also acknowledge that herbaceous plant communities are dynamic, and that their presence and absence can arise from both biophysical and cultural factors. This is further complicated by the cessation of many plant caretaking practices by Indigenous Peoples during the 19th century (Larson et al., 2014; Turner at al., 2021). As such, tying specific herbaceous species to human caretaking can be challenging, necessitating the interplay with cultural knowledge, archaeology, and pedology.

3.3.4. Periphery sites

To test the methods described in this chapter, three periphery sites were chosen (Figure 11) because of shared physiological and ecological traits with the study sites, such as the presence of estuarine root foods (*A. egedii* and/or *T. wormskioldii*) and a location adjacent to a low energy tidal site. Sites with visible histories of use by Indigenous Peoples, such as shell middens, were excluded. In using the word "periphery" instead of "control," we draw from Armstrong et al. (2021) who argue that conventional notions of control sites are poorly suited for the study of cultural landscapes on the Northwest Coast. While the form and intensity of use differed, estuaries are ecologically productive landscapes that attracted human presence on a variety of scales since time immemorial (Joseph, 2012). Furthermore, West Chatham Island is a relatively small island with cultural features found throughout. There is a reasonable chance that any periphery site chosen could have been altered by peoples at some time, but to a lesser intensity, or in a different way, than the study site.

Figure 11. Location of the study site (root garden) and the three periphery sites (PS1, PS2 and PS3) on West Chatham Island, Tl'chés, British Columbia, Canada. The green pin indicates the study site, while the three red pins are the periphery sites.

Periphery Site 1 (PS1) is 36 m southeast of the study site, at the end of the same small lagoon. It is significantly smaller than the study site, bordered by bedrock on two sides and transitioning rapidly into shrubs and trees. The sediment at PS1 slopes sharply down to the lagoon. The vegetation is dominated by *A. egedii*, sedges, and grasses. No *T. wormskioldii* was observed. A stream bed is present, but no water was observed. Being adjacent to the main garden site, it likely would have harvested from in some capacity or served as a donor area for the main garden. However, its size, and lack of terracing, differentiate it from the garden site.

Periphery Site 2 (PS2) is 317 m south-east of the root garden at the end of a larger tidal lagoon. Like other coastal sites observed at Tl'chés, PS2 is characterized by a thick, waterlogged sedimentary shelf, extending roughly 20 m inland. A narrow band of soil sits between the shelf and the treeline. PS2 is the only other site surveyed that has a community of *T. wormskioldii*, growing in a patchy distribution, though there is very little *A. egedii*. As with the previous two sites, small dry stream beds were observed, originating from a network of inland bedrock-defined vernal pools. As with PS1, the presence of food species make harvest from the site possible, though the size of the area does not denote intensive garden building and maintenance.

Periphery Site 3 (PS3) is in a large swale, on the landward edge of a brackish vernal pool. Situated at the southwestern edge of West Chatham Island, it borders a coastal anthropogenic prairie with a prolific community of Lək̓ʷəŋən-stewarded camas and chocolate lily (Lowther, 2022) and is about 100 m south of the farm where Səłłəmah grew up. The PS3 vernal pool is maintained by a combination of rainfall and sea water from winter storms washing over the gravel berms and is dry for half the year. PS3 was chosen because of its historical *T. wormskioldii* community, recorded by Dr. Nancy Turner in the 1990's (Figure 12). The site was revisited by Dr. Turner and Darcy Mathews on May 22, 2018, and the clover has since been extirpated. With its proximity to a large Lək̓ʷəŋən village inhabited until the early 1950's, it is possible that the clover growing there might have been harvested as food, though it lacks many of the other known characteristics of estuarine root gardens.

Figure 12. Nancy J. Turner holding springbank clover (*Trifolium wormskioldii*) harvested from periphery site 3 (PS3) on Tl'chés, British Columbia, Canada, 1999

3.3.5 Archaeological methodology

Four 50 cm x 50 cm evaluative units were excavated in the study site between November 8-9, 2018 (Bosman, 2019) (Figure 13). These plots were chosen based on a judgemental sampling method, targeting different plant communities to determine why *T. wormskioldii* grows in certain areas and not others. These evaluative units were excavated to glacial till. Soil profiles were examined as part of the excavation process. *A. egedii* and *T. wormskioldii* roots and rhizomes, when present in the units, were removed, weighed, and later replanted.

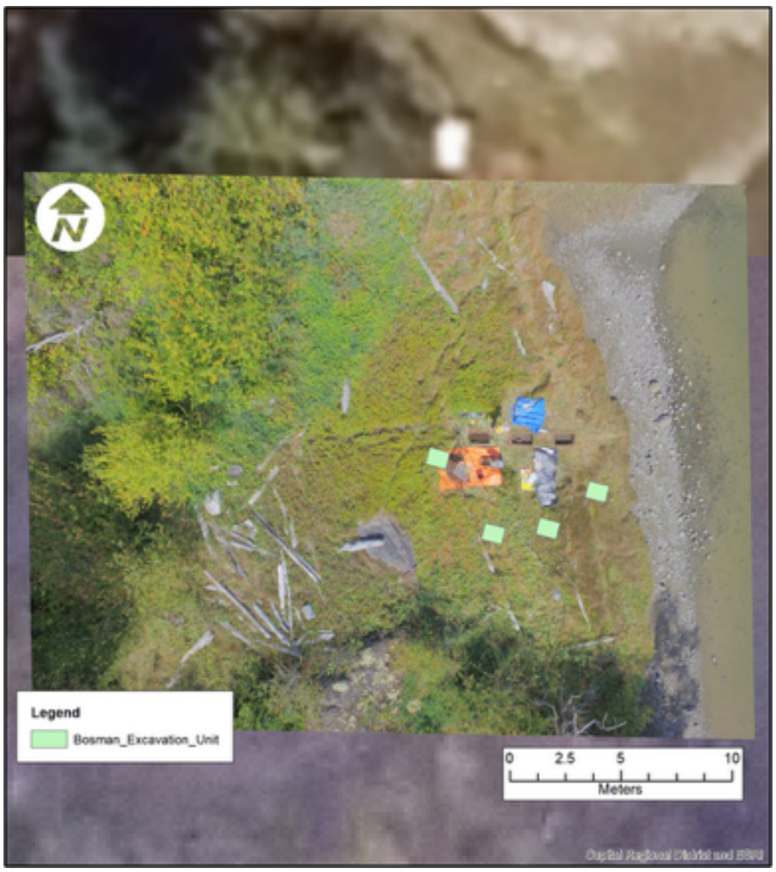

Figure 13. Map of excavation units at the study site (root garden) on Tl'chés, British Columbia, Canada, showing a transition from sediment shelf to soil.

Three subsequent 1m x 50cm units were excavated between August 26 – September 1, 2019. These units extended perpendicularly from the shoreline, capturing the transition from sedimentary shelf to soil supporting a dense *T. wormskioldii* patch. The sedimentary shelf was deemed high potential for preserved organic materials related to estuarine root garden management (Hoffman et al., 2016; Stafford, 2020). As with the previous units, *A. egedii* and *T. wormskioldii* roots and rhizomes, when present, were visually identified, removed, weighed, and replanted when the units were backfilled. The unit closest to the shoreline was designated as UA3, transitioning to UA2 and UA1. As with the previous excavations, units were dug until hitting the glacial till (a maximum of 23 cm Depth Below Surface (DBS). Charcoal extracted from UA1 was sent to Beta Analytic for AMS radiocarbon dating.

3.3.6 Ecological methodology

As discussed by Armstrong et al. (2021), human land-use legacies are an important driver for present-day plant communities, affecting taxonomy and structure more than 150 years after the cessation of management. As such, we hypothesized that species richness would be higher in the periphery sites, while the study site would support a higher density of the culturally important target species. Furthermore, in coastal ecosystems, the gradient of abiotic factors varying with relative height is likely to have an over-riding impact on vegetation (Vermeersch & Van Kerckvoorde, 2016). Estuarine root gardens, supporting plant communities shaped by anthropogenic factors, may express more uniformity than otherwise encountered in similar, unmodified ecosystems. As such, trying to understand plant communities in estuarine root gardens should account for gradation and changes in species composition away from the shoreline.

To capture this ecological gradient, we combined shore-normal line transects (placed perpendicularly to the water, covering the beach-inland gradient) and contiguous sampling plots (Del Vecchio et al., 2019; Prisco et al., 2016). A 1m x 1m quadrat was used, with the percent cover of each specie directly estimated within the sample area (Buckland et al., 2007). Due to the overall small surface area of the study sites, contiguous sampling allowed for a more thorough cover of the area, increasing the likelihood that *T. wormskioldii* would be encountered in the quadrats. Depending on their overall surface size, between four and five transects were established at each site, which were contiguously sampled from the shoreline to the treeline (again, a variable distance, dependent of site size).

To compare plant community composition between the hypothesized garden site and the peripheral sites, we conducted non-metric multidimensional scaling (NMDS), analysis of similarities (ANOSIM) across all four sites, and indicator species analyses. To visualize differences between plots of different types and sites, we conducted an NMDS analysis with the R package vegan ver. 2.5–7 (Oksanen et al., 2020) using three axes (k=3) and the Bray-Curtis dissimilarity index and visualized the results with the R package ggplot2 ver. 3.3.3 (Wickam 2011). To identify species strongly associated with specific types of plots ("indicator species"), we carried out an indicator species analysis using the "multipatt" function in the R Core Team (2013) package indicspecies ver. 1.7.8 (De Caceres et al., 2016) with 9999 permutations. Finally, to test for statistically significant differences between garden and periphery plots, we conducted an analysis of similarities (ANOSIM) with the vegan package using the Bray-Curtis dissimilarity index and 9999 permutations.

3.3.7 Pedological methodology

Pre-excavation, a ProCheck Soil Sensor was used at all plots (garden and periphery) to determine soil temperature, moisture, and bulk electrical conductivity. A soil penetrometer (or a Dickey-John Soil Compaction Tester) was used to measure soil compaction. Once units were opened, we conducted an in-situ stratigraphic analysis.

Samples gathered from the root garden site and periphery sites were sent to the laboratory of the Ministry of Environment in Victoria, B.C., for analysis. Elements measured were cation exchange capacity (CEC), exchangeable cations, available Phosphorous (P), pH, Nitrogen (N) and Calcium (C). Once results were returned, we conducted an indicator species analysis using the "multipatt" function in the R Core Team (2013) package indicspecies ver. 1.7.8 (De Caceres et al., 2016) with 9999 permutations to statistically analyze and visualize differences in soil qualities between the study and periphery sites.

3.4 Results

3.4.1 Archaeology

Archaeological investigation of this site did not reveal a direct association with estuarine root garden management, in the way that a rock wall terracing feature or the preserved tip of a broken digging stick would (Hoffman et al., 2016; Stafford, 2020). However, the archaeological record indicates the clear presence of cultural activities. A small feature in UA1, consisting of a concentration of charcoal and a small cluster of fire altered rock (FAR) was uncovered at 14-16cm DBS. While this might constitute a small hearth, the feature was not consolidated and may have been disturbed. Considering that we hypothesize a considerable degree of turbation from root gardening activities (such as digging and tilling), finding a concentration of charcoal and FAR, but not a clearly delineated hearth, is consistent with site formation processes. Charcoal for this feature was radiocarbon dated and calibrated to 510-426 cal BP, or between 1440-1524 cal AD, pre-dating European arrival in Lək̓ʷəŋən territories. A shoe nail, consistent with a style that would have been worn by Lək̓ʷəŋən peoples living on Tl'chés from the mid to late 1800's, was recovered in UA2 between 15-17cm DBS.

3.4.2 Ecology

In comparing plant community composition between the study and periphery sites (a list of which can be found in the supplementary materials), an ANOSIM test indicated the sites were significantly different from one another ($p < 0.0001$), though with a low degree of differentiation ($R = 0.084$). The stress value was 0.15, indicating that the NMDS performed relatively well with three axes. The NMDS visualization indicates some differentiation between garden and periphery plots (Figure 14), especially along NMDS3 (Figure 15 and Figure 16), but there is significant overlap with periphery plots 2 and 3. The garden and periphery sites also contain characteristic indicator species that distinguish them from each other. Among the six statistically significant indicator species characteristic of the remnant garden plots measured are two of the key edible root/rhizome plants Pacific silverweed (*Potentilla anserina* ssp. *pacifica*; $p = 0.0001$) and springbank clover (*Trifolium wormskioldii*; $p = 0.0278$). While eighteen species were statistically significant indicator species for the periphery plots, none are known to be culturally salient edible root/tuber/bulb/rhizome-bearing plants.

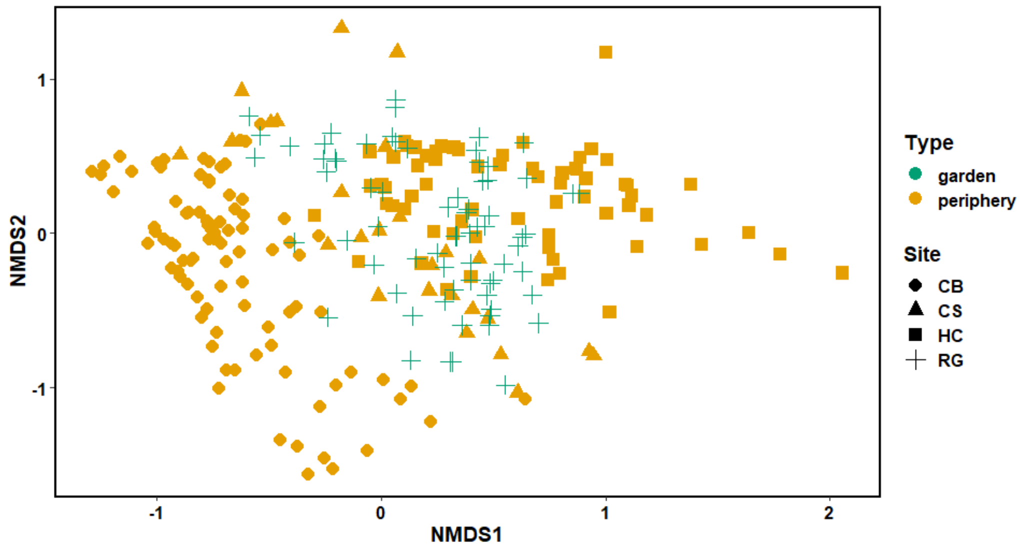

Figure 14. Visualizations of the non-metric multidimensional scaling (NMDS) analysis of plant species composition in the root garden (RG) and three periphery/control sites (PS1, PS2, PS3) at the study site (Tl'chés, British Columbia, Canada). This figure displays NMDS axis 1 and NMDS axis 2. Each shape represents one plot where species composition was assessed. Proximity of shapes indicates similarity of species composition between plots.

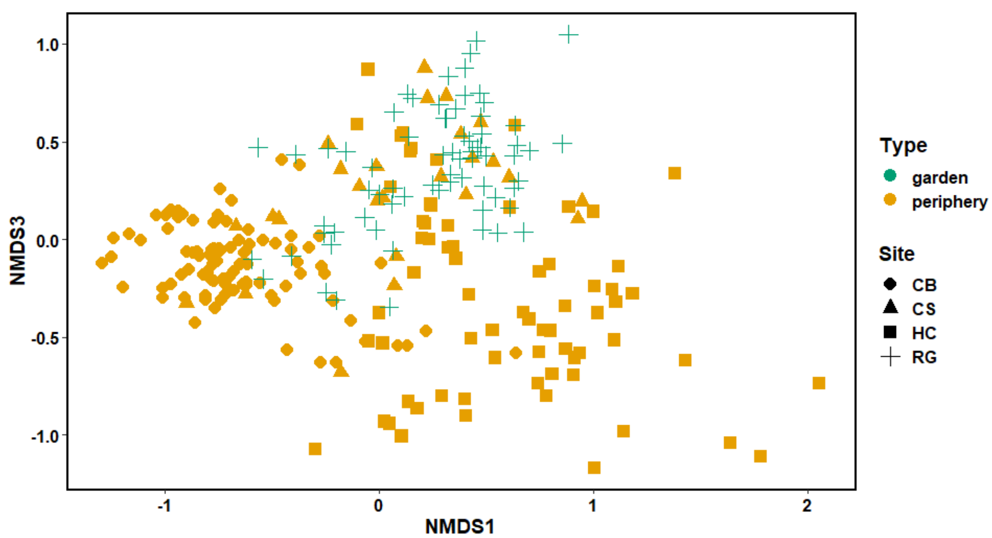

Figure 15. Visualizations of the non-metric multidimensional scaling (NMDS) analysis of plant species composition in the root garden (RG) and periphery/control sites (PS1, PS2, PS3) at the study site (Tl'chés, British Columbia, Canada). This figure displays NMDS axis 1 and NMDS axis 3. Each shape represents one plot where species composition was assessed. Proximity of shapes indicates similarity of species composition between plots.

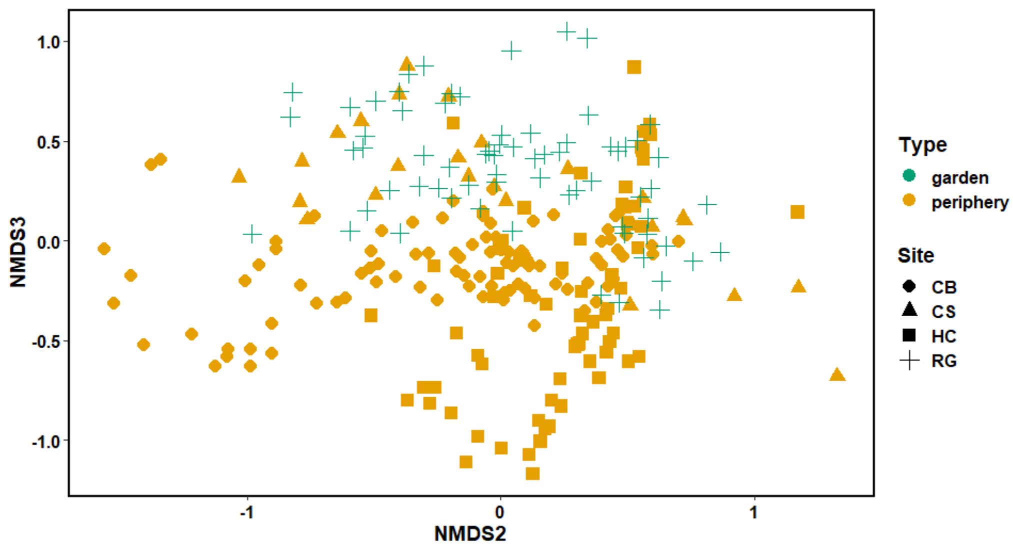

Figure 16. Visualizations of the non-metric multidimensional scaling (NMDS) analysis of plant species composition in the root garden (RG) and periphery/control sites (PS1, PS2, PS3) at the study site (Tl'chés, British Columbia, Canada). This figure displays NMDS axis 2 and NMDS axis 3. Each shape represents one plot where species composition was assessed. Proximity of shapes indicates similarity of species composition between plots.

3.4.3 Pedology

In examining the results from the study site, the sediment of UA2 and UA1 is remarkably consistent; dark, loose, uncompacted, organic-rich loam with small proportion of sub-rounded pebbles and cobbles, which otherwise litter the beach directly to the south of the site. UA3, the unit closest to the water, differed in being highly compacted, biotically active and waterlogged. At 12cm DBS, it transitioned to a 50% composition of rounded and sub-rounded pebbles and cobbles, likely fluvial. In all units, no visible stratigraphic differentiation was observed.

Analysis of soil samples from the root garden site and periphery sites yielded significant differentials. As expected, both plant-available P and P were higher in the root garden than in the periphery sites (Figure 17). Other elements of significance were higher levels of calcium and carbon in the root garden site as well as elevated levels of certain trace metals. Not statistically significant, though notable, is that compaction at the study site was, on average, lower. The only statistically significant indicator for the periphery sites is higher levels of nitrogen.

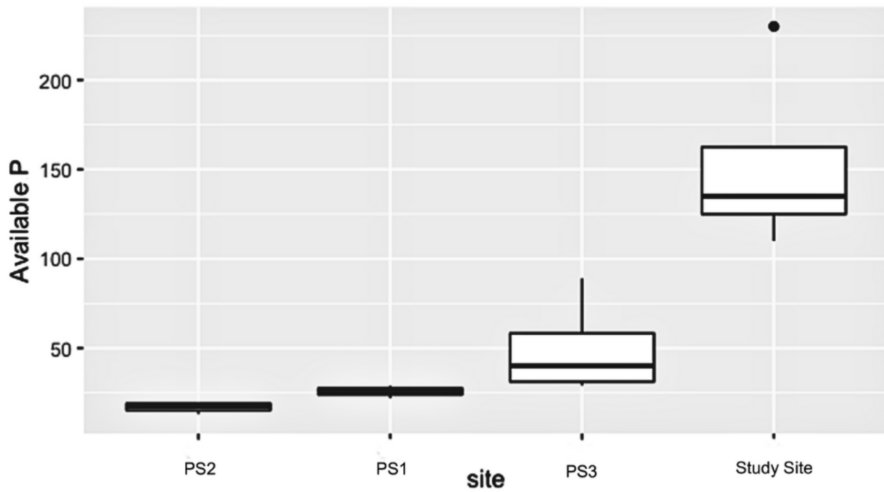

Figure 17. Available phosphorous (P) levels differentials in the periphery sites (PS1, PS2, PS3) and study site (root garden) on Tl’chés (British Columbia, Canada).

3.5 Discussion

The study results indicate significant differences between the study site and the periphery sites. Specifically, culturally important food species cultivated in the context of estuarine root garden management— *A. egedii* and *T. wormskioldii* —emerged as indicator species for the estuarine root garden site. This is an exciting future avenue of research when looking at the sites in Coast Salish territories, where *T. wormskioldii*, specifically, is less common and abundant than in wetter climates characterized by larger estuaries. Additionally, soil analysis reflected this garden/periphery site differentiation, with the garden site displaying high key nutrient levels, such as phosphorous (P) and carbon (C), concurrent with what is expected of areas that were actively utilized and managed by peoples (Howard, 2017). P is a sensitive and persistent indicator of human activity, and its detection has long been used by geoarchaeologists to detect past human occupation, as well as the type and intensity of human activity (Lauer et al., 2013; Wilson et al., 2008; Wilson et al., 2009;). P gets introduced into the soil through anthropogenic additions, such as ash from fires, bones, and other animal products (Gleason, 1994). Once introduced, it is less susceptible to leaching, oxidation and plant uptake than other elements, cycling through the soil in geological time, making it a long-lasting marker of past land use (Holliday, 2004; Holliday & Gartner, 2007). Past fertilization practices, such as the burying of fish carcasses in garden plots, may account for heightened levels of P at the study site. This is supported by ethnographic and community accounts describing the addition of marine detritus to cultivated plots (Deur, 2000; Suttles, 1974; Turner ,1973; Turner & Efrat, 1982). Notably, the second highest P content was at PS3, an area that had dense *T. wormskioldii* population into the 1990's. Though this could indicate that the area was similarly stewarded, the proximity of PS3 to the house where Səƚƚəmah grew up, and the concurrent presence of farm animals (such as sheep, chicken, geese and ducks) in the area, would have also contributed to P concentration in the soil (Forest-Hammond, 2020). Carbon, similarly, is tied to the addition and enhancement of SOM, and, in some cases, can persist in soil (Holliday, 2004).

The absence of visible stratification and horizonation in the sample site soil may be indicative of cultural site formation processes. Certain past actions, such as tilling, digging and ploughing, even out the distribution of soil particles, preventing the natural development of soil horizons (Gleason, 1994). Estuaries are biotically and abiotically active areas, with soil churning happening resulting from tidal influences and water flow as well as animal activity. As such, a lack of visible stratigraphy may be naturally occurring. However, it is also concurrent with past management practices, which would have involved the regular churning of soil during harvest time and as part of routine management of the site (Deur, 2000). These practices are also aligned with the ethnoecologically well-documented and culturally known Lək̓ʷəŋən practices associated with the stewardship of *kwetlal* (Beckwith, 2004). The finding of the shoe nail in UA2 at a greater depth than the radiocarbon-dated unconsolidated hearth feature is indicative of this turbation. Site disturbance in a biotically active contexts is, by itself, not unusual, and could be associated with burrowing organisms, tidal disturbances, or root activity. However, the estuary itself is relatively low energy, protected by a berm from most tidal inundations. Furthermore, there are very few animals living on Tl'chés capable of larger scale disturbance[26]. As such, a

[26] It should be noted that introduced and non-migratory Canada geese (*Branta canadensis*) populations are associated with estuarine and coastal marshland erosion and impacts to vegetation propagation through extensive grazing (Janus, 2022). Though Canada geese are prevalent (and problematic) on Tl'chés today, during the period in which this research was conducted, their population was controlled by predation from Stqéyə, a lone wolf that lived on the islands for close to a decade.

cultural explanation for the buried shoe nail and the unconsolidated hearth is most likely. Furthermore, the presence of the sedimentary shelf at the edge of the study site would have served as an effective erosional barrier, in much the same way that rock walls did in ‘Na̲mg̲is territories (Deur, 2000). The remarkable consistency in width of the coastal shelf at the study site raises the intriguing possibility of Lək̓ʷəŋən engineering – transforming some of this shelf into garden soil while retaining enough of it to serve as an erosion barrier.

Another point of note is the texture of the soil at the study site. Loose and uncompacted, it contrasts with PS1 and PS2, which are characterized by deep peat-like sedimentary shelves, higher clay contents, and the presence of boulders and pebbles. Comparatively, the study site presents only a small number of rocks in the soil matrix, though the abutting beach is covered in them. This indicate that people were likely tossing them towards the shore while churning the soil, a practice associated with the management of estuarine and terrestrial root gardens as well as clam gardens (Deur et al., 2015; Lepofsky et al., 2015). Of all the periphery sites, the soil at PS3 most closely resembles the study site, also showing high P readings. As noted previously, this area supported *T. wormskioldii* as late as the 1990’s, though it has since been extirpated. These soil characteristics might be a legacy of past estuarine root food cultivation in the area.

T. wormskioldii and *A. egedii* are both ecological indicator species for the study site. This supports Armstrong et al. (2021)’s findings that human land-use legacies are important shapers of present-day plant communities, with long-lasting impacts on taxonomy and diversity at cultivated sites. Though these plants naturally occur in the Coast Salish, the range of *T. wormskioldii* in Lək̓ʷəŋən territories, specifically, appears to be constricted by ecological and hydrological factors. While their presence in this small, sheltered tidal estuary at Tl’chés is not necessarily evidence of human driven translocation, their enduring conspicuous density, combined with the unique pedological and archaeological features of the site, suggest that Lək̓ʷəŋən peoples were able to engineer and maintain ecological conditions that ensured their ongoing presence and productivity (Armstrong et al., 2021; Turner et al., 2021). Furthermore, as noted previously, *A. egedii* and *T. wormskioldii* roots were temporarily removed during excavations and re-buried in the upper soil level when the units were backfilled. This impromptu ecological experiment yielded interesting results. A year after excavation and reburial, UA2 supported a much denser population of *T. wormskioldii* than pre-excavation – doubling from the previous year to covering almost 50% of the surface area . Other vegetation that usually overshadowed the clover (such as *A. egedii*) was not as tall as in surrounding plots, which likely contributed to the expansion of the clover population. These findings correspond with traditional management techniques. For example, the weeding of competing plants from estuarine gardens, sometimes in conjunction with soil turning activities (often performed several times of year) encouraged the growth of these culturally preferred species, which might otherwise be outcompeted. Talking about the gardens of Kingcome Inlet, the late clan chief Kwaxsistalla/Adam Dick explained:

> We *siixa* it; we call it "*siixa*," when you pull all the weeds out of there. They worked on it all day. They wouldn't let anything, one little grass on there. They'd go down there, I don't know how many times a year, just to keep that [garden] clean. If there's lots of [weeds], it doesn't grow good" (quoted in Deur, 2002b, p. 21).

Weeding, in Coast Salish territories, was a well-known practice. In talking about the management of camas, Suttles (1997) describes talking about areas consisting solely of camas bulbs, where no grass was present "because the patches were cared for" (quoted in Deur, 2000, p. 56). After harvest, and when the earth had been churned, broken or immature roots and rhizomes would also be replanted, ensuring a harvest for the following year. Many ethnographic sources make this practice explicit (see Compton, 1993; Edwards, 1979; Turner & Efrat, 1982). On this, Kwaxsistalla explained that "you don't take those little pieces [of root]. You leave them here. They come back. You put them in the ground 'cause that's going to be your *texwsus* [*Trifolium*] and *tliksem* [*Potentilla*] next year" (quoted in Deur, 2000, p. 93).

As noted above, Lək̓ʷəŋən stewardship played an outsized influence on the clover population, the ecological legacies of which persist today. These practices resulted in plots that were dominated by specific culturally important species: the Lək̓ʷəŋən enhancement of a natural estuarine landscape. Therefore, it is unsurprising that excavating a plot, which involved digging soils and replanting roots in ways that mimicked traditional stewardship practices, positively impacted these plants. In four years of regularly visiting the garden site, this was the first, and only time, that *T. wormskioldii* was witnessed flowering there (Figure 18).

Figure 18. **S**pringbank clover (*Trifolium wormskioldii*) in bloom at the study site (root garden) at Tl'chés (British Columbia, Canada), 1-year post excavation.

Since colonization began, Lək̓ʷəŋən landscapes have been significantly altered by urbanization and development. As a result, *T. wormskioldii* is now relatively rare in Coast Salish territories, which we attribute to the interplay between the disappearance of coastal wetlands (including habitat fragmentation), competition with invasive and non-native species, changing hydrology, ongoing climate change, and the cessation of human management (McCune et al., 2013; Nicholas, 2017c). Early colonialism on the Coast Salish has had enduring impacts of ecosystem integrity, food systems, and cultural knowledge. Lək̓ʷəŋən peoples have since witnessed the expansion of Victoria into a major urban center which has buried their cultural landscapes and important food harvesting areas under layers of concrete.

3.6 Conclusion

Based on the ecology, pedology, and archaeology of this site, we are confident in our assessment that this was a cultivated Lək̓ʷəŋən estuary root garden—the first of its kind formally identified and studied in Coast Salish territories. Its location and context within a complex mosaic of a

Lək̓ʷəŋən cultural landscape, as well as the evidence discussed in this paper, support this conclusion. This is significant for several reasons, the first being that understanding the specifics of past cultural practices in shaping ecosystems is a key component to restoring them (McCune et al., 2013; Turner et al., 2021). Tl'chés, as one of the archetypal examples of a CKP (Cuerrier et al., 2015), is central to Lək̓ʷəŋən desires for eco-cultural restoration and reconnecting with territories and traditional practices, especially in the context of youth engagement. As Səłləmah states:

> *I was raised on Tl'chés by my great grandparents Tom and Alice James. They were so loving and sharing, I never knew a harsh word, never knew hunger. My grandparents were healers, and they taught me that Tl'chés has always. been a place of healing and learning. These are the values that I was taught: sharing, kindness, respect, and listening. These are our morals, and what needs to be taught to people today and in the future. Our work together at my home shows our youth the many kinds of foods our old ones cared for, and that sustained our people. These are lessons the land has to teach us, and we need to continue this relationship today and into the future. Tl'chés has always been a place of healing, and these plants are both our food and medicine. Our youth can learn to cook our traditional foods in a safe and harmonious traditional way. This means not just cooking food, but doing it in a good way, where we clear our minds and hearts of bad or troubling things because they will affect the food. We must value our connection to our traditional foods and history, and what this means for the next generations. There are so few knowledge keepers, as well as archaeological, sacred, and traditional food sites left, these places need protection right now.*

Successful long-term restoration of the Tl'chés estuarine root garden is complicated by the hydrological trajectory of the site. Even if management were to be renewed, with regular harvests, weeding, and tilling of the soil, the lack of freshwater would continue to negatively impact *T. wormskioldii* and, to a lesser degree, *A. egedii*, leading to its eventual extirpation. Furthermore, near-future climate change-induced global sea level rise threatens to inundate coastal cultural sites such as this. However, this is not to say there is no value in eco-cultural restoration efforts, or that this should not be attempted; indeed, doing so would likely slow the decline in clover population while continuing to positively impact the hardier *A. egedii*. More importantly, as outlined in Bosman's (2019) restoration prescription for the site, it would provide an important nexus point for youth and community members to re-introduce these sites and foods into their traditional diets and knowledge systems. These are important acts of cultural resurgence. As Lək̓ʷəŋən Songhees ethnobotanist Cheryl Bryce reminds us, Indigenous resurgence "is about reconnecting with homelands, cultural practices and communities, and is centered on reclaiming, restoring, and regenerating homeland relationships" (Corntassel & Bryce, 2012, p. 153). When Səƚƚəmah talks about the importance of bringing youth back to Tl'chés, she often brings up the need for them to learn to be self-sufficient on the land, to re-assert relationships with the islands that are based on responsibility and reciprocity. This is deeply tied to community resurgence in the face of ongoing cultural harm, harm that, in Lək̓ʷəŋən territories, cannot be separated from ongoing processes of urbanization and colonial alienation of peoples from their land-base. For peoples to return to homelands, to teach youth and to renew stewardship and harvesting practices, is both a political act and an act of Indigenous resurgence (Joseph & Turner, 2020).

This paper makes the assertion that interdisciplinary methodologies are key to the future study of estuarine gardens. This calls for a re-evaluation of what is considered "valid" archaeological evidence while expanding our understanding of site variability, looking beyond known estuarine garden features (such as rock walls) towards what we might have been missing. Future work should focus on locating and identifying other sites in the Salish Sea, where the dual pressures of colonialism and rapid urban development and habitat fragmentation put them at particular risk. On a wider scale, this work highlights the pressures on wetlands and estuaries, which are nexuses of human use and management globally. The disappearance of these ecologically, culturally, and socially important ecosystems is part of an ongoing process of landscape alteration that are putting these sites under severe threat worldwide. It is estimated that between 64 and 76 % of the world's wetlands have been lost since 1900. In the Fraser Lowlands of British Columbia and Vancouver Island, about 70% of wetlands are believed to have destroyed (Staveren et al., 2006).

T. wormskioldii is part of a continuum of well-known Lək̓ʷəŋən stewardship practices that enhanced the productivity of plant and animal communities on landscapes of high cultural salience. Suttles (1974) notes parallels in camas and clam management, in which family-stewarded places had stones cleared, soils or sediments loosened and dug, along with other care-taking practices. Lək̓ʷəŋən camas and clam stewardship provide important analogues for considering estuarine root gardening as another form of lesser-studied management by Indigenous Peoples. While camas filled the starch/carbohydrate dietary need in Lək̓ʷəŋən territory that *T. wormskioldii* and *A. egedii* filled in places like Kingcome Inlet, this study illustrates that *T. wormskioldii* /*A. egedii* gardening also occurred here, albeit likely on a smaller scale than in other parts of the coast. This study contributes to a form of management previously unstudied in this region. In the Lək̓ʷəŋən context, the cultural importance of estuarine landscapes has largely been ignored by settler researchers, while ongoing colonial landscape changes have further alienated Lək̓ʷəŋən peoples from these places. We assert that the loss of community knowledge about estuarine root gardens today exists as an artifact of colonialism. This knowledge, however, remains in the ground and in the plants, re-emerging as part of this collaborative re-learning process. It is coming home.

Chapter 4 – Estuarine root gardens and Indigenous soils: Enduring legacies of 'Namgis First Nation caretaking at the Gwa'ni/Nimpkish River estuary

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Author contributions: I. M. H. and D. M. conceived the manuscript idea. I. M. H. prepared and conducted the research with the help of D. M. A. C. M. contributed to the data analysis and rendering of figures. The document was written by I. M. H., with contributions and support by D. D. and editorial support from D. M. K. R.-C. and D. S.-S. grounded this work in their knowledge of associated cultural practices. Mapping was done by D.M. and I.M.H.

4.1. Abstract

Estuarine root gardens are a form of coastal stewardship in Kwakwa̱ka̱'wakw First Nation territories on the West Coast of British Columbia, Canada. These were places where culturally, economically, and nutritionally important foods, like *t'əx̱ʷsús* (springbank clover*, Trifolium wormskioldii*), *dləksəm* (Pacific silverweed, *Potentilla egedii*) and *xúkʷkʷem* (northern rice-root lily, *Fritillaria camschatcensis*)*,* were grown in enormous quantities. In 'Na̱mg̱is territories, the stewardship practices of the Gwa'ni (Nimpkish) River estuarine root garden were relatively well documented, a rarity for plant stewardship sites on the Pacific Northwest Coast. This deep time perspective offers a rare glimpse into certain important aspects of estuarine root garden stewardship. However, the unique characteristics of these places, and the impacts caused by the cessation of active caretaking, remains poorly understood. By employing a novel interdisciplinary methodology that combines ecological surveys, soil analyses and archaeological excavations, we detected more subtle signals of past human caretaking, situating this garden within the emerging wider regional understanding of estuarine root gardens and informing the future identification of undocumented estuarine root gardens sites. Furthermore, understanding the site histories and trajectories of these garden sites informs future eco-cultural restoration, while shedding light on the changes that have occurred since active caretaking ceased.

4.2. Introduction

4.2.1. Estuarine root gardens on the Northwest Coast

Globally, humans have stewarded their environments for millennia (Ellis et al., 2021). Wetlands have been nexus points for these forms of stewardship, from the c*hinampas* system of raised fields in Tenochtitlan, Mexico, to the ancient aquaculture systems of the Amazonian rainforest (Beach & Luzzader-Beach, 2012; Beach et al., 2015; Krause et al., 2019). On the Northwest Coast of North America, Indigenous Peoples have a deep history of modifying estuaries, transforming them into gardens from which key, carbohydrate-rich root foods could be harvested. In Kwakwa̱ka̱'wakw territories, on northeast Vancouver Island and the adjacent mainland coast (Figure 19), estuarine root garden foods (including *dləksəm* (Pacific silverweed, *Argentina egedii (Wormsk.)* Rydb.; syn. *Potentilla pacifica* (L.) Howell.), *t'əx̱ʷsús* (springbank clover, *Trifolium wormskioldii* Lehm), and *xúkʷkʷem* (northern rice-root lily, *Fritillaria* *camschatcensis* (L.) Ker Gawl) and others[27] were stewarded, harvested, and traded in great quantities. These gardens were documented by early anthropologists (e.g., Boas ,1934, 1947; Boas & Hunt, 1921; Drucker, 1951; Edwards, 1979) and, more recently and systematically, by academic researchers working in collaboration with Kwakwa̲ka̲'wakw elders and knowledge holders (e.g., Deur, 2000, 2002a, 2002b, 2005; Deur et al., 2013; Dick et al., 2022; Lloyd, 2011). Here, we are indebted to the knowledge of the late Kwaxsistalla Wathl'thla (Adam Dick) of the Qawadiliqəlla Clan of the Dzawada7ēnuxw of Kingcome Inlet – a leader of unique training, sequestered by clan chiefs from the colonial world as a child and trained in traditional stewardship, including the technologies and protocols of estuarine root gardening. Carrying forward and offering additional details to the teachings of Kwaxsistalla have been knowledgeable members of his family, including Mayanilth (Dr. Daisy Sewid-Smith) and Oqwilowgwa (Kim Recalma-Clutesi); together, these three Kwakwa̲ka̲'wakw cultural leaders have been key in understanding how these gardens were built and cared for, as well as their central importance in the economic, social, and spiritual lives of the Kwakwa̲ka̲'wakw peoples.[28]

[27] Indigenous peoples' plant terms presented in this paper are in the Kwak'wala language–the language of the Kwakwa̲ka̲'wakw people. The spelling of plant terms here follows the conventions advised by Kwak'wala language expert Mayanilth (Dr. Daisy Sewid-Smith) and codified in such works as the extended botanical appendix reproduced in Lloyd (2011). The scientific names of the plants were verified with the IPNI (2025) index.

[28] For biographical overviews of Kwaxistalla Adam Dick and his contributions to understanding Northwest Coast ethnobiology, as well as the collaborative contributions of Mayanilth and Oqwilowgwa, see Dick et al., 2022; Deur, Recalma-Clutesi & Dick, 2020; Deur, Recalma-Clutesi & White, 2020.

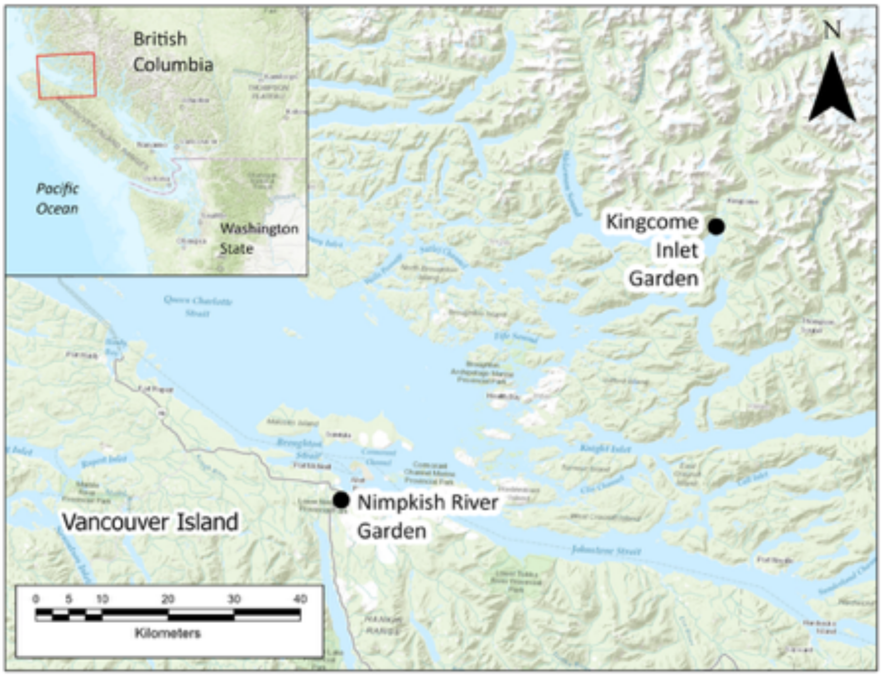

Figure 19. Locations of the Kingcome Inlet and Gwa'ni [Nimpkish] River root gardens in Kwakwaka'wakw First Nation territories, on the northwest of Vancouver Island and the adjacent mainland, British Columbia, Canada.

Kwakwaka'wakw communities traditionally enhanced the yield of culturally important plants through various methods. In parts of Kwakwaka'wakw territories and the root garden site discussed in this paper, stewardship of these highly bio-dynamic sites commonly involved extensive terrestrial and hydrological modifications. Boas describes Kwakwaka'wakw gardens as being "separated by stone walls, but often also by blocks [or "planks"] which are put up on edge right into the ground" (1934, p. 166). Cedar posts were also used to mark the boundary of individual plots (Deur, 2000, 2005; Lloyd, 2011; Pukonen, 2008). These barriers separated plots and provided the baseline for sedimentary infilling and soil building, which occurred both naturally and anthropogenically. Accordingly, in Kwak'wala, the language of the Kwakwaka'wakw Peoples, the word for these gardens is *t'akí'lakw*, or "place of human-manufactured soil." As Kwaxsistalla shared with Deur (2002a, p. 47): "It's called *t'aki'lakw* because you made that soil . . . it's yours!" In time, these alterations increased the size of the cultivable estuarine marshland, positively affecting outputs. This, combined with other practices associated globally with the tending of plants, such as weeding competing species, fertilizing soils with organic matter, aerating and tilling sediments, and replanting roots and rhizomes to ensure future crops, resulted in biotically simplified landscapes and reliable access to desired foods (Deur, 2000, 2005; Turner & Kuhnlein, 1982).

During the 19th century, many Northwest Coast Nations responded to the demographic collapse caused by introduced European diseases and the radical reshaping of economic forces by amalgamating and consolidating their villages (Boyd, 1990; Deur, 2000). The growing exploitation of territories by expanding colonial industrial interests, as well as the gradual transformation of traditional diets, also affected plant caretaking practices (Dick et al., 2022). Although estuarine root foods were still eaten, and people returned to some of their gardens, it was usually to collect remnants of previously stewarded populations rather than to invest labour in their building and maintenance, as previous generations had (Bouchard & Kennedy, 1990). Prior studies (e.g., Deur, 2000; Lloyd, 2011; Pukonen, 2008) have posited that estuarine root gardens have soils, vegetation, and other characteristics distinct from un-stewarded places where these same plants naturally grow. They have also alluded to the potential for archaeological signatures indicative of stewarded gardens. However, these studies did not systematically test garden sites to identify signatures of past stewardship. This lack of data on post-caretaking trajectories limits our ability to identify estuarine root garden sites, particularly in cases where descendants are no longer aware of the exact locations. As such, the main goal of this study was twofold: first, to determine the present-day archaeological and ecological condition of the Gwa'ni River estuarine root garden—a site reported by Kwakwa̱ka̱'wakw elders and recorded by non-Indigenous academic ethnographers and ethnobotanists since the early 20th century. Second, drawing on previous work at an estuarine root garden in Lək̓ʷəŋən territories (see Maurice-Hammond et al., 2023), we applied methods for determining enduring ecological, pedological, and archaeological markers of estuarine root garden stewardship.

This work helps to formulate a broader understanding of post-stewardship trajectories, thereby increasing our ability to identify estuarine root garden sites elsewhere. This is an especially pressing issue considering existing Heritage and Conservation Act (HCA) legislation in British Columbia, which limits protection to sites exhibiting material evidence of stewardship, such as rock walls (Lepofsky et al., 2021; Stafford, 2020) or artifactual evidence, such as preserved digging sticks (Hoffman et al., 2016). However, gardens that exhibit more subtle stewardship signatures are likely to be overlooked, impacting the ability of descendant communities to reconnect with these culturally important foods (Joseph, 2020; Joseph & Turner, 2020). By triangulating archaeology, pedology, and ecology, this research suggests that an interdisciplinary approach to studying estuarine root gardens is essential for accurately identifying these unique and threatened coastal sites.

4.2.2. Study site

The Gwa'ni root garden site is located at the tidal mouth of the Gwa'ni River, one of the largest rivers to drain Vancouver Island, flowing northeast into the Queen Charlotte Strait. The tidal flats are half a kilometer upstream from Queen Charlotte Strait in the river estuary. They are partially inundated with brackish water during peak tides and stream flows, transforming the flats into an island. The island is approximately 500 m long and 170 m wide, and 5.5 ha in area. The island is low-lying, with a maximum elevation of less than 2 m ASL. The margins of the island grade into the river—at low tide, the island is partly connected to the south bank of the river. The island is situated within the Coastal Western Hemlock biogeoclimatic zone, characterized by a cool, mesothermal climate with mild, wet winters and cool summers (Pojar et al., 1991). The garden is part of a mosaic of dense archaeological sites, including resource use and habitation sites. The main ‘Namgis village of Xwalkw was located on the north bank of the mouth of the Gwa'ni River, a short distance northeast of the root garden.

The root garden, registered as archaeological site EdSr-17, was recorded in 1983 as a "cinquefoil and clover root garden harvesting site." However, the recording archaeologists noted that "no materials pertaining to this specific site type was found" (Ham & Howe, 1983, p. 41). This assessment was informed by earlier ethnographic sources that recorded the island's cultural significance and unmistakably anthropogenic nature (Boas, 1934; Boas & Hunt, 1921). The island was built up from the natural low, tidal marsh of the island into higher, flat ground by a network of intersecting rock walls separating 59 named individual plots (Figure 20), tied to a complex tenure system (Boas, 1934). Some of these plot names include "place of eating clover roots," "made soil, garden," "place of boiling cinquefoil roots," and "having long cinquefoil roots" (Boas, 1934, Map 21). Since then, root management and harvest slowed and then stopped, followed by the dissolution of the rock boundaries and ensuing soil erosion (Deur, 2000; Bouchard & Kennedy, 1990).

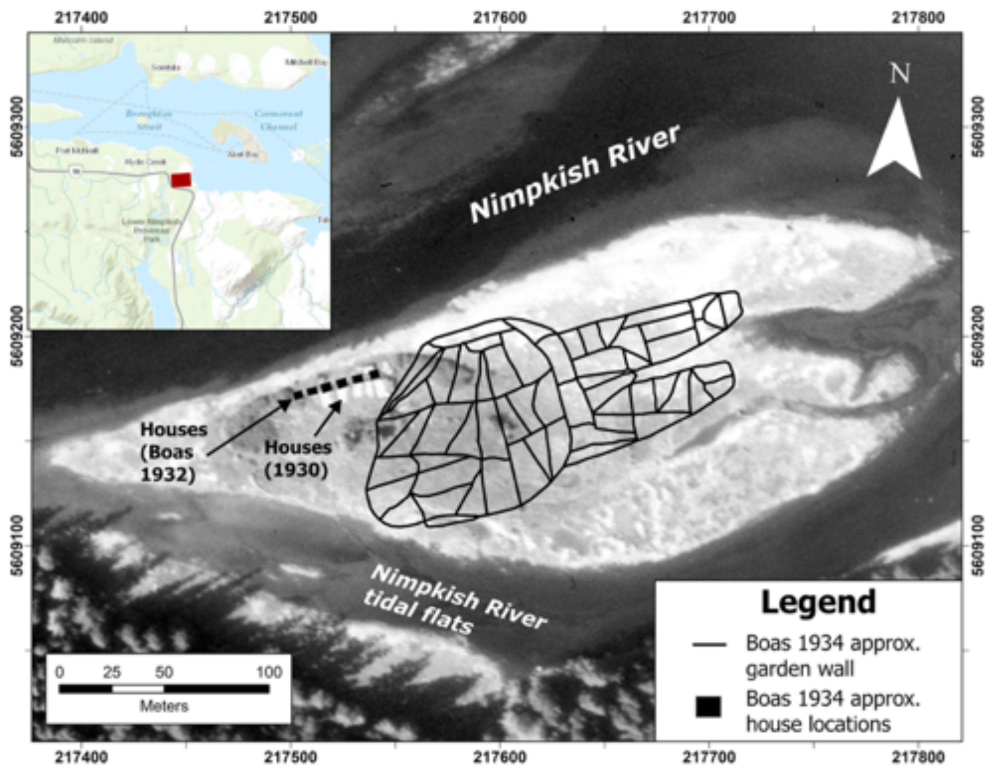

Figure 20. 1930 aerial image of the Gwa'ni [Nimpkish] root garden with digging houses (National Air Photo Library, A7239). Franz Boas' (1934) garden map is overlain, although Boas’ map is more schematic than a true geographic representation.

Boas (1934) noted a substantial raised oval platform on the northeastern side of the island. This feature was likely constructed to create a level and well-drained platform for digging houses, structures where garden plot owners would stay while maintaining the garden and harvesting and processing roots. ‘Namgis and other Kwakwaka'wakw elders identified these digging houses as pre-contact features (Boas, 1934; Boas & Hunt, 1921; Deur, 2000), and Kwakwaka'wakw elder Mayanilth has indicated that her mother was born in one of those houses (Deur, 2000).

4.3. Methods

4.3.1. Research design

To investigate the long-term legacies of past Kwakwa̱ka̱'wakw stewardship at the Gwa'ni River Garden, we conducted an initial archaeological survey and small-scale excavation, followed by ecological inventories, pedological analyses, and sampling. The methodological framework of this work was guided by traditional management practices known to have occurred at estuarine root garden sites (Table 4).

Table 4. Model of estuarine root garden components showing the relationship between known estuarine root garden site management techniques, expected associated outcomes of these techniques, and methods to measure those outcomes.

Ethnographic estuarine root garden stewardship practices	**Potential observable or measurable impacts**	**Methods of data collection and analysis**
Anthropogenic inputs to soil: Fertilization or addition of Soil Organic Matter (e.g., the addition of fish remains, and organic remains brought with the tides). Humans associated with increased phosphorous and nitrogen.	Increase in nutrients phosphorous, nitrogen, carbon, calcium, potassium, magnesium, and sulphur	Multi-element soil analysis (ICP-AES, ICP-MS, XRF)
Tillage: the regular turning and mounding of soil.	Lowered levels of compaction	Soil penetrometer
	Less defined stratigraphy/stratigraphic indicators in the upper 30-40 cm	Visual in-field observation of soil profile
	Changes in ecological gradation, succession. Species found in different zones than expected	Shore-perpendicular line transects/measuring slope gradation (laser range finder)
Use of tools to work/maintain the gardens.	Remnants of broken or discarded tools (e.g., digging stick tips)	Archaeological recovery of artifacts related to garden management.
Terracing	Little to no shoreline slope, heightened soil retention, archaeological evidence (e.g., rock and log/plank walls)	Archaeological excavation of terrace features
Selective weeding and transplanting	Heightened relative abundance of culturally important species, changes in overall species richness on the landscape	Shore-perpendicular line transects and quadrat sampling

4.3.2. Periphery sites

To test the methods employed in this paper, two periphery sites were surveyed in addition to the main estuarine root garden site (Figure 21). By calling these periphery instead of control sites, we follow Armstrong et al. (2021) in challenging the expectation that natural reference sites, devoid of human influence, are available, especially in a cultural landscape like the Gwa'ni River estuary. The two areas surveyed were chosen due to their proximity to the tidal island and their similar ecological compositions. Both are low-lying tidal marshes, supporting visually similar plant communities and affected by the same hydrological factors. Additionally, though they are located directly adjacent to recorded archaeological sites, neither are known to contain archaeological features. Though the periphery areas are not believed to have been part of the root garden structure, it is likely that they would have served as seed banks or transplant sources for the garden grounds. Additionally, they could have been harvested from in time of need or by individuals that did not have rights to the anthropogenically modified (and more productive) garden grounds. As such, periphery sites should not be understood and un-stewarded, but as constitutive elements of a stewarded landscape existing under a different management regime.

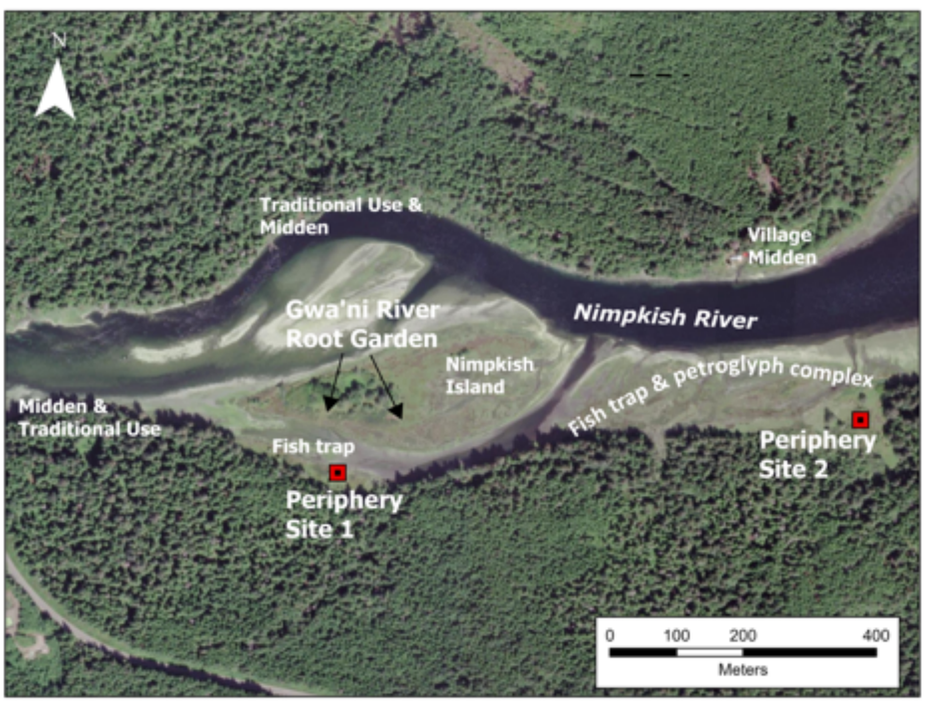

Figure 21. Map of the Gwa'ni [Nimpkish] River estuarine root garden and surrounding cultural sites, as well as the two comparative periphery sites (PS1 and PS2).

Periphery Site 1 (PS1) is a 10 m wide strip of tidal marsh on the south bank of the Gwa'ni River opposite the estuary root garden island. It is bordered by forest on three sides and faces the tidal channel to the north.

Periphery Site 2 (PS2) is also on the south bank of the Gwa'ni River, 700 m east of PS1. PS2 is larger than PS1, and the entire surface area could not be surveyed. It is roughly wide between river and the tree line.

4.3.3. Archaeological methodology

As we identified in Table 4, there is an expectation of terracing and associated archaeological features and materials. An initial surface survey of the tidal island was undertaken to identify possible root garden structures and other archaeological materials and assess the site integrity in the extended absence of stewardship. This process helped determine where to conduct archaeological testing. The eastern edge of the island, facing the strait, was significantly eroded, with tidal channels cutting into the island sediment and areas of bare gravel. No retaining walls were observed. There is a small flat, prairie-like area on the southwestern side of the island. These areas, which primarily supported low-lying vegetation such as grasses and forbs and were devoid of shrubs or trees, were adjacent to an elevated oval platform running east-west on the northern side of the island. This platform, made of sub-rounded and rounded boulders and cobbles piled over a meter in height, created an elevated area upon which the pre-contact digging houses were built (Boas & Hunt, 1921; Deur, 2000). We chose one of those prairies as a locality for further investigation. This prairie is located directly adjacent to and to the south of the housing platform, facing the tidal flats on the southern banks of the Gwa'ni River (Figure 22). During our initial investigation of the site, we located a series of boulders arranged in linear patterns buried under a layer of vegetation and sediment. These are likely sections of the walls described by Boas in 1934 and observed later by Deur through the 1990s.

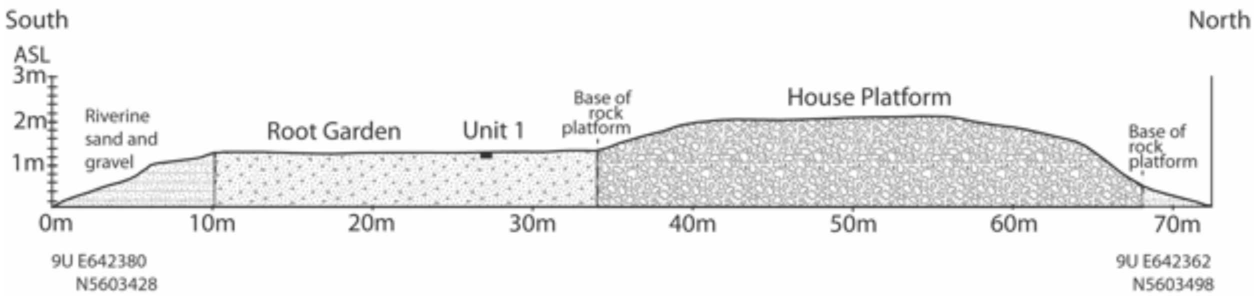

Figure 22. Elevation profile of the Gwa'ni [Nimpkish] River estuarine root garden, showing the elevated garden flats and the house platforms, as well as archaeological excavation Unit 1.

At this site, directly adjacent to a series of boulders comprising a section of wall, we established a 1 m x 1 m excavation unit (Unit 1) to evaluate the subsurface component of the wall (Figure 23). We excavated in 10 cm arbitrary levels within stratigraphic units. This unit was excavated until water seepage made further excavation impossible at a depth of 53 cm below surface (DBS). Excavated sediment was screened through 1/8" mesh for artifacts. Column samples for multi-element soil analysis were sent to the laboratory of the Ministry of Environment in Victoria, B.C. A sample from a buried cedar plank (see Results) and an organic sample from the base of a rock wall were sent to Direct AMS for radiocarbon dating.

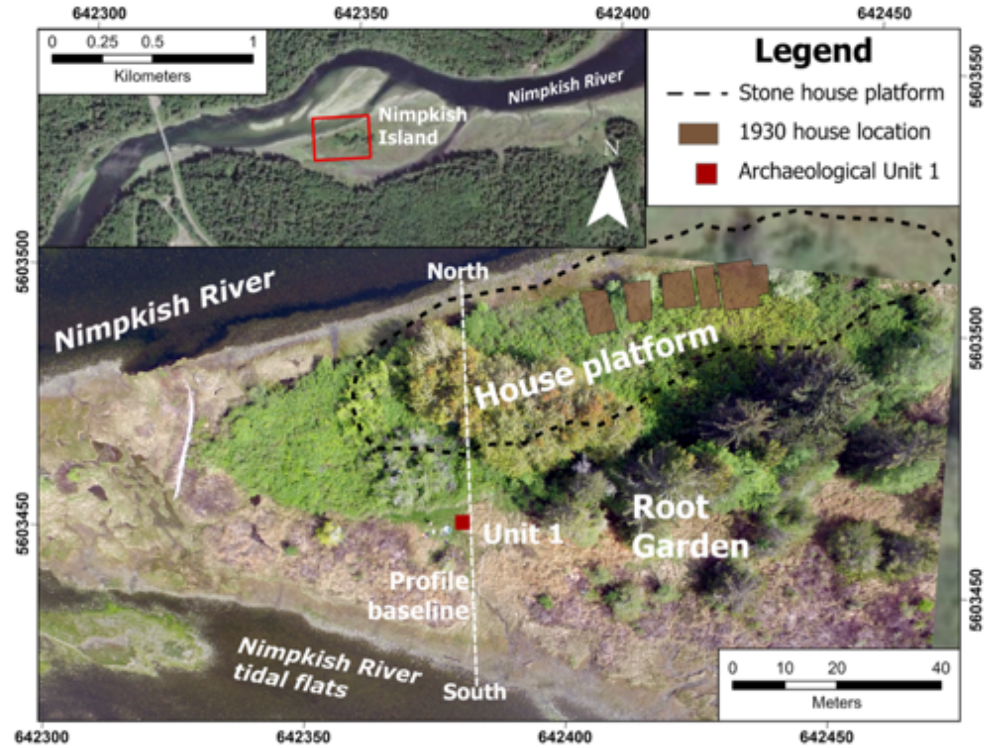

Figure 23. Location of the archaeological excavation unit (Unit 1) in relationship to the housing platforms and recorded estuarine root garden structure at the Gwa'ni [Nimpkish]River.

4.3.4. Ecological methodology

Human land-use legacies are a significant driver of present-day plant communities, influencing taxonomy and structure more than 150 years after the cessation of management (Armstrong et al., 2021). As such, we hypothesized that species richness would be higher in the periphery sites. At the same time, the root garden would support a higher density of cultivated species (in this case, *dləksəm* [*A. egedii*], *t'əx̱ʷsús* [*T. wormskioldii*], and *xúkʷkʷem* [*F. camschatcensis*]). Furthermore, vegetation patterns in coastal and alluvial sites are closely associated with their vertical topographic positioning above and a lateral distance away from water (Bowman & McDonough, 1991; Van Coller et al., 2000; Vermeersch & Van Kerckvoorde, 2016). Intertidal root gardens, which support plant communities shaped by anthropogenic factors and terracing, may exhibit more uniformity than those encountered in similar but non-stewardship ecosystems. As such, interpreting changes in estuarine root garden plant communities should account for gradation and changes in species composition and species richness away from the shoreline, with the assumption that a managed area would display a higher cover of *dləksəm*, *t'əx̱ʷsús,* and *xúkʷkʷem,* and an overall lower species richness compared to periphery sites.

Shore-normal line transects are particularly suited to capturing the zonation of coastal ecosystems (Almeida et al., 2017; Prisco et al., 2016; Steinhardt & Selig, 2009) and successional gradients (Jerling, 1983). This method was combined with contiguous sampling plots (or quadrats) along the transects (placed perpendicularly to the water, covering the beach-inland gradient) (Del Vecchio et al., 2019). A 1 m x 1 m quadrat was used (Figure 24), with the percent cover of each species directly estimated within the sample area (Buckland et al., 2007). Depending on the site's overall surface size, between four and five transects were established, which were contiguously sampled from the shoreline to the treeline.

Figure 24. Field assistant D. Leschasin placing a 1 m x 1 m quadrat along a shore normal line transects at periphery site 1, Gwa'ni [Nimpkish] River estuary.

To compare the community composition of plants across sites, we conducted non-metric multidimensional scaling (NMDS), analysis of similarities (ANOSIM), and indicator species analyses. To visualize differences between individual plots of different types and sites, we carried out an NMDS analysis using the R package vegan ver. 2.5–7 software (Oksanen et al., 2020). This facilitated the analysis of similarities and differences between plots using three axes (k=3) and the Bray-Curtis dissimilarity index. We were then able to visualize the results with the R package ggplot2 ver. 3.3.3 (Wickham 2011). To identify species strongly associated with specific types of plots or the "indicator species" of plots, we conducted an indicator species analysis using the "multipatt" function in the R Core Team (2013) package indicspecies ver. 1.7.8 (De Caceres et al., 2016) with 9999 permutations. Finally, to test for statistically significant differences between garden and periphery plots, we conducted an analysis of similarities (ANOSIM) with the vegan package using the Bray-Curtis dissimilarity index and 9999 permutations. NMDS analysis was also used to compare soil characteristics across plots using the same settings as described above.

4.3.5. Pedological methodology

Before excavation, a ProCheck Soil Sensor was used at all plots (garden and periphery) to determine moisture and bulk electrical conductivity. Before units were excavated and soil samples removed, a soil penetrometer (or a Dickey-John Soil Compaction Tester) was used to measure soil compaction. Lower relative soil compaction could be indicative of past human activity (Table 1), as repeated tilling, digging, and weeding loosen soils (Grossman et al., 2010; Sandor, 1992). This was done at all sites except for PS2 (due to instrument availability). Once units were opened, we conducted in situ stratigraphic analysis. We expected garden-associated tilling, digging, and weeding to turbate pre-existing sediments and strata and impair the natural development of soil horizons (Miller & Gleason, 1994). This is especially identifiable in cases where the soil was rapidly buried shortly after use, preserving its structure (Holliday, 2004). In this case, soil stratigraphy was visually evaluated for the presence of buried anthrosols post-excavation and before units were closed.

Soil element analysis was conducted to identify potential human-derived chemical modification of root garden soils. Samples gathered from the Gwa'ni root garden and periphery sites were sent to the laboratory of the Ministry of Environment in Victoria, B.C., for analysis. Measured elements included available Phosphorous (P), pH, Nitrogen (N), Calcium (C), and trace metals, in addition to cation exchange capacity (CEC), exchangeable cations, and loss of ignition (LOI). Once results were returned, we conducted an indicator species analysis using the "multipatt" function in the R Core Team (2013) package indicspecies ver. 1.7.8 (De Caceres et al., 2016) with 9999 permutations to statistically analyze and visualize differences in soil qualities between the study and periphery sites.

4.4. Results

4.4.1. Archaeology

The 1 m x 1 m unit was excavated directly adjacent to a segment of rock wall. This wall is comprised of sub-rounded and rounded boulders infilled with smaller cobbles and pebbles and large portions of FAR (fire-altered rock). The unit was excavated to 53 cm DBS and further excavation was impossible due to rapid water infilling caused by rain and high tides. A clear stratum change was identified at 40 cm DBS, transitioning from dark, highly organic sandy loam to hard-packed coarse sand and sub-rounded pea gravel and pebbles, likely the transition from garden soils to the original fluvial sediment base upon which the wall was constructed. The wall itself extends above ground to an estimated height of 64 cm (Figure 25). Though only a small portion of it was excavated, the wall extends north and south of the unit and intersects with other rock wall features.

Figure 25. Cross-section of estuarine root garden rock walls at the Gwa'ni [Nimpkish] River estuarine root garden site. The mage on the left shows the rock wall (running N-S) structure and ground water seepage. The image on the right shows the cedar plank perpendicularly wedged into the rock wall, overlaying an E-W wall and underneath a large boulder.

The waterlogged and anaerobic conditions of the basal wall preserved a 7 cm thick shaped cedar plank. It was uncovered partly wedged into the rock wall from 28-35 cm DBS. It extended further into the west and north walls of the unit. Due to hydrological conditions and storage issues the plank was not excavated further. A woody fragment taken from the plank was radiocarbon dated to $1\sigma \pm 24$ 529 Before Present (BP) (D-AMS 049925), predating European contact by almost 300 years. Results were corrected for isotopic fractionation with an unreported $\delta^{13}C$ value measured on the prepared carbon by the accelerator. Unfortunately, the second sample sent in for radiocarbon dating (D-AMS-049926), which we hoped would reflect the initial build of the rock wall structures, came back as a contemporary fragment of western hemlock bark, reflecting the impacts of groundwater infilling during excavation. No artifactual materials were recovered.

4.4.2. Ecology

The ANOSIM test indicated that the garden is significantly different from the periphery sites ($p < 0.0001$), with a moderate degree of differentiation ($R = 0.3022$). For the NMDS analysis, the stress value was 0.127, indicating that the NMDS performed relatively well with three dimensions. The NMDS visualization indicates some degree of differentiation between garden and periphery plots (Figure 26), especially along NMDS1. There is also some degree of differentiation between the two periphery sites. The garden and periphery are characterized by distinct indicator species (Table 5). Among the statistically significant indicator species characteristic of the periphery plots are two of the principal edible root/bulb plants: *dləksəm* (*P. anserina* ssp. *pacifica*; $p = 0.0001$) and *xúk*^{w}*k*^{w}*em* (*F. camschatcensis*); $p = 0.0001$).

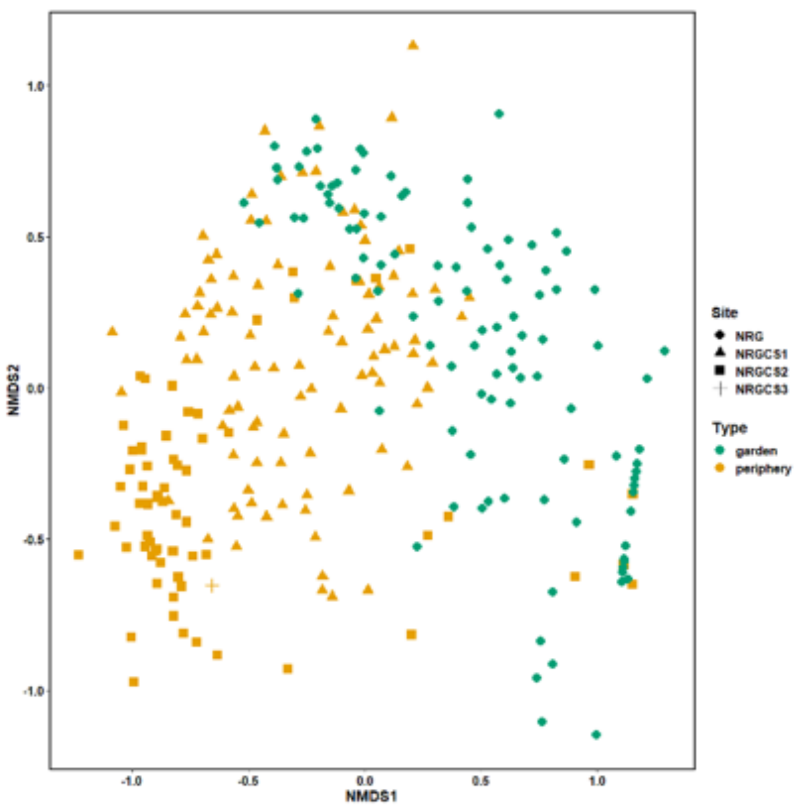

Figure 26. Visualization of non-metric multidimensional scaling (NMDS) analysis of vegetation in the Gwa'ni [Nimpkish] River estuarine root garden and periphery plots (PS1 and PS2). This visualization highlights the differences in species composition between the garden and periphery sites.

Table 5. Indicator species for the Gwa'ni [Nimpkish] River Garden and periphery sites

Species	Common Name	P- Value
Garden		
Carex lyngbyei	Lyngbye's sedge	0.0001
Myrica gale	Bog-myrtle	0.0001
Veronica scutellate	Marsh speedwell	0.0002
Equisetum arvense	Common horsetail	0.0003
Juncus effusus	Common rush	0.0035
Periphery		
Potentilla anserina ssp. *pacifica*	Pacific silverweed	0.0001
Dodecatheon pulchellum	Dark throat shooting star	0.0001
Claytonia sibirica	Siberian miner's lettuce	0.0001
Ranunculus occidentalis	Western buttercup	0.0001
Dactylis glomerata	Orchard grass	0.0001
Achillea millefolium	Yarrow	0.0001
Oenanthe sarmentosa	Water parsley	0.0001
Poa compressa	Canadian bluegrass	0.0001
Fritillaria camschatcensis	Riceroot lily	0.0001
Plantago macrocarpa	Alaska plantain	0.0001
Plantago lanceolata	English plantain	0.0003
Glaux maritima	Sea milkwort	0.0007

4.4.3. Pedology

The soil analysis indicated differentiation based on site type, with garden soils relatively distinct from periphery sites (Figure 27).

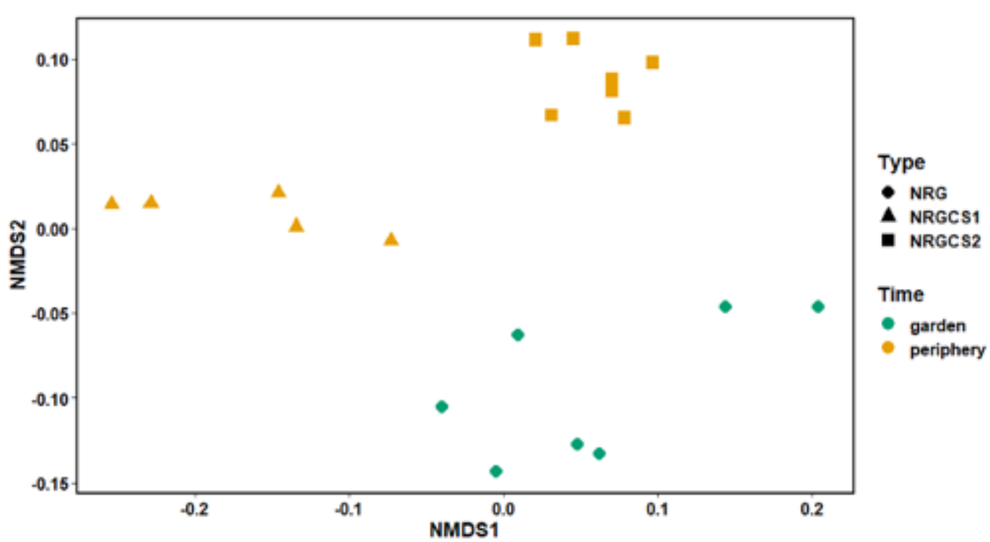

Figure 27. Non-metric dimensional scaling (NMDS) analysis of soils sampled at the Gwa'ni [Nimpkish] River estuarine root garden and periphery plots (PS1 and PS2) indicating a clear differentiation between soil characteristics across sites.

Furthermore, sediment characteristics in the walled areas of the tidal island differed from the PS1 and PS2. In the walled area, excavations and soil sampling revealed a 40 cm dark (10YR), organic, charcoal-rich loam strata. Additionally, available soil phosphorous (P) in the walled sections is significantly elevated (Figure 28). In contrast, sediment in the periphery sites extended to an average depth of 10-12 cm, terminating in a layer of sub-rounded pea gravel and pebbles mixed with rough sand, consistent with fluvial deposits. These sediments (in the upper 12 cm of the test units) are categorized as regosols—young soils with little or no horizon development, typically found in active fluvial sites characterized by frequent flood events (MacKenzie & Moran, 2004). Despite the periphery sites supporting dense communities of culturally important plants (such as *dləksəm* and *xúkʷkʷem*), sedimentary characteristics are not indicative of active cultivation.

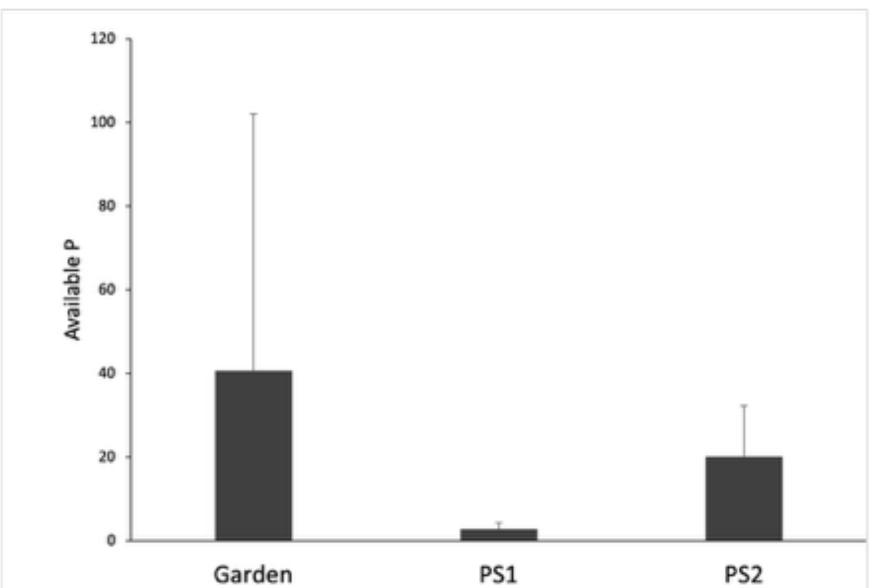

Figure 28. Bar chart illustrating the difference in available soil phosphorous at the Gwa’ni [Nimpkish] River estuarine root garden site and periphery (PS1 and PS2) sites, with significantly higher levels at the garden site.

4.5. Discussion

4.5.1. Archaeology

The archaeological profile of the Gwa'ni root garden exhibits many of the expected characteristics associated with these site types. During our field investigations, we discovered a large segment of intersecting rock walls in the southwestern part of the island, which is also the most elevated and terraced area, exhibiting relatively little erosion. However, only the very top of the rock walls remain visible; the rest is buried by an active soil horizon. The presence of this sediment speaks to the endurance of Indigenous caretaking practices in creating conditions facilitating enduring sedimentary accumulation and soil building (Deur, 2000).
Establishing the temporal sequence of plant food cultivation sites remains a challenge. However, the radiocarbon dating of the cedar plank lodged into one of the rock walls aligns with Boas' (n.d., 1934) observations about cedar planks and stone walls used to define gardens, lending confidence to the spatial and temporal association. However, caution should be used in assigning the date of the plank to the actual garden since the radiocarbon date is the age at which the tree stopped living. Accounting for the context and use-history of the plank and the potential old wood effect means considering that it's unlikely that a new cedar plank was added to a garden. Accepting this means the plank could predate the garden by decades or even centuries, originally used as a house plank before being repurposed as part of a garden wall. However, a later addition of the plank would still be indicative of a time of active caretaking and wall maintenance at the garden, leading us to assume that is has been in place for at least 100 years, and likely much longer. Further work should target dating these sites, providing an age range for use and management of estuaries and, in association, the cultivation of root foods, contributing to the growing body of knowledge on the development and antiquity of plant cultivation practices on the Northwest Coast (Lepofsky & Lertzman, 2008; Lepofsky & Lyons, 2003, 2013; Stafford, 2020; Turner et al., 2013).

As noted previously, the rock wall consisted of stacked boulders and cobbles, infilled with smaller pebbles and large amounts of FAR. We theorize that this stacking and infilling resulted from both intentional wall building, maintenance, and field clearing, consistent with Boas' (n.d., p. 166) observations of women clearing "the ground of pebbles, which are thrown up in large piles or in walls which surround a bed." The routine clearing and turning over of garden soils would have led to the extraction of these rocks, as Kwaxsistalla also noted to Deur (pers. comm., 1999). The addition of such large amounts of FAR would have been a by-product of long-term use and inhabitation of the site.

4.5.2. Ecology

We theorized that periphery sites would support a higher diversity of plant species, while the root garden site, shaped by hundreds of years of management, would show a higher density of the culturally important species, *dləksəm* (*A. egedii*), *t'əx̱ʷsús* (*T. wormskioldii*), and *xúkʷkʷem* (*F. camschatcensis*). Though our first assumption was proven correct, our second was not; in fact, indicator species for the periphery sites included two of the culturally important food species (*dləksəm* and *xúkʷkʷem*), while indicator species for the root garden were more indicative of low marsh vegetation. We attribute this to the impact of coastal gradation and ecological succession in the absence of continuing Indigenous stewardship. In coastal and alluvial sites, change in gradient affects important environmental variables, accounting for the ecological transitions from vegetation that is more tolerant to flooding and higher levels of salinity to flood-intolerant vegetation that relies more strongly on access to the water table and is more strongly defined by interspecies competition (Olff et al., 1997; Seliskar & Gallagher, 1983; Walker & Wardle, 2014).

Terracing, and the building of rock walls created conditions that disrupted pre-existing ecological zonation, altering hydrological and ecological factors and the successional trajectory of the site. In the garden site, active stewardship promoted the growth of the desired species and maintained plant communities through patterns of anthropogenic disturbance (Deur, 2005; Turner et al., 2021). With the cessation of active stewardship, the plants for which these gardens were built are gradually becoming replaced through secondary succession, shifting towards mid-successional vegetation such as salt-intolerant graminoids and woody shrubs. Though *dləksəm* and *t'əx̱ʷsús* are still consistently observed, *xúkʷkʷem* no longer appears to be present. Comparatively, the ecological sampling at the periphery sites—low-lying floodplains, defined by frequent tidal inundation—were relatively consistent in their ecological composition, with some transition into high marsh vegetation at the upper edges of the estuarine prairie.

Though *dləksəm* has been described as a pioneer species (Seliskar & Gallagher, 1983), *xúk*^{w}*k*^{w}*em* is believed to be sensitive to disturbance and invasion (Zox, 2008), leading us to suspect that it was outcompeted by the graminoids that now dominate the plots. Similarly, *t'əx̲*^{w}*sús* is sensitive to competition by grass species (Nicholas, 2017c). This aligns with the ecological trajectories of other known estuarine root garden sites, such as Kingcome Inlet. Kwaxsistalla, when talking about his family's gardens, stated, "You don't see them [root gardens] anymore. It's all overgrown with those tall grasses in the flats … it's never been looked after…So it's gone" (Dick et al., 2022, p. 556). PS1 and PS2, on the other hand, are relatively ecologically stable. The narrow estuarine band that they occupy, regularly flooded by the tides, support a narrow range of highly adapted species, primarily vascular hydrophytes (Van der Val, 1981), and are therefore unlikely to follow the same ecological trajectory as the root garden site.

4.5.3. Pedology

Estuarine root gardens were places of "manufactured soils." According to Kwaxsistalla, "you've got to keep that earth soft…soften it up! You'd… "plow" it, I guess…and then you continue on that, digging the soft ground…so it will grow better every year". Good soils, he observed, were understood to "have a little bit of everything"—a set of diverse materials of varying size and composition" (Deur, 2000, p. 88). The estuaries of the Northwest Coast, shaped by wave and fluvial processes, tend to produce sedimentary structures characterized by distinct strata bands and uniformly textured soils (Deur, 2000). This is concurrent with sediment at the periphery sites, where young soils with little to no horizon development overlap coarse sand and gravel (MacKenzie & Moran, 2004). The root garden site, on the other hand, is characterized by over 40 cm of deep, dark, organic-rich soils with no observable stratigraphy, likely the result of anthropogenic mixing and soil enhancement through purposeful fertilization, such as that described by Deur (2000, 2002a, 2002b, 2005) and Lloyd (2011). These anthropogenic modifications also emerged in the multi-element soil analysis, which highlighted elevated levels of phosphorous, a sensitive and persistent indicator of human activity that geoarchaeologists have long used to detect past human occupation as well as the type and intensity of human activity (Holliday & Gartner, 2007; Howard, 2017; Lauer et al., 2013; Wilson et al., 2008; Wilson et al., 2009). Heightened levels of phosphorous are associated with a plurality of human activities, and at the estuarine root garden site, likely result from past fertilization practices, such as the addition of fish carcasses to plots (Deur, 2000; Suttles, 2005, 1974; Turner & Bell, 1973).

The clearing of garden stones and the creation of deep, texturally diverse soils contributed to the growth of long, straight roots and rhizomes. These were prized for ceremonial and nutritional reasons. Small, gnarled roots, on the other hand, were associated with supernatural bad luck (Mcllwraith, 1948), while breaking a root while extracting it was seen as shameful, especially if the root was to be used in feasts of social or ceremonial importance (Deur, 2000). Significantly, all of the above are associated with unmanaged areas—rocky grounds with shallow soils, such as PS1 and PS2. Comparatively, Lloyd (2011, p. 116), when conducting an ecological experiment, determined that sandy loam supported "significantly more growth", as well as greater root thickness, number, and biomass. As such, the question is not so much *whether* these plants grow in these ecosystems—they occur widely in the region—but *how* they grow, which is directly tied to the creation and stewardship of Indigenous soils.

4.6. Conclusion

The Gwa'ni River presents many of the archaeological features associated with estuarine root gardens, including rock walls, terracing, and association with a larger cultural landscape centred around a winter village site. Furthermore, ethnographic and cultural information specific to this garden describes how it was cared for by 'Namgis peoples into the 20th century. The presence of intact rock wall segments and a preserved cedar plank highlights exciting possibilities for further study of these sites, such as the potential to build a more robust genealogy of the initial building process and continued stewardship. Furthermore, this study emphasizes the importance of considering factors beyond physical site structure in developing a comprehensive understanding of these sites and their post-stewardship trajectories.

In areas that do not display recognizable anthropogenic features, such as rock walls, the plants and soils themselves are an important source of cultural information. However, the stories they tell are highly variable and dependent on local cultural practices, hydrologies, and ecologies, ultimately highlighting the importance of considering site-specific successional trajectories and the impacts of competition when looking at plants as long-term indicators of stewardship. What has emerged strongly, however, is the importance of considering *soils* as indicators of human care and stewardship. Beyond the physical characteristics of these soils, which include being deep, organic-rich, mixed, and uncompacted, multi-element analysis can highlight specific chemical differences resulting from anthropogenic amendments, such as heightened levels of phosphorous. Harnessing these tools on a larger scale could help us identify other root garden sites that may not be as well-known or documented, thereby reinserting them into a broader context of Indigenous management and potentially contributing to the ability of Indigenous peoples to reclaim these areas as key points within wider cultural landscapes. Increasing our ability to identify these sites, even in complex post-stewardship contexts, will have profound implications on our understanding of site formation processes and potential present-day morphological variations. This, in turn, will aid in the increased identification of other sites while also helping to provide concrete information to communities that may be seeking to reconnect with these ancient foods on their territories. It also challenges the notion of what constitutes an archaeological site and what defines evidence for establishing detectable archaeological signatures and, therefore, heritage protection.

Estuarine root gardens represent long-term, reciprocal relationships between peoples and their homelands. However, these are also places where forced interruption to stewardship and subsequent ecological and morphological changes should be understood as facets of ongoing colonial violence. This colonial violence, which separated peoples from their homelands and interrupted traditional lifeways, has since been compounded by large-scale and destructive landscape changes. Today, the Gwa'ni River root garden looks nothing like it did almost a century ago. Beyond the striking changes to its plant communities, the island is today marred by erosional pockets and deep gullies, with the soil that was carefully created and enhanced over generations washing away, along with fragments of rock walls. These changes are likely to be compounded by climate change, driven by rising sea levels and increasingly severe storm surges. This highlights the urgency of this work; estuaries, which are already some of the most at-risk and impacted ecosystems on the Northwest Coast, are changing rapidly. With the rate of these changes, it is possible, even likely, that many of these sites will be irreparably altered over the next half-century. As such, this work is both necessary and timely, and we hope to expand it to other estuaries and territories in the future. Finally, it should be noted that these estuarine sites cannot be separated from their broader cultural contexts; their protection should extend beyond their ecological and archaeological boundaries into the wider territories of the Nations to which they belong.

Chapter 5 – Bringing the teachings to ground: Pathways towards the identification, protection, and restoration of estuarine root gardens in coastal British Columbia, Canada.

5.1. Abstract

Estuarine root gardens on the Pacific Northwest Coast of North America are living archaeological sites, with enduring and distinct cultural soils, ecological assemblages, and tangible heritage assemblages. However, the historic and ongoing lack of consideration of these places by heritage practitioners in British Columbia continues to limit their identification, minimizing their importance within current understanding of culturally important plant stewarding systems. In this paper, I consider three estuarine root gardens in three distinct eco-cultural areas on Vancouver Island, British Columbia: southern Lək̓ʷəŋən Coast Salish territories, north-eastern ‘Na̲mg̲is Kwakwa̲ka̲'wakw territories, and northwestern ʕaaḥuusʔatḥ Nuu-chah-nulth territories. Basing myself in historical ecology, I highlight the challenges in identifying root gardens in ethno-linguistically and geographically distinct areas, as well as variability in post-stewardship trajectories at these sites. I argue that a cumulative effects approach must be taken in considering historical and ongoing impacts to these places and their changes over time. However, these landscapes, even when significantly altered, are not gone, and pathways to reclamation and restoration remain. Finally, I argue that an interdisciplinary and community-driven approach to the study of estuarine root gardens is key to increasing our abilities to protect and restore these places, supporting processes of Indigenous resurgence.

5.2. Introduction

Estuaries are some of earth’s most biodiverse and nutrient-rich ecosystems, supporting a vast array of plant and animal life and serving as an interface between marine, intertidal, and terrestrial ecosystems (Day et al., 2012). Estuaries are also places on the edge, where habitats and successional stages interface, resulting in high levels of biodiversity, productivity, and species richness (Turner et al., 2003). This edge effect, which allows peoples to access several key and productive ecosystems, makes them nexuses for human use, occupation, stewardship, and well-being, both historically and into the present (Erlandson et al., 2019; Mathews & Turner, 2017). Global examples for this abound; in central and south America, coastland and wetland stewardship systems enabled the growth of culturally important plants while enhancing access to both marine and terrestrial species (Beach et al., 2015; Krause et al., 2019; Prestes-Carneiro et al., 2019). In parts of Asia, people learned to shift the hydrological processes of wetlands to develop large rice cultivation complexes, many of which still operate today (Yunfei et al., 2009; Zong et al., 2007). Similarly, in Europe, evidence of the alterations of coastal wetlands to "reclaim" lands for agricultural purposes dates to at least the Roman period, though this process accelerated in the 1500s alongside population growth (Nabarte et al., 2022). On the West Coast of North America, similarly, wetland and estuarine environments have been used and stewarded by Indigenous Peoples for at least 11, 800 years, resulting in the enhanced access and output of culturally, nutritionally, and economically important species (Erlandson et al., 2019). These tended coastal wetlands fit within a wider paradigm of plant and ecosystem stewardship practices central to Indigenous Peoples' lives and subsistence (Lepofsky & Lertzman, 2008; Turner, 2020a; Turner et al., 2013).

In this paper, I consider the importance of Indigenous Peoples of coastal British Columbia's relationships with estuaries–relationships that extend from the deep past into the present and the future. Estuaries, which occur at the confluence of fresh and saltwater systems, are interfaces to a variety of highly culturally important landscapes, such as intertidal and riverine fish traps, clam gardens, coastal village sites, terrestrial managed plant communities and estuarine root gardens (Armstrong et al., 2021; Mathews & Turner, 2017; Smith et al., 2019; Zahn et al., 2018). Estuarine root gardens–like all Indigenously stewarded landscapes–are a highly adapted food production system, calibrated to the individual and specific conditions of these dynamic coastal sites. They are areas of high intertidal marshland stewarded to foster the growth of certain culturally, nutritionally, and economically important plant foods, such as Pacific silverweed (*Argentina egedii (Wormsk.)* Rydb.; syn. *Potentilla pacifica* (L.) Howell.)), springbank clover (*Trifolium wormskioldii* Lehm), and riceroot lily (*Fritillaria camschatcensis* (L.) Ker Gawl). The roots and rhizomes of these plants were of high nutritional, cultural, and economic importance, featuring prominently in winter feasts, potlatches, and exchanges between communities (Boas, 1910, 1921, 1934; Deur, 2000; McIlwraith, 1984; Turner & Kunhlein, 1982). Care for these places occurred on a variety of scales, from weeding out competing species and the selective harvesting of rhizomes, to the extensive modifications of coastal systems through terracing and soil-building (Deur, 2000, 2002a, 2002b; Edwards, 1979; Turner, 2020a; Turner et al., 2021).

Despite the importance of these places within traditional Indigenous food systems, they remain under-represented within the archaeological record in British Columbia and under-considered in the context of coastal and estuarine restoration projects. Long-standing dismissals of Indigenous plant stewardship practices by settler researchers, combined with historic and ongoing colonial impacts on coastal places and Indigenous Peoples, have created unique challenges in the ability of descendant communities to reconnect with these ancient food-producing landscapes (Deur, 2002b; Kennish, 2021; Letham et al., 2023). Within the context of heritage research in British Columbia, the under-representation of estuarine root gardens significantly impacts both their long-term survival in the face on ongoing colonial "development" (and, increasingly, climate change impacts), and the subsequent ability of Indigenous communities to reconnect with these places and re-insert them within traditional stewardship systems (Lepofsky et al., 2020; Thorne et al., 2018).

Engaging with this crucial context, this paper asserts that estuarine root gardens are living archaeological sites–places where tangible archaeological features intersect with living ecologies (Vanier et al., 2025). This dynamism challenges dominant, static, and colonial approaches to the management of cultural heritage, requiring the development of an approach that centers the historic relationships that created these places and their ability to support Indigenous futures. Using a novel framework that combines ecological, archaeological and pedological indices, I consider in detail three estuarine root garden sites on Vancouver Island, British Columbia, each existing in their own eco-cultural context (Figure 29). This approach, grounded in historical ecology and the ancestral/ongoing relationships between these stewarded landscapes and the Indigenous communities that shaped them, provides crucial information on the enduring, unique, and identifiable characteristics of estuarine root gardens as well as the ways that they can change over time. This project fits within a larger push in British Columbian archaeology (and elsewhere) to move beyond a narrow focus on material culture (i.e., the stones and bones of archaeological research) and engage more fully with cultural landscapes, legacy ecosystems, and the ongoing relationships that exist between descendant communities and the places that their ancestors shaped (e.g., Armstrong et al., 2021; Letham et al., 2023; Vanier et al., 2025). Ultimately, recognizing these as places of living heritage means recognizing them as places of both Indigenous past and futures, re-inserting them within traditional territories, food systems, and networks of inter-generational knowledge sharing (Sachs et al., 2025).

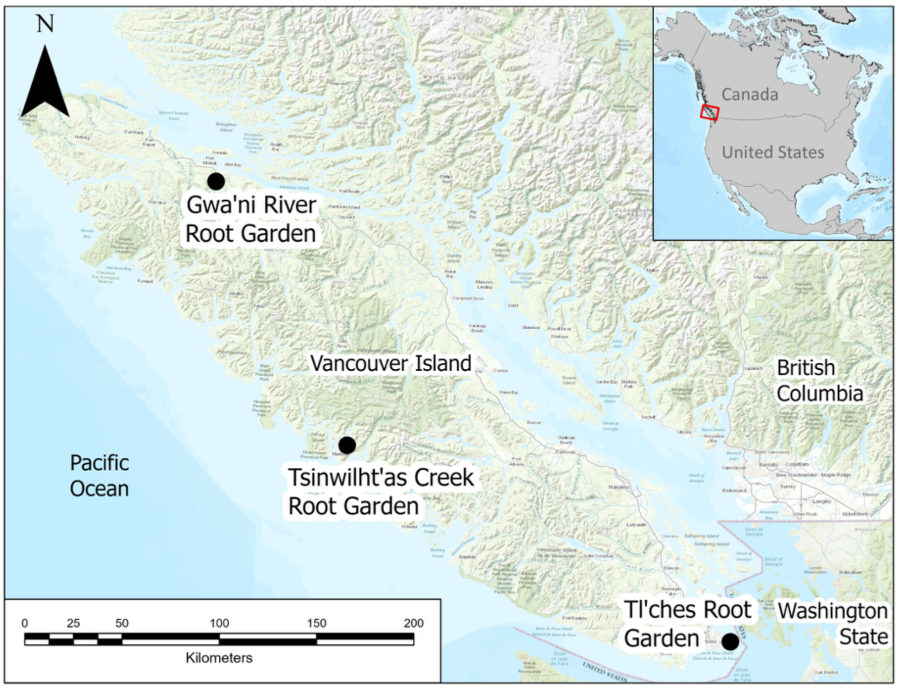

Figure 29. Approximate location of three estuarine root garden sites (the Tl’chés root garden, the Tsinwilht’as Creek root garden, and the Gwa’ni River root garden) on Vancouver Island, British Columbia, Canada.

5.3. Material and Methods

5.3.1. A tale of three gardens: Areas of investigation

As previous work has suggested, estuarine root gardens are variable in form and presentation (Deur, 2000; Lloyd, 2011; Maurice-Hammond et al., 2023; Pukonen, 2008). These variations are based on cultural, ecological, hydrological, and environmental factors, dictating the size and morphology of these gardens, and, to some extent, their species composition (Turner et al., 2021). However, at the outset of this project, I hypothesized that specific ecological, pedological and archaeological evidence would signal the presence of estuarine root garden sites, even when their specific cultural and historical context is no longer known by descendant communities (see Maurice-Hammond et al., 2023). This hypothesis is grounded on previous work on legacy stewarded ecosystems in British Columbia (e.g., Armstrong et al., 2021; Lepofsky et al., 2003; Lyons et al., 2021; Vanier et al., 2025), which highlight how Indigenous Peoples' alterations of their landscapes, plant communities, and soils have resulted in distinct and lasting signatures that remain measurable even a century after active stewardship has ceased (Armstrong et al., 2021; Vanier et al., 2025).

In this paper, three estuarine root garden sites are considered in detail, each occurring in differing cultural, ecological, and hydrological contexts. The first, located on the southern Coast Salish island archipelago of Tl'chés (Chatham and Discovery Islands), is in the territory of the Lək̓ʷəŋən speaking Songhees First Nation. Tl'chés is an archetypical Cultural Keystone Place (CKP), with profound and ongoing ties to the Lək̓ʷəŋən Peoples who continue to steward it to this day for the benefit of future generations (Cuerrier et al., 2015). Led by knowledgeable individuals (such as Cheryl Bryce), Lək̓ʷəŋən Peoples are working to better understand the impacts of colonial and climactic changes to their islands and important cultural and ancestral places[29]. This ongoing work involves restoring food systems (e.g., renewing traditional burning practices to restore *kwetlal*[30] prairies), bringing youths back to the land, and harvesting. The work on Tl'chés discussed in this paper was guided by *sʔéləxʷ* (elder) Səłłəmah, Joan Morris, who was born and raised there by her great-grandparents. Despite her profound cultural expertise and knowledge of her home, Səłłəmah does not remember estuarine root foods being stewarded at Tl'chés. Information about estuarine root stewardship on Tl'chés (and Lək̓ʷəŋən territories more broadly[31]) is lacking from the ethnographic literature, paralleling the broader Coast Salish context. Though estuarine root foods were widely prized and eaten in the Coast Salish (e.g.,

[29] This work is occurring alongside, and supported by, Dr. Darcy Mathew's Ethnoecology lab at the University of Victoria, to which this dissertation is a contribution. See also, Bosman, 2019; Gomes, 2012; Lowther, 2022; Lysgaard, 2022; Nicholas, 2017).

[30] *Kwetlal* is the Lək̓ʷəŋən word for blue camas, *Camassia quamash* and *Camassia leichtlinii*

[31] Though some context cues do exist, such as the presence of Clover Point a short distance from Tl'chés. The area derives its name from a "large area of ground […] covered with a species of red clover, growing most luxuriantly" (James Douglas quoted in Walbran, 1909, p. 96). Extensive land alterations have since led to the almost complete extirpation of this clover (assumed to be *T. wormskioldii*) from the area (Turner, 1999).

Gunther, 1945; Suttles, 1974; Turner & Bell, 1971), the location of specific stewarded estuaries is rarely mentioned[32], making it challenging to rely on ethnographic information to locate these places. Furthermore, early colonial influences in the region, leading to the removal of communities from homelands and the rapid alterations of coastlines and estuaries, both dislocated Indigenous Peoples from these important places and impacted their material ability to harvest from them (Lutz, 2010; Robb, 2014; Sachs, 202). As such, the fact that the methods discussed in this paper were successfully used to identify an estuary on Tl'chés as a root garden site is significant, especially since it is the first to have been recognized in the Coast Salish to date (see Chapter 3). By comparison, the second estuarine root garden considered, the Gwa'ni (Nimpkish) River garden in 'Na̱mgi̱s Kwakwa̱ka̱'wakw First Nations territory, was identified as an important root garden site by 'Na̱mgi̱s ancestors, and is still recognized as key cultural landscape within the present-day 'Na̱mgi̱s community. Furthermore, over a century of ethnographic and archaeological research at the site provides important information on the formation, stewardship, and traditional governance of the garden, as well as changes occurring since colonization (Boas, 1921, 1934; Deur, 2000; Ham & Howe, 1983). By contributing to this already robust data set, I was able to identify changes and resiliency within these living archaeological sites and legacy ecosystems (Vanier et al., 2025).

The last garden considered, at the Tsinwilht'as (Anderson) Creek, was encountered and investigated as part of an archaeological impact assessment (AIA) led by archaeologist Jim Stafford (2020) for the ʕaaḥuusʔatḥ First Nation. Although it contains invaluable (and rare, in an archaeological context) information about the archaeology, soils, and, to a certain extent, ecology of a traditionally stewarded estuary, the methods deployed at the Tl'chés and Gwa'ni gardens could not be replicated in this context. As such, it is mostly used for comparative purposes to help illustrate the differences and similarities that define estuarine root garden sites across different territories and how these might be discernible to archaeologists and others engaged in their study and recovery. Furthermore, although estuarine root gardens are recognized features in Nuu-chah-nulth territories (e.g., Bouchard & Kennedy, 1990; Deur, 2000), this specific garden site was not previously known by descendant communities prior to Stafford's (2020) work in the

[32] With some notable exceptions, such SELEȻTEŁ (the Goldstream River estuary) (Turner & Bell, 1971, p.87).

area. However, its archaeological characteristics (mainly, the presence of rock walls) made it relatively easy to identify as a root garden. This is markedly different from somewhere like Tl'chés, where less "classic" archaeological signatures (e.g., the lack of a rock wall feature) force us to engage with the variability in these sites and the impacts of cultural/regional specificity.

5.3.2. Periphery sites

At the Tl'chés and the Gwa'ni River estuarine root garden sites, periphery sites were surveyed in addition to the main root garden sites for comparative purposes. More commonly referred to as "control" sites within the ecological literature, the term "periphery" highlights the unlikeliness of encountering landscapes that are neutral and external to human influence, especially in places as culturally important as estuaries. Rather, periphery sites were selected due to their hydrological and ecological similarities to the garden sites, with the assumption that they were not similarly stewarded derived from all available data (Armstrong et al., 2021). However, these "periphery" places are still constitutive elements of cultural landscapes, existing under their own management regimes. For example, they might have served as seed banks or donor grounds for the main gardens or occasionally harvested from in times of need (e.g., Edwards, 1979) or by peoples who did not have rights to the more productive garden grounds.

At Tl'chés, two periphery sites were chosen due to their relative proximity with the estuarine root garden site. A third site was chosen due to the historic and dense *T. wormskioldii* population recorded by Dr. Nancy Turner at the location in 1999 (pers. com., 2018). At the Gwa'ni River, two periphery sites were chosen, both a short distance away from the main estuarine root garden site. Neither area was known as estuarine root garden locations.

5.3.3. Research Design

A methodological approach, based on known stewardship practices associated with estuarine root garden stewardship and their potential enduring impacts (Table 6), was devised and applied at the Tl'chés and the Gwa'ni River estuarine root gardens and periphery sites.

Table 6. Model of estuarine root garden components

Ethnographic estuarine root garden stewardship practices (Deur, 2000;	Potential observable or measurable impacts	Methods of data collection and analysis
Anthropogenic inputs to soil: Fertilization or addition of soil organic matter (SOM)–the addition of fish remains and organic remains brought with the tides. Humans associated with increased phosphorous and nitrogen.	Increase in certain key nutrients – especially phosphorous, nitrogen, carbon, calcium, potassium, magnesium, and sulphur	Multi-element soil analysis (ICP-AES, ICP-MS, XRF).
		Non-metric multidimensional scaling (NMDS), analysis of similarities (ANOSIM)
Tillage – the regular turning and mounding of soil.	Lowered levels of compaction	Soil penetrometer
	Less defined stratigraphy/stratigraphic indicators in the upper 30-40 cm	Visual in-field observation of soil profile
	Changes in ecological gradation, succession. Species found in different zones than expected.	Shore-perpendicular line transects
Use of tools to work/maintain the gardens.	Remnants of broken or discarded tools (e.g., digging stick tips)	Archaeological recovery of artifacts related to garden management.
Terracing	Little to no shoreline slope, heightened soil retention, archaeological evidence (e.g. rock walls)	Archaeological excavation of terracing features
Selective weeding and transplanting	Heightened relative abundance of culturally important species, changes in overall species richness on the landscape	Shore-perpendicular line transects and quadrat sampling.
		Non-metric multidimensional scaling (NMDS), analysis of similarities (ANOSIM), and indicator species analyses

Ecological data were derived from these sites using continuous quadrat sampling along a shore-normal line transect, capturing changes in vegetation from the shoreline to the outer edge of the estuarine prairie (Almeida et al., 2017; Prisco et al., 2016; Steinhardt & Selig, 2009). A 1 m x 1 m quadrat was used, with the percent cover of each species directly estimated within the sample area (Buckland et al., 2007). Depending on the site's overall surface size, between four and five transects were established. To compare the community composition of plants across sites, we conducted non-metric multidimensional scaling (NMDS), analysis of similarities (ANOSIM), and indicator species analyses. To visualize differences between individual plots of different types and sites, we carried out an NMDS analysis using the R package vegan ver. 2.5–7 software (Oksanen et al., 2020). This facilitated the analysis of similarities and differences between plots using three axes (k=3) and the Bray-Curtis dissimilarity index. We were then able to visualize the results with the R package ggplot2 ver. 3.3.3 (Wickam, 2011). To identify species strongly associated with specific types of plots or the "indicator species" of plots, we conducted an indicator species analysis using the "multipatt" function in the R Core Team (2013) package indicspecies ver. 1.7.8 (De Caceres et al., 2016) with 9999 permutations. Finally, to test for statistically significant differences between garden and periphery plots, we conducted an analysis of similarities (ANOSIM) with the vegan package using the Bray-Curtis dissimilarity index and 9999 permutations.

Before excavation, a ProCheck Soil Sensor was used at all plots (garden and periphery) to determine moisture and bulk electrical conductivity. Before units were excavated and soil samples removed, a soil penetrometer (or a Dickey-John Soil Compaction Tester) was used to measure soil compaction. Once units were opened, we conducted an in situ stratigraphic analysis. Soil samples were then gathered from garden and periphery sites and sent to the laboratory of the Ministry of Environment in Victoria, B.C., for analysis. Measured elements included available Phosphorous (P), pH, Nitrogen (N), Calcium (C), and trace metals, in addition to cation exchange capacity (CEC), exchangeable cations, and loss of ignition (LOI). Once results were returned, we conducted an indicator species analysis using the "multipatt" function in the R Core Team (2013) package indicspecies ver. 1.7.8 (De Caceres et al., 2016) with 9999 permutations to statistically analyze and visualize differences in soil qualities between the study and periphery sites. NMDS analysis was also used to compare soil characteristics across plots using the same settings as described above.

Archaeological excavations occurred at the Tl'chés, Gwa'ni River, and Tsinwilht'as Creek estuarine root gardens. At Tl'chés, three 50 cm x 1 m units were excavated along a gradient extending from the shoreline towards the treeline. At the Gwa'ni gardens, the excavation area was selected due to the presence of a remnant terraced prairie and the identification of buried rock wall features, a section of which was then uncovered in a 1m x 1m unit. In both cases, units were excavated in 10cm arbitrary levels within stratigraphic units, and excavated sediments were screened through 1/8" mesh for artifacts. At Tl'chés, units were excavated to a maximum DBS of 20-30cm before hitting a layer of sand, boulder, and cobbles. At the Gwa'ni River, excavation was conducted to a maximum depth of 53cm, after which extensive ground water intrusion and infilling made further excavation impossible. At the Tsinwilht'as estuary, more extensive excavations were undertaken, resulting from systematic field surveys of the area and the use of evaluative units (EU's). Subsurface testing included two deep shovel tests on each side of Tsinwilht'as Creek as well as a systematic survey of the creek exposures and 19 auger tests. Six 1x1 m units were placed in areas with rock clusters identified near the surface, and below surface during the AIA testing. Materials were screened through ¼ or 1/8-inch mesh screens or gone through with fingers, depending on matrix density (Stafford, 2020).

5.4. Results

Results from the three gardens considered in this paper are outlined in Table 7.

Table 7. Comparison of estuarine root garden characteristics

Location and Eco-cultural context	Archaeological characteristics	Pedological characteristics	Ecological characteristics	Site interpretations
Tl'chés (Chatham and Discovery Islands) - Lək̓ʷəŋən/Songhees First Nation				
Tl'chés (Chatham and Discovery Islands), is an archipelago in the Salish Sea, off the southern shore of Vancouver Island. It is part of Lək̓ʷəŋən/Songhees First Nation territory. The islands are characterized by dense concentrations of Lək̓ʷəŋən inhabitation and stewardship sites. The estuarine root garden, located in a low energy tidal estuary, is adjacent to a small shell midden, a reef net location, and Douglas Fir Culturally Modified Trees (CMT's). Freshwater inflow to the estuary is highly seasonal and fed by adjacent pools.	Small portions of Fire Altered Rock (FAR) were recovered in the garden sediment, as well as a collection of lithic stone flakes (<5). Charcoal (plant materials) from a possible heart feature (14-16cm DBS) were sent to Beta Analytic for radiocarbon dating (Beta 559020), with an age range of 510-426 cal BP (390 +/- 30), calibrated using the 2013 INTCAL program (Reimer et al., 2013). A historic shoe nail (recovered at 15-17cm DBS) concurrent with a style that would have been common in the mid to late 1800's, was recovered adjacent to and at a greater depth than the above hearth feature, indicating that sediment was turbated after deposition, possibly through root digging.	Garden soils show heightened and statistically significant levels of available Phosphorous (P) and Calcium (Ca) when compared to periphery sites. Sediments at the garden site consist of 20-30 cm of loose, uncompacted and organic loam (10YR) overlying cobbles and boulders. Comparatively, sediment at the periphery sites were shallow (~10cm DBS), except for Periphery site 3 (PS3), where *T. wormskioldii* was recorded as late as 1999 (pers. com. N. J. Turner, 2022). PS3 also showed comparatively elevated levels of P. No rock wall was identified, but a narrow band of waterlogged sediment serves as an erosional barrier at the edge of the garden.	Pacific silverweed (*Argentina egedii ssp. Pacifica*) and springbank clover (*Trifolium wormskioldii*) are statistically significant ecological indicators for the garden site. (Maurice-Hammond et al. 2023). *A. egedii* is abundant and widely distributed at all sites; however, the only other place where *T. wormskioldii* was observed at Tl'chés is a small population at periphery site 3.	Past caretaking of food plants – namely, *T. wormskioldii* – has had lasting impacts on present-day ecologies. The creation and caretaking of cultural soils, and the removal of encroaching and competing plant species, allowed the continued presence of these plants in a context where they would have otherwise been extirpated (as is the case with most of Tl'chés). This might be a more Coast Salish specific site signature, where T. *wormskioldii*, specifically, is increasingly rare. Pedological characteristics of the site emerge as a strong and enduring marker of past stewardship, specifically in high P contents and deep, uncompacted and organic cultural soils.
Gwa'ni (Nimpkish River) estuary - 'Na̱mgis /Kwakwa̱ka̱'wakw First Nation				
The estuarine root garden is located on a tidal island at the mouth of the Gwa'ni (Nimpkish) River estuary on north-eastern Vancouver Island. It is part of 'Na̱mgis /Kwakwa̱ka̱'wakw First Nation territories.	Rock wall fragments were uncovered adjacent to the housing platform that runs east-west on the western end of the island. The wall was only discernible as boulders emerging out of the turf forming a linear pattern. Composed of larger rounded and sub-rounded boulders	Root garden sediment showing statistically significant heightened levels of soil P when compared to periphery sites. Sediment at the garden site consists of 30-40 cm of loose, uncompacted and unstratified organic, charcoal-	*A. egedii* and *T. wormskioldii* are statistically significant indicator species for the comparative periphery sites. Comparatively, the	The deep, organic, cultural soils at the Gwa'ni root garden were ideal for the growth of prized long, straight roots; however, the loss of anthropogenic disturbance regimes created conditions where ecological replacement through succession became possible. Comparatively, natural disturbance

The root garden site is part of a dense archaeological assemblage and is closely associated with several pre and post contact village sites, Western red cedar CMT's, fish traps, petroglyphs, and other features. The estuary is located at the confluence of the Gwa'ni River, one of the largest rivers on Vancouver Island, and is characterized by daily high energy tidal inundations that cut off the garden island from the adjacent mainland.	and cobbles, and infilled with pebbles and FAR, the wall, which runs parallel to the housing platform, extends to a minimum of 40cm DBS and intersects with other wall features. A preserved Western red cedar plank was uncovered running perpendicular to the excavated rock wall fragment. It was radiocarbon dated with Direct AMS (049925) to and average age of 529 cal BP (+/-24) with a 1σ 0.28, contemporary with caretaking at the site.	rich loam (10YR) overlaying gravels cobbles, and compacted sand. Comparatively, sediments at periphery sites are significant shallower on average (<10cm).	walled garden areas are more closely associate with lyngbye's sedge (*Carex lyngbei*) and bog-myrtle (*Myrica gale*).	regimes at the periphery sites (i.e., tidal inundations) have maintained ecological balance, resulting in a continued abundance of *A. egedii, T. wormskioldii*, and riceroot lily (*F. camschatcensis).* Archaeological legacies of stewardship remain at the garden site, with a high potential for the further recovery of garden implements (such as digging sticks) and a basal date for rock wall construction. Furthermore, soil characteristics at the garden site emerge as a lasting indicator of 'Na̲mg̲is caretaking.

Tsinwilht'as Creek estuary – ʕaaḥuusʔatḥ/Nuu-chah-nulth First Nation

The study area is located at the mouth of Tsinwilht'as (Anderson) Creek, a well-protected and significant drainage that empties out into Matila Inlet on Flores Island. The estuary was assessed as having high archaeological potential due to its proximity to important water bodies, a primary village site Maaktusiis (Marktosis) and previously recorded Western red cedar CMT's. A fish trap structure was also identified as part of the AIA. Though estuarine root gardens are known features in ʕaaḥuusʔatḥ/Nuu-chah-nulth territories, this one was not previously recorded or indicated in the ethnographic literature.	An 'upper' and 'lower' garden platform were identified, both containing rock wall features. The upper (older) garden platform is densely vegetated and located just at/slightly above the high tide line. A charcoal sample was extracted from 26-28cm DBS (overlying sterile sand and underneath a large cobble) and radiocarbon dated to 1081-1163 cal BP (D-AMS 032037), likely indicating early construction. The 'lower' garden is believed to be a more recent attempt at extending the root garden, sitting just below the high tide line and consists of a rock wall 30-50cm in height, with very little soil build up and retainment. A basal stake fragment was removed from this area, likely the tip of a root digging stick	The upper walled garden site consists of 30-40 cm of organics and organic silt overlying compact sandy gravels with cobbles and boulders. Deep tests sands, silts and clasts, with increase in sands at 100cm DBS. At the lower root garden, a dense root mat overlies 10cm of brown organic silts with trapped organics/charcoal	*A. egedii* and *T. wormskioldii* were observed in dense quantities at the upper garden site. Large quantities of yarrow (*Achilllea millefolium*) are also observed. *F. camschatcensis* was noted as likely to occur in the study area but was not observed.	The upper garden is the result of long-standing estuarine stewardship, with similar sediment characteristics as the Tl'chés and Gwa'ni estuarine gardens. The enduring presence of estuarine food plants [*A. egedii* and *T. wormskioldii*] indicate that the site has remained relatively stable since the cessation of active stewardship, though the presence of *A. millefolium* might indicate a shift in moisture regime towards a dryer, more prairie-like environment, possibly resulting from previous water diversion at the site. The lower garden, accessed by Stafford (2020) as a more recent attempt to expand the garden site, was not actively utilized for a long to ensure sedimentary infilling (i.e., the creation and addition of cultural soils). The comparatively shallow band of organic silt, though productive, would not have allowed the growth of preferred long roots and rhizomes

Drawing from these results, and the methods used to elicit them (see Table 1), an evaluation of methods effectiveness is provided, with some suggestions concerning future directions for the work (Table 8).

Table 8. Model of estuarine root garden components: Outcomes and suggestions for future work.

Anthropogenic impacts associated with estuarine root garden stewardship	Methods of data collection and analysis	Outcomes and suggestions
1. Increase in certain key nutrients in root garden sediment	Multi-element soil analysis (ICP-AES, ICP-MS, XRF).	**Retain and expand**. A larger sample size is needed for conclusive evaluation. However, heightened P levels emerge as a strong indicator of stewardship. When possible, samples should be retrieved from a minimum of 30cm DBS to account for natural bioturbation/deposition. Though P tends to remain relatively stable in the soil column, high levels of moisture over time can shift P down the soil column, where it will accumulate above impermeable layers, such as rock or sterile sand (Zhao et al., 2021). As such, samples taken from known/suspected estuarine root garden sites should be taken at depth to best reflect P contents. Further samples should be taken at varying distances from the suspected estuarine garden boundaries to help determine boundaries and shifting intensity of use.
	Non-metric multidimensional scaling (NMDS), analysis of similarities (ANOSIM)	**Retain**. Provides a good visualization of chemical pedological characteristics at garden and periphery sites.
2. Lowered levels of compaction	Soil penetrometer	**Inconclusive, remove**. All sediments tested were uncompacted. Impacts of tilling on soil compaction are ephemeral, generally fading within 12-36 months of treatment (Mohammadshirazi et al., 2017).
3. Less defined stratigraphy/stratigraphic indicators	Visual in-field observation of soil profile	**Retain, expand**. This approach is key in determining extend of anthropogenic soils. However, it should account for natural post-stewardship deposition and soil building, likely impacting the upper 10-20 cm (varying depending on site dynamism).
4. Changes in ecological gradation, succession. Species found in different zones than expected.	Shore-perpendicular line transects with continuous quadrat sampling	**Inconclusive, remove.** Species gradation is tied to hydrological regimes and salt-water tolerance. A visual evaluation is sufficient to determine whether changes are associated with terracing.
5. Remnants of broken or discarded tools (e.g., digging stick tips)	Archaeological recovery of artifacts related to garden management.	**Retain**–see Hoffman et al., 2016; Stafford, 2020.
6. Little to no shoreline slope, heightened soil	Archaeological excavation of terracing features	**Retain, with consideration for garden variability**. Many estuarine root garden sites were not anthropogenically

retention, archaeological evidence (e.g. rock walls)		terraced. Terracing would only be necessary in places that would otherwise be more marginal for root food production. Large deltaic estuaries provided ideal conditions, improved through pedological and ecological amendments. Additionally, naturally occurring bands of dense and waterlogged sediment on the margins of estuarine prairies would have provided sufficient erosional barriers, especially in low energy tidal environments (see Maurice-Hammond et al., 2023). However, in places where rock wall terracing is present, features could be identified in erosional cut-banks or by "probing" sediment with a metal implement (e.g., a spade). Future work could also focus on basal dates for terrace construction (see Stafford, 2020).
7. Heightened relative abundance of culturally important species, changes in overall species richness on the landscape	Shore-perpendicular line transects and contiguous quadrat sampling.	**Retain**. Provides information about ecological composition, species richness, and impacts of stewardship on ecological succession. Depending on site/goals, variable study designs could be considered (e.g., randomized quadrat plotting in larger estuaries).
	Non-metric multidimensional scaling (NMDS), analysis of similarities (ANOSIM), and indicator species analyse	**Retain.** Good approach for visualizing and comparing species compositions at garden versus periphery sites.

5.5. Discussion

Drawing from this research process, it is apparent that recoverable and diagnostic ecological, pedological and archaeological characteristics delineate estuarine root gardens from un-stewarded estuarine landscapes. However, variability in appearance and presentation is broad and based on a multitude of factors, such as specific cultural practices and needs (affecting the size, composition and plot delineations of the gardens), local hydrology (determining whether terracing is necessary, as well as rates of sediment accumulation), and local ecologies and climate (determining which species are present at the gardens and post-stewardship community resilience).

5.5.1. Limitation of the study

This work was conducted on a limited number of sites in different ecological, climactic, and cultural contexts. Though lessons and interpretations can be drawn from this work, this methodology needs to be replicated on a larger scale for a more positive assessment of its functionality. Additionally, estuaries are dynamic, with multiple interlocking ecological and hydrological factors affecting plant community composition and soil morphology; as such, other possible factors causing sediment accumulation and nutrient loading needs to be considered, requiring a historical ecology approach to the study of these places. Herbaceous plants, especially, are highly dynamic, making it difficult to fully assert that changes in their composition are tied to the ongoing effects of anthropogenic caretaking, necessitating the additional consideration of pedological and archaeological factors.

5.5.2. Ecological legacies

Though it is apparent that past caretaking practices at estuarine root gardens have altered plant communities in ways that are still discernible today, the trajectory of these changes is variable, with hydrology and climate impacting post-stewardship trajectories. At Tl'chés, for example, *T. wormskioldii* emerged as an indicator species for the root garden site, despite being rare on the archipelago overall, including in places where it was known to still grow in the 1990's (Figure 12). There, past caretaking of the estuarine landscape by Ləkʷəŋən Peoples appears to have had an overriding impact on the continuing presence of *T. wormskioldii*, which continues to positively respond to anthropogenic amendments.[33] Multiple factors are suspected to be at play in the decline of *T. wormskioldii* in the area, such as the gradual diminishment of available fresh water on Tl'chés,[34] impacts from introduced Canada goose (*Branta canadensis*) herbivory (Janus, 2022), and competition from other native, non-native, and invasive plant species

[33] During the 2019-2020 growing seasons, excavated sections in the root garden – places where the soil was turned, competitive grasses and forbs were removed, and the roots and rhizomes of *T. wormskioldii* and *A. egedii* were re-buried–supported a visually denser community of flowering *T. wormskioldii* the following summer (Maurice-Hammond et al., 2023)

[34] Sources that would have fed the estuarine root garden (such as the vernal pools, which Səƚƚəmah identified as sacred bathing ponds) now routinely run dry by mid Spring. Indeed, the disappearance of fresh water sources, once plentiful enough to support large populations of Ləkʷəŋən Peoples in permanent village sites, forced the extirpation of the last ləkʷəŋən families from Tl'chés in the 1950's (pers. com. Səƚƚəmah, 2018).

(Nicholas, 2017c). Indeed, a combination of these factors, themselves resulting from colonial intrusions, urbanization, landscape alterations, and the removal of Indigenous stewardship, has created conditions where *T. wormskioldii*, once a commonly found species, has become vanishingly rare (Turner, 1999a)[35]. As such, the *T. wormskioldii* population at the Tl'chés estuarine root garden is believed to be a legacy community, whose continuous presence is tied to favourable soil and landscape characteristics resulting from a history of Lək̓ʷəŋən stewardship.

Comparatively, *T. wormskioldii*, *A. egedii,* and *F. camschatcensis* grow abundantly on the banks of the Gwa'ni River. However, they seem to favour the surveyed periphery sites, highly dynamic gravelly banks covered in a thin layer of organic sediment marked by frequent depositional processed and high flood events. Today, the walled garden areas, still sporting pockets of deep cultural soils, supports a higher proportion of plant species more closely associated with higher ecological gradients more sensitive to brackish tidal inundation.[36] In this case, the creation of these deep soils–which, when actively stewarded, would have fostered the growth of the prized long roots preferred for consumption and trade–created the conditions for eventual ecological succession. Human disturbance, expressed through acts of active stewardship, was key to ecological stability at the estuarine root garden and the ongoing density of estuarine root foods. Comparatively, the highly dynamic and low-lying surrounding marshes continue to foster more stable plant communities. However, the soils in these places are shallow (10-12cm in depth on average), abutting into pea gravel and densely packed sands, which would have made the growth and extraction of long, straight roots challenging. Roots extracted from these areas are more likely to be short, gnarled and broken, which would likely have led to their rejection by past 'N<u>a</u>m<u>g</u>is caretakers as unsuitable foods–even signs of supernatural bad luck (Deur, 2000).

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[35] Another example of this in Lək̓ʷəŋən territories is Clover Point. Named so by James Douglas in 1842, the area was described as "covered with a species of red clover, growing most luxuriantly" (quoted in Walbran, 1909, p. 96). Today, and following over a century of settler disruptions to place, large tracks of Clover Point are paved, with the remaining vegetation primarily consisting of invasive and non-native grasses. No *T. wormskioldii* remains.

[36] These include forbs (e.g., orchard grass, *Dactylis glomerata*), shrubs (e.g., salmonberry, *Rubus spectabilis*, and swamp currant, *Ribes lacustre*,) and trees (e.g., cascara, *Frangula purshiana* and Douglas fir, *Pseudotsuga menziesii*). Notably, Pacific crabapple (*Malus fusca*) is found on the tidal garden island as well as the periphery sites.

Though direct comparative data are lacking, the Tsinwilht'as Creek estuarine garden appears to have supported a relatively stable plant community–at least, in the upper walled section. There, Stafford (2020) noted dense remaining populations of *A. egedii* and *T. wormskioldii.* Though *F. camschatcensis* was speculated to be likely present at the site, none was observed, reflecting the need for more thorough (and seasonally appropriate–i.e., when plants are blooming) ecological investigations as part of archaeological fieldwork in suspected plant stewardship landscapes. The intermingling of *A. egedii*, *T. wormskioldii* and yarrow (*Achillea millefolium*) indicates that the upper garden is at the higher margins of the estuarine meadow, minimally impacted by tidal inundation and salt intrusion. Like at Tl'chés, ecological conditions appeared to have remained relatively stable since active cessation of the garden ceased, allowing for the continued presence of legacy plant communities. In contrast, vegetation at the creek mouth and lower garden was sparse, likely impacted by geese herbivory and tides/storm surges though the lack of soil accumulation (discussed further in the next section) is likely another factor in limited vegetation development.

5.5.3. Pedological legacies

Soils present at estuarine root garden sites are cultural soils, legacy systems that encapsulate how Indigenous Peoples "modified their land in order to create more idealized conditions for their chosen resources" (Lowther, 2022, p. 3). Along the Northwest Coast, there is a recognition that estuarine root garden soils were different, resulting from human labour and stewardship. For the Kwakwa̱ka̱'wakw, they were *t'aki'lakw* or "[places of] human-manufactured soil" (Kwaxsistalla as quoted in Deur, 2000, p. 90). Amongst the Nuu-chah-nulth, they were *ts'isakis*, or "place with soil" (Bouchard & Kennedy, 1990, p. 464). Though no similar word is known for estuarine soils in Coast Salish territories, the creating and maintaining of cultural soils was widespread across several systems. For example, *kwetlal*[37] prairies were regularly burned, fertilized and tilled to increase productivity (Suttles, 2005; Turner, 1999b), while increased portions of charcoal at a

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[37] the Lək̓ʷəŋən word for blue camas, *Camassia quamash* and *Camassia leichtlinii*

wapato (*Sagittaria latifolia*) garden in Katzie territories indicates knowledge of wetland stewardship going back at least 3800 years (Hoffman et al., 2016)[38].

Markers of cultural soils are found in the physical and chemical alterations caused by human activity (Howard, 2017). The estuarine root gardens discussed in this paper all displayed similar soil characteristics that were distinctive from soils surveyed at periphery sites. These soils are uncompacted and largely unstratified, with low portions of boulders and cobbles encountered throughout. When found at all, a proportionally large number of these were FAR, likely resulting from nearby cooking pits and hearths. The cultural soils at the garden sites are organically rich loam, dark in colour (estimated visually as 10YR on a Munsell scale). They are deep soils– strikingly so, when compared to periphery sites (see Table 7). At Tl'chés and the Gwa'ni River garden sites, where multi-element soil analysis was conducted, they were also found to be chemically distinct, with heightened levels of available P and Ca, both known to be biproducts of human use, occupation, and plant stewardship, as well as necessary elements to encourage plant growth (Bosman, 2019; Grossman et al., 2010; Lauer et al., 2013, 2014; Lowther, 2022; Trant et al., 2016). These are, in summary, chemically and physically distinct soils, shaped by Indigenous Peoples over time to increase the productivity of estuarine marshlands and make them more suitable for the growth of large amounts of root foods. These are *cultural soils*.

5.5.4. Archaeological legacies

Estuarine root gardens remain rare in the archaeological inventory of British Columbia. A search of the Archaeology Branch's Remote Access to Archaeological Data (RAAD) site came up with a total of four recorded estuarine root garden sites, two of which are discussed in this paper (the Gwa'ni River and Tsinwilht'as Creek gardens). The other two estuarine root gardens, EaSv-31 in Ka:'yu:'k't'h'/Chek'tles7et'h' territories (McLaren et al., 2003) and EfSr-28 (Walde-Renault et al., 2024) in Gwaewaenuk territories, were summarily described, with the garden at EfSr-28 grouped in with a crab apple (*Malus fusca*) orchard and a berry patch. The only intertidal root food identified was *A. egeddi*. The garden appears to be a known cultural component in the area, as

[38] For a broader discussion on cultural soils and anthrosols, see Chapter 1.

identified by both the Gwaewaenuk Nation and Boas (1934). The garden at EaSv-31 was noted during a clam garden survey, with a terrace supporting *A. egedii* and sea asparagus (*Salicornia pacifica*) populations. However, the co-occurrence of these species in an estuarine root garden does not align with the findings of this paper, with *S. pacifica* preferring a lower tidal bracket characterized by a higher tidal inundations and salinity. Though co-occurrences do occur at the outer edges of gardens, terracing and cultural soils in stewarded landscapes would limit the growth of *S. pacifica*.

The limited presence of estuarine root gardens in RAAD supports the premise that these places have been systematically under-recorded by archaeologists in British Columbia. It is worth noting that many Nations hold more specific knowledge about the location of these places in their territories, working with their own archaeologists and knowledge keepers to protect them. This, however, does not negate the need for archaeologists working in cultural resource management to become better versed in the identification of root growing places, especially in cases where disruption or destruction of the site may occur. These places may be challenging to discern, especially when visible rockwork or community knowledge about the location of gardens is no longer present or easily accessed. Additionally, many highly productive estuarine root garden sites were in large, flat, deltaic estuaries, where soil retention through rock walls was not necessary. Kwaxistalla, for example, talked about the root gardens at Kingcome Inlet being delineate by cedar pegs (Deur, 2000). Similar forms of plot delineation were noted at the Somass River flats, where individual plots–one acre in extent–were separated be six feet tall cedar posts called *tlh'ayaqiyaktlhama* (Sapir, 1914). Indeed, the presence of rock work may be more indicative of less naturally productive and more peripheral garden sites, where additional amendments were needed to create the conditions for these plants to grow in sufficient volume to support communities (Deur, 2000). This further emphasizes the need for alternative lines of evidence when trying to identify estuarine root garden sites.

Finally, ongoing impacts to estuaries since colonization have caused significant changes to hydrological and/or ecological regimes, affecting the composition of these legacy systems. For examples, changes in hydrology (resulting from water diversion, draining, or diking, amongst others) may affecting anaerobic sediment conditions and the likelihood of wet site recovery– a notable element in identifying plant stewardship places in the past[39] (Brundsen et al., 2010). Furthermore, certain places that were identified in the past may need to be re-characterized, with Deur (2000) highlighting the likelihood of "defunct fish traps" (i.e., rock wall features located at a tidal height not conducive to fish capture) or clam garden walls actually being constitutive of estuarine root garden features.

These challenges highlight the importance of understanding site use history and post-stewardship colonial impacts to place. Furthermore, alternative lines of evidence should be followed in developing a more robust understanding of these cultural landscapes, moving away from rigid conceptions of what constitutes material culture towards perspective that encompasses ecological heritage (Vanier et al., 2025) (Table 9). In certain cases (like at the Tl'chés estuarine garden), tangible indicators typically preferred within archaeological research (such as rock wall remnants) may not be present; this, however, does not mean that these places were not stewarded by Indigenous Peoples, or that they should not be included within our broadening understandings of what constitutes cultural heritage or sites of tangible material culture in British Columbia. In these cases, evidence of stewardship can be found in legacy ecosystems and cultural soils.

Table 9. Estuarine root garden checklist for archaeological practitioners

Estuarine root garden checklist	
Cultural and ecological associations	Association with other cultural features, such as village sites (winter village sites or seasonal sites, such as digging houses or clusters of cooking hearths), clam gardens, known fishing locations, etc. **Note** that some smaller root gardens may be more peripheral within territories but would be associated through seasonal rounds.
	Association with other terrestrial and intertidal foods and food stewardship systems. Are there other cultural foods nearby, such as groves of Pacific crabapple trees (*Malus fusca*), berry patches, culturally managed trees (such as bark stripped Western red cedar, *Thuja plicata*), or other culturally important plant species? Are these known shellfish harvesting, duck netting, hunting, or fishing locales nearby?
	Presence of intertidal root foods, such as springbank clover (*Trifolium wormskioldii*), Northern riceroot lily (*Fritillaria camschatcensis*) and, to a lesser degree, Pacific silverweed (*Argentine egedii ssp. Pacifica*). **Note**: a lack of a wide

[39] For example, the recovery of digging stick fragments in a wetland in Katzie territories was a key element in helping to categorize it as an ancient wapato (*Sagittaria latifolia*) garden (Hoffman et al., 2016). Similarly, a digging stick fragment was recovered in the *Tsinwilht'as* estuary, while a piece of preserved cedar plank (likely a wall feature) was found preserved at the Gwa'ni root garden (Stafford, 2020; see Chapter 3).

	distribution of these species does not automatically discount the presence of an estuarine root garden site, especially if other factors align. Rather, terracing and past soil amendments can create conditions favouring replacement through succession. Furthermore, the wide distribution of *A. egedii* means that its presence alone is not a strong indicator of estuarine root garden stewardship. *T. wormskioldii* and F. *camschatcensis* are stronger indicators, especially in areas where they have a limited distribution (e.g., the Coast Salish); however, this should be co-related with other factors discussed in this table.
Soil characteristics	Sediments below the root mat can be characterized as deep, extending roughly 30-60cm DBS before hitting boulders, cobbles and sand constitutive of riverine and marine deposits. Sediments observed in situ are unstratified, uncompacted, highly organic, dark in colour (10YR on a Munsell chart), with very few cobbles and boulders found throughout. When rocks are recovered in units, a proportionally large amount of it is fire altered (FAR).
	Chemical differences in the sediment, such as high levels of available soil phosphorous (P) and proportionally higher levels or carbon (C). **Note**: comparative periphery sites should be identified and tested to determine significance. These sites should be located near the targeted estuary, have similar ecological and hydrological characteristics, and be determined to be low probably for past estuarine root garden stewardship. Furthermore, inputs from incidental anthropogenic activities, such as the presence of dwellings or fire pits, should be accounted for and isolated. Soil samples to determine P should be taken at depth, since P can migrate down the soil column and accumulate above impermeable layers (e.g., sterile sand).
Built features	Evidence of terracing and plot delineation. This may take the form of rock walls made of piled cobbles and boulders, usually infilled with smaller cobbles, pebbles and FAR. Carved cedar planks or posts may also be recovered from water-logged sediments. Sedimentary infilling and vegetation accretion that have occurred since times of active stewardship may make these features hard to identify. If these features are suspected, a digging implement may be used to gently "probe" the vegetation and sediment in search of hard surfaces. Furthermore, coastal erosion in high energy sites is associated with the dissolution of external barriers; as such, energy should be dedicated to investigating features further inland. **Note**: not all estuarine root gardens required the building of rock walls. In some cases, low tidal energy, combined with naturally existing sedimentary conditions (such as dense, waterlogged sedimentary tidal margins) created conditions that mimicked rock barriers. Indeed, many large, productive estuarine root garden discussed (e.g., Kingcome Inlet, the Somass River, or the San Juan River) were in deltaic river flats, discounting the need for terracing, which would have only been necessary to improve areas with more marginal root growing conditions.
Tool recovery	Recovery of tools used in estuarine root garden management, such as preserved digging sticks.

5.5.5. Gardens on the edge: Cumulative impacts on estuaries

Estuarine root gardens are gardens on the edge. They are the edge of ecotypes, the boundaries separating, and connecting, marine and terrestrial systems (Turner & Mathews, 2017). They are also places that we have pushed to the edge through colonial, cumulative, and unsustainable practices, starting with the forced interruption of Indigenous stewardship. Indigenous Peoples, forcibly removed from their homelands, were pushed into settler colonial economies of wage labour, impacting abilities to continue caring for traditionally stewarded landscapes and harvesting traditional foods (Joseph & Turner, 2020). The removal of generations of children to residential schools, and the outlawing of practices where traditional foods and knowledge would have been shared (such as the potlatch) compounded these impacts, leading to a nutritional transition and the rapid adoption of introduced foods (Joseph & Turner, 2020; Lutz, 2009). Furthermore, the places that people would harvest from–traditional berry picking grounds, stands of cedar trees, estuarine root gardens–were themselves impacted by settler forms of extraction, resulting in changes to these landscapes and harvestable populations. As Dick et al. (2022, p. 559) put it:

> Harvests of camas, springbank clover, silverweed, and other food plants are not less intensive merely because of cultural change. Rather, the plants are not harvested due to the elimination of the anthropogenic habitats necessary to provide safe, viable subsistence quantities of these food products.

This context then, is one of cumulative harms, affecting species, landscapes and peoples on a range of temporal and geographical scales. At estuarine root gardens, the removal of Indigenous stewardship has had impacts on ecological composition (e.g., replacement of plant foods through succession or competition) and site integrity (e.g., erosion of cultural soils due to the dissolution of barriers and terracing). More challenging to identify, however, are the myriad other ways in which these systems have been affected by settler colonial systems of resource extraction and land alterations. For example, the construction of pulp mills and sewage processing plants, often located in estuaries, has led to the contamination of sediments and waters, making traditional foods unsafe for consumption. In many cases, estuaries were also seen as prime locations for the establishment of settler forms of agricultures, with sedimentation and hydrological regimes altered due to diking, draining, infilling, and the introduction of cattle (Deur et al., 2013; Dick et al., 2022; Kennish, 2021). Many of these places, especially in the southern Coast Salish region of British Columbia, have since been further altered through urbanization, with growing coastal populations straining these systems (Freeman et al., 2019). Today, on the Pacific Coast of British Columbia alone, 85% of estuaries have already been significantly or irrevocably altered (Janousek, 2024).

These impacts are cumulative, compounding, hard to quantify, and ongoing. The three estuaries considered in this paper were chosen, in part, due to relatively limited settler colonial impacts to their integrity. Both the Tl'chés and Gwa'ni gardens are located on un-developed reserve lands, while Tsinwilht'as Creek–adjacent to ʕaaḥuusʔatḥ reserve land–has only seen minimal historic alterations. This, however, does not remove them from the possibilities of colonial impacts. Tsinwilht'as Creek was homesteaded by settlers in the 1930's, who clear-cut the surrounding forests and introduced cattle. Water from the creek was later diverted in the 1950's for the original water license, which was then amendment several times and eventually led to the diversion of over 17 million gallons of water per year (Stafford, 2020). Though garden structures appear to be relatively intact in this case, the introduction of non-native species and hydrological changes are likely to impact ecological and sedimentary characteristics in the estuary, thus potentially impacting the stability of tangible archaeological materials. At the Gwa'ni garden, impacts of loss of human stewardship have had significant impact on ecological trajectories and the erosion of barriers. However, down-river sedimentation and changes in water flow caused by more than a century of intensive logging needs to be considered, as well as impacts caused by under-water dredging in nearby bays (e.g., Port McNeil) and the historic presence of log booms within the estuary itself (see Gerwing et al., 2018; Wenger et al., 2018). In other cases, cumulative changes may be tied to the introduction of invasive and non-native species into estuarine and coastal landscapes, compounded by intensive changes to hydrological regimes–issues of particular concern in the urbanized Coast Salish regions of British Columbia (Kennish, 2021; Nicholas, 2017c)[40]. These factors, finally, need to be considered through the lens of anthropogenic climate change. Already, increases in storm surges is leading to coastline erosion, further impacting the margins of estuarine gardens and altering sedimentation regimes.

[40] For example, the introduction of Canada geese (*Branta canadensis*) from eastern Canada in the 1970's created non-migratory populations that occupy estuaries year-round, grazing the vegetation and actively contributing to coastal erosion (Janousek, 2024)

Projected sea level rise will only compound these factors, while increases in salt-water flood events impacting the delicate ecological balance of plant communities already growing on the ecological edge (Olivares-Aguilar et al., 2022).

5.5.6. Estuarine root gardens as places of Indigenous futurity

As living, growing archaeological sites, estuarine root gardens blur temporal boundaries. They are places of Indigenous pasts, built by the labour of ancestors, resulting in the creation of distinct cultural soils, plant communities, and materials associated with garden building and maintenance. They are also places of Indigenous futures and resurgence, where ongoing networks of care and reciprocity intersect with the potential for the relationally guided healing of traditional homelands, a restoration of balance centered on respecting and honouring mutual dependency with land and non/more than human kin (Grenz, 2024; Joseph et al., 2022). This fluid, relational engagement with landscapes and the beings that inhabit them aligns with Indigenous conceptions of heritage and cultural landscapes,[41] contradicting static understandings of heritage management and spatially/temporally bounded archaeological sites (Kelly et al., 2024; Nicholas, 2017a). Rather, by centering the role of communities in the creation and maintenance of these places, we can begin to understand these as landscapes that are alive not just in their ecological compositions, but in the reciprocal, respectful, and generous relationships that they hold (Vanier et al., 2025). By continuing to respect and uphold these principles, Indigenous People renew relationships with lands and traditional foods while ensuring the inter-generational continuity of this knowledge. For Joseph & Turner (2020), the act of returning to and caring for land encompasses lessons and ways of being that support the physical, spiritual, and cultural health of Indigenous Peoples, folded into an ethical worldview that foregrounds reciprocal care for human and non-human relations (Coulthard, 2014).

Examples of these relationships of care and reciprocity being enacted on cultural landscapes can be seen in the revitalization of Indigenous food systems, which is at the core of

[41] Nicolas (2017a, p. 11) defines Indigenous cultural heritage as “an amalgam of ideas, experiences, worldviews, objects, forms of expression, practices, knowledge, spirituality, values, kinship ties, obligations and relationships with each other and with other-than-human beings, places and land”

Indigenous-led eco-cultural restoration of homelands (Grenz & Armstrong, 2023). In recent years, Nations on the west coast of North America have taken on the revitalization of their ancient intertidal (e.g., shellfish harvesting and fishing technologies)[42] and coastal places (Augustine, 2025; Larson, 2023). The Quw'utsun/Xwulqw'selu estuarine restoration project on south-eastern Vancouver Island, for example, aims to restore 70 hectares of salt marsh while working with Quw'utsun Peoples (Cowichan Tribes) to revitalize traditional food systems (The Nature Trust of BC, 2025). A short distance away, on Salt Spring Island, the Stqeeye' Learning Society (formed by Quw'utsun Elders and their relatives) is restoring the lands around their ancestral village site of Xwaaqw'um, re-introducing acres of wetlands to encourage the return of salmon and renewing the stewardship of their Garry oak (*Quercus garryana*) ecosystems and camas prairies (Stqeeye' Learning Society, n.d.). In all these cases, ancestral relationships with lands, visible in the interlocking presence of archaeological sites and culturally important species, are being revitalized through Indigenous-led reciprocal enactments of restoration and care.

Archaeologists, working with descendant communities and knowledge holders, can help support these forms of resurgence. By engaging in collaborative work, focused on the building of reciprocal and lasting relationships of care and processes of co-learning, the knowledge gained from a better understanding of garden formation and subsequent impacts can help inform best practices for renewing stewardship of estuarine garden sites (or in the building of new gardens, if desired) (Castleden et al., 2021; Dickson-Hoyle et al., 2022). Even when eco-cultural restoration is not immediate, this process can aid in renewing relationships between Peoples, place, and the plants cared for by their ancestors, itself an important element of Indigenous resurgence (Joseph, 2020). Finally, this knowledge, encapsulating deep-time perspectives, landscape-level connectivity, cultural relationships to place and non/other than human beings, and cumulative settler impacts, contributes to the shift towards the re-framing of cultural heritage in British Columbia According to Vanier et al. (2015, p. 505), places of living heritage, when combined with a profound engagement with the communities that created and maintained them, "initiates

[42] E.g., the Pauquachin First Nation clam garden build in July 2025, or the clam garden build hosted by the Swinomish tribe in Washington state in 2023. For more examples, see Chapter 1.

opportunities to enrich archaeological interpretations, engage broader publics, and contribute to powerful conservation goals.” This shift necessitates a re-framing of understandings of heritage and material culture to include the living and non-artifactual elements of a landscape, such as legacy plant communities and cultural soils, as well as an understanding that the relationships that created these elements are ongoing (Kelly et al., 2024; Lepofsky et al., 2020). As such, an archaeological study of these landscapes must include and center Indigenous communities, advocating for and supporting their access to these landscapes and deferring to their desires for their futures.

5.6. Conclusion

The balance of evidence indicates that Indigenous caretaking of estuaries resulted in distinct, identifiable and enduring archaeological, ecological and pedological markers that are still present and quantifiable more than a century after the cessation of active stewardship. However, this evidence is additive–that is, multiple lines of evidence should be pursued to gain a more complete understanding of site formation processes and the history of the place, as well as post-stewardship trajectories. Furthermore, estuarine root garden sites, shaped by overlapping cultural, ecological, climactic, and hydrological factors, need to be considered on a landscape scale. Approaching these places as spatially bounded sites obscures both the connectivity of these places with other nearby cultural features and the distinct cultural, ecological and hydrological processes affecting both the formation of, and impacts to, these gardens. By approaching these as landscapes, we understand them as dynamic, shaped and imbued of meaning by the Peoples who know them and who are shaped by them in return, an essential dialectic process (Johnson & Davidson-Hunt, 2011). Furthermore, the living and persistent nature of these landscapes as legacy ecosystems means that they are places where tangible archaeological heritage and ecological heritage overlap so as to essentially be one and the same. The association of remnant plant communities and cultural soils with archaeological features and sites means that static approaches to cultural management and/or mitigation are insufficient; rather, the continuity of these places as gardens makes them places of living heritage, intrinsically tied to descendant communities’ relationships to place, ancestral foods, knowledge transfer, and the honouring of ancestors (Vanier et al., 2025).

Profound Indigenous stewardship of estuaries is expressed in the building and maintenance of garden structures, the creation of cultural soils, and the preservation of distinct plant communities, as well as the stories and deep knowledge ties to garden sites and responsibilities of care and reciprocity for these places. However, the under-reporting of estuarine root gardens in British Columbia's archaeological record indicates that archaeologists have been slow to catch up to what is now a broader movement towards the re-consideration of Indigenous plant stewardship systems. This under-recording impacts how these places are investigated, limiting potentials for protection under current Heritage and Conservation legislation and the inclusion of these places within ongoing land claim processes. Furthermore, this lack of protection impacts the ability of descent communities to access these places that were shaped by their ancestors, challenging processes of renewal with traditional foods and a return to systems of reciprocal care with land and kin (be they human or otherwise). By helping counter these systems, archaeologists and heritage practitioners can help support Indigenous resurgence, and Indigenous futures.

Chapter 6 – Conclusion: Estuarine root gardens for the future

6.1. Overview of project and critical context

Estuarine root gardens are living archaeological sites, places where elements of tangible Indigenous heritage (such as terracing and cultural soils) overlap with the legacies of stewarded plant communities (in this case, Pacific silverweed (*Argentina egedii (Wormsk.)* Rydb.; syn. *Potentilla pacifica* (L.) Howell), springbank clover (*Trifolium wormskioldii* Lehm) and northern rice-root lily, *Fritillaria camschatcensis* (L.) Ker Gawl). These complex cultural landscapes result from the actions of generations of Indigenous Peoples, caring for and shaping coastal estuarine systems to maximize their access to highly nutritionally and culturally important root crops (Deur, 2000). However, as highly dynamic places, estuaries are also formed through an array of variable ecological, climactic, and hydrological factors, all of which affect estuarine root garden formation processes and preservation after the cessation of active stewardship. These interlocking factors, combined with the long-standing dismissal of Indigenous plant stewardship practices by settler archaeologists and ethnographers in British Columbia, has resulted in the chronic under-representation of estuarine root gardens in the archaeological record, impacting their level of protection under current provincial legislations (i.e., the Heritage and Conservation Act, or HCA) (Lepofsky et al., 2021). Furthermore, the continued use of many of these places after 1846 (the cut-off date for heritage consideration under the HCA) illustrates how care for living heritage and cultural sites is dynamic, ongoing, and tied to the descendant communities that still hold relationships of responsibility and reciprocity for their home territories and the beings that inhabit them (Kelly et al., 2024). As such, these places do not fit within static understandings of heritage in British Columbia, which imagines archaeological sites (spatially bound assemblages of tangible materials, such as stone tools) as belonging to the past. Living archaeological sites–productive and culturally important landscapes that have the potential to still fulfill the functions for which they were built–are links to the future, portal spaces for the revitalization of traditional knowledge and a turning back to inter-generational sharing and stewardship of territories (Sachs et al., 2025; Joseph & Turner, 2020; Vanier et al., 2025). They are places of Indigenous futurity.

With these issues in mind, this research project sought to determine whether specific and replicable archaeological, ecological and pedological indicators could be used to determine the presence of an estuarine root garden, even in cases where exact locations are no longer known by descendant communities, or where more easily discernible material evidence (e.g., visible rock walls) is not available, confounding archaeologists and cultural heritage practitioners. By developing these methods, I also sought to better understand post-stewardship processes, or the ways in which these landscapes have changed since the cessation of active caretaking over the last two centuries. A final area of interest was in trying to determine whether different eco-cultural areas would have associated patterns of difference in the building and maintenance of estuarine gardens, and whether these patterns could be used to aid in the location and study of garden sites in different regions. To answer these questions, I developed a set of inter-disciplinary methods, drawing from known activities associated with traditional estuarine stewardship (e.g., weeding, terracing, etc.) and the potential measurable outcomes of these practices (e.g., simplified plant communities, expanded growing areas with rock/wood walls, chemical alterations to sediments) (see Table 6). To determine the replicability of these methods, two estuarine root gardens were chosen for investigation, one relatively-well documented and still known by descendant communities (the Gwa'ni, or Nimpkish River, estuarine root garden site, in 'Na̲mg̲is Kwakwa̲ka̲'wakw territories) (see Chapter 4) and one no longer known by community, in an area where estuarine root gardens had, to date, not been identified as known sites (in Coast Salish territories, on the archipelago of Tl'chés, or Chatham and Discovery Islands, on Lək̓ʷəŋən Songhees First Nation territory) (see Chapter 3). A final estuarine root garden, Tsinwilht'as (or Anderson) Creek in ʕaaḥuusʔatḥ Nuu-chah-nulth territories, excavated as part of an Archaeological Impact Assessment (AIA), was considered for comparative purposes, helping refine understandings of estuarine root garden formation and typography (see Chapter 5; Stafford, 2020). This site, however, was not visited in person as part of this research process, meaning that the methods discussed above could not be replicated.

6.2. Summary of findings

6.2.1. Ecology

Ultimately, these methods show significant promise. Looking beyond archaeological assemblages, which were present in all sites observed (though in varying ways), plant community composition emerged as indicators of past human occupation and use of estuaries. In the case of estuarine root garden, the dynamic herbaceous plant communities that characterize these places are enduring markers of Indigenous stewardship, though not necessarily in the ways that were expected. Basing myself on studies focusing on longer-lived plant species, such as Pacific crab-apple trees (*Malus fusca*) (see Armstrong et al., 2021; Vanier et al., 2025), or Western redcedar (*Thuja plicata*) (see Trant et al., 2016), I theorized that past caretaking of estuarine root crops, geared toward maximizing the output of these nutritionally and culturally important plants, would have resulted in enduringly dense communities of *A. egedii, T. wormskioldii*, and *F. camschatcensis*. This was the case at the Tl'chés root garden, where the garden site still supports conspicuously dense populations of *T. wormskioldii* in an environment where it has otherwise become sparse or altogether extirpated (Turner, 1999). Here, past caretaking practices, such as soil creation and amendments, selective weeding, and transplanting, resulted in enduring communities of culturally important foods – the living legacies of Lək̓ʷəŋən stewardship. The low-energy estuary in which the garden is located means that external factors, such as regular tidal inundations and sediment deposition/erosion, is limited, likely only impacting the area a few times a year with particularly strong storm surges. As such, ecological equilibrium in the garden, and the prevalence of *T. wormskioldii* (and, to a lesser extent, *A. egedii*, a species that maintains a robust distribution on Tl'chés and was observed at every site) was maintained by Lək̓ʷəŋən Peoples. Declines in these root foods, then, is tied to the cessation of active stewardship over the last century, as well as the decline in freshwater availability on Tl'chés (Nicholas, 2017c). The positive association between human stewardship and *T. wormskioldii* was best captured by the expansion of the population in the estuarine root garden following our excavation and reburying of the roots and rhizomes. This process mimicked traditional stewardship practices (i.e., turning over the soil and removing competing specie, resulting in a dense and blooming plot of *T. wormskioldii*–the first such occurrence observed at the garden site.

By contrast, the Gwa'ni River estuarine root garden displays an ecological trajectory characterized by succession at the garden site itself, with root foods becoming replaced by mid-successional vegetation (such as salt-intolerant graminoids and woody shrubs), while the un-stewarded periphery sites held most of the *A. egedii, T. wormskioldii*, and *F. camschatcensis* populations. This can partly be explained by local ecological and climactic conditions capable of supporting naturally robust populations of these plants, putting them in stark contrast to the more challenging ecological and climactic conditions of the Coast Salish[43]. Furthermore, the dynamic tidal and fluvial processes at the mouth of the estuary, characterized by high flows and the formation of regosols,[44] creates conditions where ecological stability is maintained through natural processes of disturbance (e.g., the frequent deposition and removal of sediments). Comparatively, terracing at the garden site, and the building of cultural soils, created conditions where human disturbance was necessary to maintain stewarded plant populations. With the gradual cessation of active 'Na̲mg̲is stewardship over the last century, root food populations, though still present, have gradually diminished. Though the communities of *A. egedii, T. wormskioldii*, and *F. camschatcensis* at the periphery sites are robust, shallow, unmanaged sediments result in short, gnarled roots and rhizomes, which would have made them an undesirable food source in a context where long, straight roots were prized (Deur, 2000). Here, once again, the importance of considering site specific ecological and cultural factors is crucial in developing our understanding of what these places might look like after active stewardship has ceased.

Though this fine-grained ecological data is lacking from the ʕaaḥuusʔatḥ AIA, the presence of plants such as yarrow and grasses, which were noted in the upper garden site, might be indicative of a similar successional trajectory as noted at the Gwa'ni River estuarine root garden. However, robust *A. egedii* and *T. wormskioldii* populations were observed in that walled

[43] Roughly 85% of estuaries in the Salish Sea have been impacted by settler forms of landscape alterations, in many cases resulting in the partial or complete loss of high marsh habitats preferred by these species, or profound changes to hydrological regimes that would otherwise have supported more robust populations (Janousek, 2024).

[44] Young soils with little or no horizon development, typically found in active fluvial sites characterized by frequent flood events (MacKenzie & Moran, 2004).

areas, with *F. camschatcensis* assumed to be present (but not directly recorded) (Stafford, 2020). Without comparative data and a more thorough ecological inventory, we can only speculate on whether root foot populations at the garden site was statistically more robust than in surrounding, periphery areas. Furthermore, this information is no longer available following the disturbance caused by the AIA, highlighting the importance of conducting ecological surveys early in the assessment process and during seasonally appropriate windows.

Finally, when working in suspected or known stewarded plant growing areas (especially those supporting root foots), archaeologists should make a practice of differentiating between these species and other plants during excavations, setting roots and rhizomes aside to be re-buried afterwards (as was done at Tl'chés, positively impacting the *T. wormskioldii* population). Though this would add time and effort in the initial stages of excavation, it is an opportunity for archaeologists and cultural heritage practitioners to engage with land and descendant communities in a spirit of care and reciprocity. These actions support the ongoing function of these landscapes and the ability of communities to re-connect with them in the future.

6.2.2. Pedology

Ecological signatures of estuarine root stewardship are variable, affected by cultural, hydrological, climactic, and environmental factors. The presence of deep, texturally diverse and organically rich cultural soils, however, has emerged as a defining characteristic of estuarine root gardens, even ones occurring in vastly different eco-cultural and climactic contexts. This feature of estuarine root garden soils has long been recognized, with Kwaxsistalla highlighting the importance of soils that had "a little bit of everything" to ensure productive harvests of root foods (quoted in Deur, 2005, p. 314). This was true for all three estuarine root gardens discussed in this dissertation. These soils are organically rich, dark (approximatively a 10YR on a Munsell chart), loose, uncompacted, and containing remarkably few cobbles and boulders other than those placed there purposefully (i.e., during rock wall construction)[45]. Furthermore, these are

[45] When rocks were observed in estuarine root garden soils, however, a large potion were FAR (fire altered rock), with direct ties to cultural processes (e.g., cooking foods on site). FAR was also used to shore up the inner portions of the estuarine garden rock wall excavated at the Gwa'ni root garden.

deep soils (i.e., 50-60cm in depth, on average), an anomaly in hydrologically active environments that are characterized by frequent depositional and erosional processes. Finally, these soils are as chemically distinct as they are visually identifiable, containing statistically significant heightened levels of available phosphorous (P), long used by archaeologists to identify and delineate areas of human use, occupation and, notably, agriculture (Holliday, 2004; Holliday & Gartner, 2007; Lauer et al., 2013; Wilson et al., 2008; Wilson et al., 2009). The most likely explanation for the concentration of P in these specific areas (and not in adjacent tested areas, despite similarities in hydrological/ecological processes) is that it accumulated due to specific and targeted amendments, such as the addition of fertilizers in the form of fish carcasses and other marine detritus (Deur, 2000; Suttles, 1951; Turner, 1973; Turner & Effrat, 1982). However, P can also concentrate in areas because of human use and occupation; as such, several samples, distributed in different areas of a suspected (or known) estuarine root garden site should be tested to determine both a baseline and site-specific variability. Furthermore, there are rarely hard boundaries to cultural soils; rather, soil characteristics should be understood as existing in a gradient, radiating outwards from centers of human activity (Orozco-Ortiz et al., 2021). As such, testing at regular intervals could be used to determine the approximate boundaries of estuarine stewardship activities. Finally, P, despite being relatively immobile once deposited in soil, will shift downwards over time, accumulating above impermeable basal layers (e.g., fluvial deposits or sterile sand (Zhao et al., 2021). As such, samples from known/suspected estuarine root garden sites should be taken at depth to accurately reflect P contents.

The crux of these findings, however, is that Indigenous Peoples were, and are, *soil builders and creators*. Broadly, the discipline of archaeology tends to conflate archaeological sites with deposition resulting from human-transported materials. This conceptual framework, however, should be expanded to include soils developed *in situ* to support the growth of culturally important plants, themselves a tangible marker of the labour of ancestors (Lowther, 2022). Over decades and centuries, Indigenous Peoples at certain locations transformed the natural sediments of these places, resulting in the creation of rich and productive cultural soils. This is especially clear at estuarine root garden sites.

6.2.3. Archaeology

Archaeological investigations at these estuarine root garden sites highlights the continued presence of material assemblages related to the care and use of these places by Indigenous Peoples. This is most clearly illustrated at the Gwa'ni River and Tsinwilht'as Creek gardens, where linear rock wall features were uncovered beneath layers of turf and sediment accumulated since the cessation of active stewardship. While a basal date for rock wall construction was retrieved from the Tsinwilht'as Creek site (1081-1163 cal BP), timing for cessation of stewardship was harder to pinpoint. At the Gwa'ni River, a basal date could not be determined, though a shaped cedar plank, thought to be an addition to a rock wall structure, was radiocarbon to a median age of 529 cal BP, indicating a much later and continuous use of place, which was still visited regularly into the early 20th century, as remembered by still living elders (such as *Ninogaad*[46] Mayanilth, Daisy Sewid-Smith, whose mother was born in one of the digging houses) (Deur, 2000). The continued use of the tidal island by 'Na̲mg̲is Peoples as an autumnal fishing site, which likely began in earnest after the community's move to Alert Bay in the 1860's and 1870's, meant a transition in primary use of the small village site (Ham, 1980). However, occupation of the village would have coincided with fall harvesting times for estuarine root foods, making it likely that peoples were still stewarding smaller garden plots, though in a much-reduced capacity (Deur, 2000). It is likely that the garden area that I excavated (which contained the cedar plank) was one of these later additions, since it does not seem to align with Boas' (1934, map 21) representation of the garden plots[47]. As noted previously, continuous use of estuarine root gardens complicates their position as archaeological sites under current HCA legislation, which dictates that a site must be conclusively shown to pre-date 1846 for consideration. However, more recent use does not negate antiquity; rather, it highlights the importance of these places to the Peoples who continued to return and care for them, despite the severe disruptions of colonialism on their traditional food systems and abilities to access home territories.

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[46] Knowledge holder in Kwak'wala, the language of the Kwakwa̲ka̲'wakw Peoples.

[47] Another (likely, but not mutually exclusive) explanation is that Boas' (1934, map 21) interpretation of the island was more conceptual than geographically accurate.

Unlike the Gwa'ni River and Tsinwilht'as Creek gardens, known forms of material culture associated with the stewardship of these places (e.g., rock walls) were more elusive at the Tl'chés estuarine root garden site. However, rather than representing a lesser (or lack of) human engagement with place, I theorize that this reflects local ecological and hydrological site conditions. Indeed, in the low energy tidal estuary where the garden is located, dense and waterlogged coastal sediment would have served as an erosional barrier, making the construction of a rock wall redundant. This highly organic sediment is a common occurrence on the shores of Tl'chés; however, at the estuarine root garden site, its width was remarkably consistent (roughly one meter throughout) and comparatively narrow when contrasted to the periphery sites, which are characterized by a deep sediment bench[48] and a narrow high marsh ecosystem. Though this might be related to the location of the estuarine root garden site in relation to the tidal mouth of the bay (on the western edge, and relatively protected by a gravelly berm), I speculate that Lək̓ʷəŋən Peoples worked more inland portions of this sediment, breaking it down and mixing it with other materials to increase the size of the garden. This speculation is bolstered by the abrupt transition from dense sediment to loose garden soil, and anomaly amongst all the sites tested on Tl'chés. However, more work is needed to support this hypothesis, and to determine whether it is representative of a broader pattern of coastal stewardship in the region.

Overall, the non-diagnostic nature of the archaeological assemblage at the Tl'chés estuarine root garden highlights the importance of engaging with multiple forms of evidence when evaluating potentially Indigenously stewarded food growing landscapes. Here, a unique ecological assemblage (characterized by the enduring and dense presence of *T. wormskioldii*) and cultural soils present as strong evidence of estuarine root food stewardship, despite the absence of rock walls or digging stick fragments. These living, measurable legacies of Lək̓ʷəŋən stewardship represent a material and tangible heritage, one which should be equally considered in our study and evaluation of cultural landscapes in British Columbia. Indeed, the archaeological findings at Tl'chés may be more representative of estuarine root gardens in general, with many of the most productive gardens being in large, deltaic estuaries, discounting

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[48] This dense, organic and waterlogged sediment supports a much smaller number of species than those found in high marsh ecosystems–primarily, sea asparagus (*Salicornia pacifica*) and salt grass (*Distichlis spicata*)

the need for anthropogenic terracing (e.g., the Kingcome Inlet estuarine root garden and the Somass River estuarine root garden).

6.3. Regional differences in estuarine root garden formation and stewardship

Overall, the areas considered as part of this doctoral project consisted of two estuarine root gardens studied in person, with the addition of Stafford's (2020) AIA and the three other estuarine root gardens listed on the British Columbian Remote Archive for Archaeological Data (or RAAD). This sample size is too small to conclusively identify regional and cultural variations in estuarine root garden formation and stewardship. With the Tl'chés estuarine root garden being the first such site to be identified in the Coast Salish, more southern site types and formation remain elusive and largely speculative. However, one inference that can be made is that the size and dynamism of estuaries play an important role in estuarine root garden location, formation, and post-stewardship trajectories. The dynamic nature of the Gwa'ni River, for example, combined with strong tidal flows, made soil mounding and retention through rock wall structures necessary in garden building and expansion, resulting in the creation of an anthropogenically elevated island. Comparatively, the estuarine root garden at Kingcome Inlet that Kwaxsistalla grew up caring for is in a large, deltaic tidal marsh, with ideal natural conditions for estuarine root food growth. Though conditions were further improved through fertilizing, mounding cultural soils, weeding, and other forms of stewardship, intensive anthropogenic modifications (e.g., terracing) were not necessary. Here, a parallel can be drawn to sea gardens; while some locations required the building of rock walls to expand the ideal growth area for shellfish, others required less active anthropogenic alterations to make them productive, though they were still actively cared for (e.g., aerating of the sediment during harvest, replanting of spat). These places are no less Indigenously stewarded landscapes.

Following the inference that estuarine root gardens formation processes result, in part, from local hydrological and geomorphological conditions, it is likely that estuarine gardens in the Coast Salish were smaller in scale. With key exceptions (e.g., SELEȻTEȽ, the Goldstream estuary, which is a known estuarine root foods harvesting site and likely estuarine root garden– see Turner & Bell, 1971, p.), estuaries on southern Vancouver Island and the Gulf Islands, and extending into Washington State (e.g., the San Juan Islands) are small, often fed by seasonally flowing streams, affecting the hydrological conditions of these places (Brophy et al., 2019). Furthermore, though *T. wormskioldii* and *A. egedii* were known and valued foods in the Coast Salish, the nutritional niche that these plants filled in more northern territories (as an important source of carbohydrates and starches) was filled locally by *kwetlal* (*Camassia quamash* and *Camassia leichtlinii*), which was grown in large quantities and traded with more northern neighbours whose territories did not support large productions of these plants (Beckwith, 2004; Lyons et al., 2021; Turner & Kuhnlein, 1982, 1983). As such, estuarine root garden construction is unlikely to have been as intensive as in the north, making these places harder to discern.

Difficulties associated with locating estuarine root gardens in the Coast Salish have been exacerbated by relatively early settler intrusion and occupation, resulting in early reshaping of communities, land expropriation, and the alteration of traditional territories (Boyd, 1990, 1994; Duff, 1969; Lutz, 2010). Today, much of the population of British Columbia is concentrated on its southern coast, making a place like Tl'chés–uninhabited and relatively unaltered by settler impacts–a rare exceptions, and a uniquely important source of knowledge about the ways in which Lək̓ʷəŋən Peoples engaged with and shaped their homelands, with lessons for the future. For Səƚƚəmah, Tl'chés has always been a place of learning, somewhere for youth to re-connect with their home and traditions and foods, and learn how to care for, and live from, the land (pers. com., 2021). However, the resilience of Tl'chés as a cultural landscape is sharply contrasted to nearby and adjacent Lək̓ʷəŋən territories, which have seen the expansion of major settler populations in the city of Victoria and nearby municipalities. Throughout the Coast Salish, extensive and ongoing settler expropriation of estuaries and coastal areas has led to the extensive disruption (and, in some cases, destruction) of these systems, affecting the survival of potential archaeological materials and legacy plant communities (Brophy et al., 2019; Robb, 2014). Thus, expanding on this work will necessitate looking at more potential sites of Coast Salish estuarine root garden cultivation, working with communities to identify both areas of high potential and priorities surrounding renewing caretaking practices and growing estuarine and coastal resiliency in a climatically uncertain future. This work is already underway.

6.4. Implications of this research

The ecological, pedological and archaeological legacies of estuarine root gardens represent a living heritage that remains poorly understood and under-represented within the archaeological record of British Columbia. Living archaeological sites and ecological heritage blur the categorical and temporal boundaries of archaeological research while centering the importance of profound and collaborative engagement with the Indigenous communities to which these places belong. Furthermore, the ongoing relationships that Indigenous Peoples have with these places–relationships that long predate settler intrusions onto territories and will outlive them–pushes back against 1846 as the arbitrary cut-off date for heritage protection under the HCA; rather, use and care for living heritage and cultural sites is dynamic, ongoing, and tied to the descendant communities that still hold relationships of responsibility and care for their home territories and the beings that inhabit them. As such, this work, and others like it (i.e., Armstrong et al., 2021; Letham et al., 2023; Vanier et al., 2025) is part of a movement towards a reframing of archaeology in British Columbia, pushing back against ascribed boundaries that do not accurately reflect or reflect Indigenous Peoples' relationships with, or concerns about, their territories and places of cultural heritage. Indeed, heritage work in British Columbia too often continues to occur with minimal engagement with the communities to which this heritage belongs, representing not only a failure in ethical conduct, but a legal breach.

As signatories of the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP), Canada has a responsibility to support Indigenous Peoples in determining the future of their places of heritage and in revitalizing their customs.[49] As such, engaging with living heritage and living archaeological sites, developing better methodological approaches to identify and protect these places, and advocating for their futures through community-driven eco-cultural restoration projects, is a key element of engaging in more ethical archaeological practice that is aligned with International legal obligations. Furthermore, the inclusion of more food stewardship places into the archaeological record of British Columbia has implications for Aboriginal rights

[49] E.g., Article 11.1.– Indigenous peoples have the right to practise and revitalize their cultural traditions and customs. This includes the right to maintain, protect and develop the past, present and future manifestations of their cultures, such as archaeological and historical sites, artefacts, designs, ceremonies, technologies and visual and performing arts and literature.

and title proceedings. As stated in Chapter 1, most Indigenous Peoples in British Columbia never officially ceded their lands to the crown through the signing of treaties; as such, Nations today, seeking to have their claims over their traditional territories recognized within colonial legal systems, are presenting cases to provincial and federal legislative bodies (e.g., the Supreme Court). Here, archaeological evidence can be used as proof for historical and ongoing use and occupation of territories. Indeed, in Delgamuukw v. British Columbia (1997) and Tsilhqot'in Nation v. British Columbia (2014), the Supreme Court of Canada established that Aboriginal title requires demonstration of sufficient, continuous and exclusive sovereignty over territory. Archaeological evidence has been recognized by the courts as a primary means of establishing this occupation, with Lax Kw'alaams Indian Band v. Canada (2011) affirming that tangible objects recovered from surveys can produce information about the society that occupied the lands from which they were uncovered. Estuarine root gardens contribute to this evidentiary framework in specific and meaningful ways. The intensive and site-specific nature of garden stewardship–involving the creation of cultural soils, the delineation of named, individual plots governed through chiefly tenure systems, and the inter-generational sharing of knowledge and responsibility–speaks directly to the legal threshold of sufficiency and exclusivity. These are not incidental or transient uses of land: they are, in the words of the Court in Tsilhqot'in, the kind of "regular and exclusive" engagement with specific places that ground territorial claims. Furthermore, the enduring physical signatures of this stewardship, including cultural soils, legacy plant communities, and (in some cases) built, architectural features provide the kind of tangible, datable, and spatially bounded evidence that courts have found persuasive. The under-representation of estuarine root gardens in the archaeological record, as such, has direct legal consequences. Places that could contribute to demonstrating the depth and exclusivity of Indigenous territorial relationships remain invisible to the evidentiary framework that courts rely on. Increasing the identification and formal recording of these sites will not only improve best archaeological practice; it will also directly contribute to the material conditions under which Nations can assert and have recognized their rights to their home territories.

Currently, British Columbia is going through its Heritage Conservation Act transformation project, the first time the HCA has been amended since 1996. Its stated purpose is to bring the HCA in line with UNDRP and the provincial Declaration on the Rights of

Indigenous Peoples Act, with the province committing to "work with First Nations to reform the Heritage Conservation Act […] including shared decision-making and the protection of First Nations cultural, spiritual, and heritage sites, and objects" (Legislative Assembly of British Columbia, 2019, Action 4.35). Though outcomes to this are yet to be determined, Indigenous Peoples should have more of a say about what happens to their culturally important landscapes, and that conceptions of heritage should be shifted to include living and legacy ecosystems and less easily categorized tangible markers of use and care. It is my hope that this work can be a small, supportive element in this process.[50]

Finally, as stated earlier, many communities are turning to the eco-cultural revitalization of their landscapes and traditional food producing systems. This process is a key element of re-inserting Indigenous food sovereignty and revitalizing cultural practices, renewing and re-engaging in relationships of reciprocity and care with land and relatives (human and otherwise) (Corntassel & Bryce, 2012; Joseph & Turner, 2020). Advocating for an Indigenous-led and food systems focus restoration of estuaries is a diversion from the dominant western science and settler-led restoration work that is currently occurring in many of these systems, with its emphasis on low-marsh vegetation (primarily to provide habitat for salmonids. Though important, high and mid marsh habitats, and the food systems they contain/could once again provide, are often forgotten during these projects, leading to their ongoing "squeeze" (from changing hydrological pressures and encroaching anthropogenic development/ecological changes).

Though the work described in this paper was aimed at a better understanding of traditional estuarine root garden formation and stewardship, it could also be used in the restoration (or entirely new build) of estuarine root gardens, increasing not only access to important traditional foods, but the ecological complexity of these systems. As Sachs et al. (2025, p. 69) remind us, understanding pre-colonial baselines is key to setting restoration goals

[50] As of the submission of this dissertation, the Heritage Conservation Act transformation project has been paused indefinitely by the BC government. According to a statement released by the Ministry of Forests on January 19, 2026, this was done to "continue engagement to gather and incorporate additional feedback from industry, local governments and First Nations" (Continuing engagement for Heritage Conservation Act).

that are “culturally, ecologically, and historically grounded” while helping fill gaps in oral histories. As outline in Figure 7, engagements between Western scientific frameworks and Indigenous resurgence (as expressed in stewarded foods systems) can be generative and supportive of community goals, helping inform restoration work that is rounded in Indigenous futurity. However, to do so, relationships of relationality and reciprocity need to be at the core of this work, with care put into not replicating colonial forms of extraction and incorporation (both material and intellectual).

6.5. Estuarine root gardens for the future

The future of this work is inter-disciplinary, much like the methods employed during this research. Within the cultural heritage sector, this work represents an invitation to archaeologists and practitioners to engage more fully with places of plant stewardship, diversifying methodological approaches to include seasonally appropriate and thorough ecological surveys that capture the differences (and similarities) in community structures between known/suspected estuarine root gardens and nearby, ecologically and hydrologically similar areas (e.g., periphery sites). Doing this will expand understandings of the ways in which these places have changed over the last century and a half and how these changes express themselves in differing eco-cultural settings, aiding in the identification of these places in the future. Additionally, archaeological excavations of these places, whenever possible, should occur in ways that minimize harm to legacy plant communities and help ensure their continued presence on the landscape, with future stewardship and harvests in mind. This might include excavating in the early fall (the traditional harvesting period for estuary root gardens), when community could be involved in harvesting. In cases where future disruptions to site are not anticipated, roots and rhizomes of plant foods should be removed and replanted post excavation, giving the garden the opportunity to regenerate in conditions that would mimic traditional stewardship (e.g., turning over soils and the removal of non-food species).

As places of Indigenous futurity–places of renewal, food sovereignty, inter-generational sharing, ceremony, and cultural revitalization–estuaries weave together the tangible and intangible elements of cultural heritage. These are not places that can be easily bound or categorized as "sites;" rather, they are illustrative of the varied and inter-related ways in which these landscapes were cared for, both in terms of scale and temporality. This expansive approach to cultural landscapes emphasizes the importance of a methodological approache grounded in reciprocal relationships with descendant communities and place, with consideration to the ways in which these places (and their associated relationships) have changed over time.

Ultimately, this work is about the future. Today, most estuaries in coastal British Columbia have been altered in some capacity by cumulative colonial impacts, resulting in a range of impacts to ecological and hydrological conditions. These alterations occur on a spectrum, from more localized impacts to specific areas (e.g., sedimentation changes due to logging practices) to large-scale disruptions (e.g., land reclamation projects). Though restorative work is occurring today in some of these areas (e.g., the Quw'utsun/Xwulqw'selu estuary restoration work led by Cowichan Tribes), future disruptions caused by anthropogenic climate change and relative sea level rise are anticipated. Indeed, by some estimates,[51] 86-100% of present tidal estuaries could be submerged by the end of the century, with high to mid marsh habitats transitioning to low marsh. The ability of these estuaries to horizontally migrate will depend largely on ongoing sediment accretion (which has decreased due to human modification of watersheds) and available terrain (Thorne et al., 2018). This represents a crucial loss in habitat, storm surge protection to coastlines, and culturally important landscapes. Within this context, the eco-cultural restoration of estuaries as places of food stewardship needs to account for projected changes to shorelines and how this will affect high and mid-marsh vegetation. This work is daunting. It will take all of us. It is also possible, and important, and necessary. Estuaries, the foods they contain, and the relationships of reciprocity that they foreground, have existed since time immemorial, and will continue to exist long after we are gone.

6.6. Afterword–reflections on a process

I began this work with very little understanding of what working with, and for, Indigenous communities can mean. This led to me making many mistakes. If I were to start this project over

[51] According to Thorne et al., (2018), estimated projections for average sea level rise on the Pacific Coast of North America range between 0.15-1.6m over the next century.

today, I know that I would approach it completely differently. I would engage more fully in community from the get-go. I would let the project be shaped by relationships and conversations, not pre-set ideas and assumptions. I would ensure that the project, and its deliverables, were more specifically tailored to stated desires and needs in community. I would, in other words, actually engage in community led work. Though I shaped this project with the best of intentions, and a genuine desire to be of service, my approach was couched in western scientific ways of knowing, where I could benefit from my proximity to institutions (i.e., the university) to access Indigenous lands and knowledge systems without a clear path for true collaboration. Though it is true that engaging in research in the context of a global pandemic had a profound impact, it is also true that I could have, and should have, done more.

In the last almost decade of my life since I began this project, I have learned a lot, or, rather, I've been taught a lot. These lessons–shared to me by community, by friends and collaborators, by peoples that patiently showed me how to begin to dis-entangle myself from ingrained colonial systems, to show up with humility and openness and a genuine desire to learn–have been the gift of my life. Today, I know that I would do this project differently, because I am doing it differently. It will always be imperfect, but it's a start.

Hay'sxw'qa si'em. Gila'kasla. ʔuušy̓akšiƛeʔic. Merci. Thank you.

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Appendix

1. Species assemblages

1.1. Gwa'ni (Nimpkish) River estuary – Ecological inventory

1.1.1. Gwa'ni (Nimpkish) River root garden

Gwa'ni (Nimpkish) Estuarine Root Garden – Species Assemblage			
Species name (Latin)	**Code**	**Species name (common)**	**Non-Native/Introduced (X)**
Achillea millefolium	ACMI	Yarrow	
Argentina egedii ssp. Pacifica	POAN	Pacific silverweed	
Athyrium filix-femina	ATFI	Lady fern	
Carex lyngbyei	CALY	Lyngby's sedge	
Claytonia sibirica	CLSI	Siberian miner's lettuce	
Dodecatheon pulchellum	DOPU	Dark-throat shooting star	
Equisetum arvense	EQAR	Common horsetail	
Erythranthe guttata	ERGU	Seep monkeyflower	
Galium aparine	GAAP	Cleavers	
Malus fusca	MAFU	Pacific crabapple	
Myrica gale	MYGA	Bog myrtle	
Oenanthe sarmentosa	OESA	Water parsley	
Plantago lanceolata	PLLA	English plantain	X
Ranunculus occidentalis	RAOC	Western buttercup	
Ribes sanguineum	RISA	Red flowering currant	
Rumex occidentalis	RUOC	Western dock	X
Trifolium wormskioldii	TRWO	Springbank clover	
Juncus effusus	JUEF	Common rush	
Veronica scutellata	VESC	Marsh speedwell	X

1.1.2. Gwa'ni (Nimpkish) River Periphery Site 1 (PS1)

Gwa'ni PS1 – Species Assemblage			
Species name (Latin)	**Code**	**Species name (common)**	**Non-Native/Introduced (X)**
Achillea millefolium	ACMI	Yarrow	
Argentina egedii ssp. Pacifica	POAN	Pacific silverweed	
Carex lyngbyei	CALY	Lyngby's sedge	
Claytonia sibirica	CLSI	Siberian miner's lettuce	
Dodecatheon pulchellum	DOPU	Dark-throat shooting star	
Equisetum arvense	EQAR	Common horsetail	
Fritillaria camschatcensis	FRCA	Northern riceroot lily	
Galium aparine	GAAP	Cleavers	

Maianthemum dilatatum	MADI	False lily-of-the-valley	
Malus fusca	MAFU	Pacific crabapple	
Montia parvifolia	MOPA	Small-leaved montia	
Myrica gale	MYGA	Bog myrtle	
Oenanthe sarmentosa	OESA	Water parsley	
Plantago lanceolata	PLLA	English plantain	
Plantago major	PLMA	Broadleaf plantain	
Pyrola asarifolia	PYAS	Bog wintergreen	
Ranunculus occidentalis	RAOC	Western buttercup	
Ranunculus repens	RARE	Creeping buttercup	X
Triglochin maritimum	TRMA	Sea arrow-grass	
Trifolium wormskioldii	TRWO	Springbank clover	
Juncus effusus	JUEF	Common rush	

1.1.3. Gwa'ni (Nimpkish) River Periphery Site 2 (PS2)

Gwa'ni (Nimpkish) Periphery Site 2 (PS2) – Species Assemblage			
Species name (Latin)	**Code**	**Species name (common)**	**Non-Native/Introduced (X)**
Achillea millefolium	ACMI	Yarrow	
Argentina egedii ssp. Pacifica	POAN	Pacific silverweed	
Carex lyngbyei	CALY	Lyngby's sedge	
Castilleja hispida	CAHI	Harsh paintbrush	
Claytonia sibirica	CLSI	Siberian miner's lettuce	
Dactylis glomerata	DAGL	Orchard grass	X
Dodecatheon pulchellum	DOPU	Dark-throat shooting star	
Equisetum arvense	EQAR	Common horsetail	
Fritillaria camschatcensis	FRCA	Northern riceroot lily	
Galium aparine	GAAP	Cleavers	
Glaux maritima	GLMA	Sea milk-worth	
Heracleum lanatum	HELA	Cow parsnip	
Lonireca involucrata	LOIN	Black twinberry	
Myrica gale	MYGA	Bog myrtle	
Oenanthe sarmentosa	OESA	Water parsley	
Plantago macrocarpa	PLMA	Alaska plantain	
Poa compressa	POCO	Canadian bluegrass	
Pyrola asarifolia	PYAS	Bog wintergreen	
Ranunculus occidentalis	RAOC	Western buttercup	
Trifolium wormskioldii	TRWO	Springbank clover	
Juncus effusus	JUEF	Common rush	

1.2. Tl'chés ecological inventory

1.2.1. Tl'chés Periphery Site 1 (PS1)

Tl'chés Periphery Site 1 (PS1) – Species Assemblage			
Species name (Latin)	**Code**	**Species name (common)**	**Non-Native/Introduced (X)**
Anthoxanthum odoratum	ANOD	Sweet vernal grass	
Argentina egedii ssp. Pacifica	POAN	Pacific silverweed	
Atriplex prostrata	ATPR	Creeping saltbrush	X
Distichlis spicata	DISP	Salt grass	
Elymus mollis	ELMO	Dune wildrye	
Epilobium ciliatum	EPCI	Purple-leaved willowherb	
Galium aparine	GAAP	Cleavers	
Grindelia intergrifolia	GRIN	Entire-leaved gumweed	
Hedera helix	HEHE	English ivy	X
Holcus lanatus	HOLA	Velvet grass	X
Juncus balticus	JUBA	Baltic rush	
Lathyrus japonicus	LAJA	Beach pea	X
Plantago maritima	PLMA	Seaside plantain	
Prunus domestica	PRDO	Victoria plum	X
Rubus armeniacus	RUAR	Himalayan blackberry	X
Rumex crispus	RUCR	Curled dock	X
Salicornia pacifica	SAPA	Sea asparagus	
Triglochin maritima	TRMA	Seaside arrowgrass	
Trifolium wormskioldii	TRWO	Springbank clover	
Vulpia bromoides	VUBR	Barren fescue	X

1.2.2. Tl'chés Periphery Site 2 (PS2)

Tl'chés Periphery Site 2 (PS2) – Species Assemblage			
Species name (Latin)	**Code**	**Species name (common)**	**Non-Native/Introduced (X)**
Anthoxanthum odoratum	ANOD	Sweet vernal grass	X
Argentina egedii ssp. Pacifica	POAN	Pacific silverweed	
Atriplex prostrata	ATPR	Creeping saltbrush	X
Bromus hordeaceus	BRHO	Soft brome	X
Cuscuta maritima	CUMA	Saltmarsh dodders	X
Distichlis spicata	DISP	Salt grass	
Epilobium augustifolium	EPAU	Fireweed	
Festuca rubra	FERU	Red fescue	
Galium aparine	GAAP	Cleavers	
Grindelia intergrifolia	GRIN	Entire-leaved gumweed	

Hordeum brachyantherum	HOBR	Meadow barley	
Hypochoeris radicata	HYRA	Cat's ear	X
Juncus balticus	JUBA	Baltic rush	
Maianthemum dilatatum	MADI	False lily-of-the-valley	
Plantago elongata	PLEL	Slender plantain	
Plantago maritima	PLMA	Seaside plantain	
Poa pratensis	POPR	Kentucky bluegrass	X
Prunus domestica	PRDO	Victoria plum	X
Salicornia pacifica	SAPA	Sea asparagus	
Sonchus arvensis	SOAR	Perennial sow thistle	X
Trifolium wormskioldii	TRWO	Springbank clover	
Triglochin maritima	TRMA	Seaside arrowgrass	
Vicia gigantea	VIGI	Giant vetch	

1.2.3. Tl'chés Periphery Site 3 (PS3)

Tl'chés Periphery Site 3 (PS3) – Species Assemblage			
Species name (Latin)	**Code**	**Species name (common)**	**Non-Native/Introduced (X)**
Achilllea millefolium	ACMI	Yarrow	
Acmispon americanus	ACAM	Spanish clover	
Agropyron repens	AGRE	Quackgrass	X
Agrostis stolonifera	AGST	Creeping bent grass	X
Anthoxanthum odoratum	ANOD	Sweet vernal grass	
Argentina egedii ssp. Pacifica	POAN	Pacific silverweed	
Atriplex prostrata	ATPR	Creeping saltbrush	X
Bromus hordeaceus	BRHO	Soft brome	X
Cuscuta maritima	CUMA	Saltmarsh dodders	X
Cynosurus echinatus	CYEC	Hedgehog dogtail	X
Distichlis spicata	DISP	Salt grass	
Festuca rubra	FERU	Red fescue	
Grindelia intergrifolia	GRIIN	Entire-leaved gumweed	
Holcus lanatus	HOLA	Velvet grass	X
Hordeum brachyantherum	HOBR	Meadow barley	
Hypochoeris radicata	HYRA	Cat's ear	X
Juncus balticus	JUBA	Baltic rush	
Lathyrus japonicus	LAJA	Beach pea	
Prunus domestica	PRDO	Victoria plum	X
Rubus armeniacus	RUAR	Himalayan blackberry	X
Rumex acetosella	RUAC	Sheep sorrel	X
Rumex crispus	RUCR	Curled dock	X

Salicornia pacifica	SAPA	Sea asparagus	
Triglochin maritima	TRMA	Seaside arrowgrass	
Vicia americana	VIAM	American vetch	
Vulpia myuros	VUMY	Rattail fescue	X

1.2.4. Tl'chés estuary root garden

Tl'chés Estuarine Root Garden – Species Assemblage				
Species name (Latin)	**Code**	**Species name (common)**	**Percent cover (%)**	**Non-Native/Introduced (X)**
Anthoxanthum odoratum	ANOD	Sweet vernal grass	0.25	
Argentina egedii ssp. Pacifica	POAN	Pacific silverweed		
Atriplex prostrata	ATPR	Creeping saltbrush		X
Distichlis spicata	DISP	Salt grass		
Elymus mollis	ELMO	Dune wildrye		
Epilobium ciliatum	EPCI	Purple-leaved willowherb		
Galium aparine	GAAP	Cleavers		
Grindelia intergrifolia	GRIN	Entire-leaved gumweed		
Hedera helix	HEHE	English ivy		X
Holcus lanatus	HOLA	Velvet grass		X
Juncus balticus	JUBA	Baltic rush		
Lathyrus japonicus	LAPO	Beach pea		X
Plantago maritima	PLMA	Seaside plantain		
Prunus domestica	PRDO	Victoria plum		X
Rubus armeniacus	RUAR	Himalayan blackberry		X
Rumex crispus	RUCR	Curled dock		X
Salicornia pacifica	SAPA	Sea asparagus		
Triglochin maritima	TRMA	Seaside arrowgrass		
Trifolium wormskioldii	TRWO	Springbank clover		
Vulpia bromoides	VUBR	Barren fescue		X
	Other			
Driftwood				

1.0 Gwa'ni (Nimpkish) River estuary: Soil analysis results

1.1.Gwa'ni (Nimpkish) River estuarine root garden (NRG)

Gwa'ni/Nimpkish River Estuarine Root Garden (NRG) – Soil Analysis Results																	
Sample ID	**Method**	Elemental analysis via combustion			Manual meter		KCI Extraction, colometric		Muffle furnace LOI	Bray P-1 Extraction, UV	CEC and Cations via BaCl2 Extraction, ICP-OES						
	Element	N	C	S	pH (1:2, soil:$CaCl_2$)	EC (1:2 soil:water)	Available NH_4 (N)	Available NO_3 (N)		Available P	Exchangeable (E) Al	E Ca	E Fe	E K	E Mg	E Mn	E Na	Effective CEC
	Units	%	%	%	pH Units	mS/cm	mg/kg	mg/kg	%	mg/kg	cmol+/kg	cmol+/kg	cmol+/kg	cmol+/kg	cmol+/kg	cmol+/kg	cmol+/kg	cmol+/kg
	Estimated DL	0.01	0.01	0.01	0.1	0.05	0.1	0.1	0.1	1	0.4	0.3	0.1	0.07	0.001	0.05	0.08	
NRG - 1		2.4	42	0.39	NS	NS	9.1	130	78	14	0.26	36	0.049	0.7	41	0.16	6.3	84
NRG - 2		2.1	35	0.3	5.1	NS	10	130	67	18	0.23	31	0.046	0.57	34	0.17	4.1	70
NRG - 3		1.1	16	0.25	5	0.79	5.8	14	31	17	<DL	8.9	<DL	0.65	10	<DL	2.2	22
NRG - 4		1.3	22	0.4	4.9	0.55	5	1.1	38	4.2	0.55	10	0.065	0.79	11	<DL	2.2	25
NRG - 5		0.93	15	0.31	4.8	0.56	1.3	0.23	24	150	0.58	5.1	0.042	0.4	6	<DL	2.1	14
NRGU1 - 1		0.94	16	0.34	4.8	2.9	25	<DL	24	130	0.68	4.6	0.055	0.46	5.6	<DL	5.7	17
NRGU2 - 2		1	17	0.34	4.8	0.58	5.3	0.69	33	190	0.55	7.7	0.094	0.34	7.9	<DL	1.3	18

Gwa'ni/Nimpkish River Estuarine Root Garden (NRG) – Soil Analysis Results (Cont.)																					
Sample ID	**Method**	Metals via Acid (Microwave) Digestion - ICP-MS Analysis																			
	Element	Ag	Al	As	B	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	Hg	K	Mg	Mn	Mo	Na	Ni	P
	Units	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	Mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
	Estimated DL	0.05	10	0.01	10	1	0.06	10	0.02	0.02	2	1	5	0.03	20	5	1	0.5	20	0.2	5
NRG - 1		<DL	7,800	2.3	18	8.3	0.069	10,000	0.11	9	13	52	11,000	0.15	410	7,000	530	2.2	1,300	13	1,700
NRG - 2		<DL	11,000	1.9	14	9.5	0.096	12,000	0.13	9.5	25	38	14,000	0.14	420	7,100	450	1.6	960	21	1,400
NRG - 3		<DL	16,000	1.2	<DL	13	0.095	14,000	0.075	9.5	40	26	18,000	0.11	540	6,200	240	<DL	640	29	1,200
NRG - 4		0.069	14,000	1	<DL	16	0.075	13,000	0.098	8.4	19	29	13,000	0.24	570	4,400	180	0.5	600	14	1,600
NRG - 5		0.079	20,000	1.1	<DL	16	0.092	19,000	0.11	11	25	37	21,000	0.24	400	6,500	280	<DL	640	23	2,200
NRGU1 - 1		0.19	19,000	1.4	<DL	27	<DL	18,000	0.35	13	22	50	20,000	0.45	470	6,100	250	<DL	1,300	23	3,400
NRGU2 - 2		0.17	17,000	1.5	<DL	19	0.12	18,000	0.46	28	28	42	18,000	0.52	440	5,700	230	<DL	520	27	3,300

Gwa'ni/Nimpkish River Estuarine Root Garden (NRG) – Soil Analysis Results (Cont.)													
Sample ID	**Method**	Metals via Acid (Microwave) Digestion - ICP-MS Analysis								Compaction	Volumetric water content	Temperature	Bulk electrical conductivity
	Element	Pb	S	Se	Sn	Sr	U	V	Zn				
	Units	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	psi	%	°C	dS/m
	Estimated DL	0.05	500	0.1	0.01	0.1	0.01	0.5	1				

NRG - 1		67	3,600	0.62	0.2	130	12	30	22	0	49.8	16.6	0.28
NRG - 2		32	2,900	0.49	0.44	130	7.6	46	21	0	47	16.6	0.25
NRG - 3		18	2,600	0.22	0.59	90	2.4	65	24	0.5	57.9	15.4	0.24
NRG - 4		18	3,500	0.35	0.57	87	2.4	57	20	0	55.7	14.8	0.2
NRG - 5		11	2,500	0.43	0.77	110	1.9	70	31	0	32.5	15.1	0.1
NRGU1 - 1		7.6	3,400	0.99	0.65	99	2.1	68	35	N/A	N/A	N/A	N/A
NRGU2 - 2		14	3,300	0.78	0.58	110	2.4	70	46	N/A	N/A	N/A	N/A

1.2. Gwa'ni (Nimpkish) River estuarine root garden (NRG) Periphery Site 1 (PS1)

Gwa'ni/Nimpkish River Estuarine Root Garden (NRG) Periphery Site 1 (PS1) – Soil Analysis Results

Sample ID	**Method**	Elemental analysis via combustion			Manual meter		KCI Extraction, colometric		Muffle furnace LOI	Bray P-1 Extraction, UV	CEC and Cations via BaCl2 Extraction, ICP-OES							
	Element	N	C	S	pH (1:2, soil:$CaCl_2$)	EC (1:2 soil:water)	Available NH_4 (N)	Available NO_3 (N)		Available P	Exchangeable (E) Al	E Ca	E Fe	E K	E Mg	E Mn	E Na	Effective CEC
	Units	%	%	%	pH Units	mS/cm	mg/kg	mg/kg	%	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	cmol+/kg
	Estimated DL	0.01	0.01	0.01	0.1	0.05	0.1	0.1	0.1	1	0.2	0.25	0.04	0.03	0.01	0.04	0.09	
NRGPS1-1		0.23	2.9	<DL	5	0.18	3.2	2.3	5.7	6	0.22	1.5	<DL	0.16	2.2	<DL	0.61	4.8
NRGPS1-2		0.23	2.7	<DL	5.3	0.15	1.3	9.6	6	9.5	<DL	3.2	<DL	0.12	3.4	<DL	0.47	7.3
NRGPS1-3		0.71	10	0.16	4.9	0.32	1.7	2.3	15	7.3	0.32	4.1	<DL	0.32	5.1	<DL	0.9	11
NRGPS1-4		0.7	10	0.18	5.1	0.34	2.5	5.7	17	7.8	0.25	3.8	<DL	0.31	5.6	<DL	1.3	11
NRGPS1-5		1.2	17	0.22	5.3	0.47	5.1	35	23	4.4	<DL	10	<DL	0.4	10	<DL	1.2	22

Gwa'ni/Nimpkish River Estuarine Root Garden (NRG) PS1 – Soil Analysis Results (Cont.)

Sample ID	**Method**	Metals via Acid (Microwave) Digestion - ICP-MS Analysis																			
	Element	Ag	Al	As	B	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	Hg	K	Mg	Mn	Mo	Na	Ni	P
	Units	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
	Estimated DL	0.05	10	0.01	10	1	0.06	10	0.02	0.02	2	1	5	0.03	20	5	1	0.5	20	0.2	5
NRGPS1-1		<DL	28,000	1.7	<DL	16	0.1	25,000	0.063	21	26	50	36,000	<DL	290	12,000	460	<DL	420	38	510
NRGPS1-2		<DL	28,000	2.5	<DL	16	0.11	24,000	0.07	20	30	51	38,000	<DL	290	12,000	510	<DL	400	43	620
NRGPS1-3		<DL	26,000	4	<DL	17	0.084	20,000	0.073	17	31	65	35,000	0.045	370	11,000	460	0.51	460	40	960
NRGPS1-4		<DL	27,000	2.9	<DL	16	0.085	21,000	0.066	17	30	50	33,000	0.055	420	11,000	440	<DL	540	39	890
NRGPS1-5		<DL	24,000	2.9	<DL	14	0.1	20,000	0.092	14	29	49	30,000	0.067	390	11,000	540	<DL	450	36	1,100

Gwa'ni/Nimpkish River Estuarine Root Garden (NRG) PS1 – Soil Analysis Results (Cont.)

Sample ID	**Method**	Metals via Acid (Microwave) Digestion - ICP-MS Analysis	Compaction	Volumetric water content	Temperature	Bulk electrical conductivity

	Element	Pb	S	Se	Sn	Sr	U	V	Zn				
	Units	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	psi	%	°C	dS/m
	Estimated DL	0.05	500	0.1	0.01	0.1	0.01	0.5	1				
NRGPS1-1		35	58	0.11	0.83	110	2.1	73	52	2.5	26.4	18.8	0.09
NRGPS1-2		44	530	0.16	0.82	100	3.6	76	49	0	51.8	16.9	0.22
NRGPS1-3		50	1,400	0.36	1.7	96	5.3	91	45	0.75	53.7	18.6	0.21
NRGPS1-4		13	1,700	0.3	0.84	100	4.7	91	41	0	54.9	18.1	0.15
NRGPS1-5		26	1,600	0.4	0.76	100	6.1	84	42	0	39.3	16	0

1.3. Gwa'ni (Nimpkish) River estuarine root garden (NRG) Periphery Site 2 (PS2)

Gwa'ni/Nimpkish River Estuarine Root Garden (NRG) Periphery Site 2 (PS2) – Soil Analysis Results																	
Sample ID	**Method**	Elemental Analysis via Combustion			Manual meter	KCI Extraction, colometric		Manual meter, conductivity	Bray P-1 Extraction, UV	Muffle furnace	CEC and Cations via BaCl2 Extraction, ICP-OES							
	Element	N	C	S	pH (1:2, soil:$CaCl_2$)	Available NH_4 (N)	Available NO_3 (N)	EC 1:2 (soil:water)	Available P	LOI	Exchangeable (E) Al	E Ca	E Fe	E K	E Mg	E Mn	E Na	Effective CEC
	Units	%	%	%	pH Units	mg/kg	mg/kg	%	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	cmol+/kg
	Estimated DL	0.01	0.01	0.01	0.1	0.1	0.1	0.1	1	1	0.2	0.25	0.04	0.03	0.01	0.04	0.09	
NRGPS2-1		1.6	21	0.32	5.5	22	22	2.8	9.3	42	<DL	17	<DL	0.58	19	0.068	7.8	45
NRGPS2-2		1.4	18	0.29	5.5	21	30	3.1	6.8	39	<DL	18	<DL	0.78	20	0.068	8.5	47
NRGPS2-3		0.86	11	0.21	5.6	12	32	2.2	6.3	24	<DL	11	<DL	0.44	14	<DL	5.4	31
NRGPS2-4		1.3	17	0.30	5.4	16	14	2.7	4.7	30	<DL	13	<DL	0.5	16	<DL	6.8	37
NRGPS2-5		1.2	17	0.32	5.0	13	2.6	2.4	10	36	0.47	12	<DL	0.56	14	<DL	5.6	32
NRGPS2-6		1.6	26	0.90	4.9	12	3.2	3.2	12	50	0.44	11	<DL	0.47	15	<DL	6.1	33
NRGPS2-7		1.5	19	0.31	5.5	14	23	2.7	3.7	38	<DL	17	<DL	0.56	21	0.05	7.1	46

Gwa'ni/Nimpkish River Estuarine Root Garden (NRG) – Soil Analysis Results (Cont.)																					
Sample ID	**Method**	Metals via Acid (Microwave) Digestion - ICP-MS Analysis																			
	Element	Ag	Al	As	B	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	Hg	K	Mg	Mn	Mo	Na	Ni	P
	Units	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
	Estimated DL	0.05	10	0.01	10	1	0.06	10	0.02	0.02	2	1	5	0.03	20	5	1	0.5	20	0.2	5
NRGPS2-1		0.069	20,000	6.7	19	14	0.37	18,000	0.19	11	41	46	26,000	0.1	890	9,800	570	2.8	2,500	39	1,700
NRGPS2-2		0.059	21,000	6.2	17	22	0.16	19,000	0.14	12	47	50	28,000	0.087	880	10,000	590	2	2,300	46	1,600
NRGPS2-3		0.058	24,000	7.3	12	14	0.25	22,000	0.11	13	37	46	33,000	0.071	870	11,000	560	1.5	2,000	38	1,400
NRGPS2-4		0.063	23,000	8	15	14	0.41	21,000	0.13	13	43	48	34,000	0.083	990	11,000	690	1.7	2,400	42	1,700
NRGPS2-5		0.05	21,000	5.3	13	17	0.36	19,000	0.097	11	35	49	30,000	0.091	900	9,800	340	1.3	1,800	36	1,400
NRGPS2-6		<DL	18,000	2.7	12	11	0.48	18,000	0.048	7.6	45	73	17,000	0.083	910	7,300	240	1.6	1,900	37	1,000
NRGPS2-7		0.067	22,000	6	16	13	0.25	20,000	0.12	12	41	48	29,000	0.11	950	11,00	580	<DL	2,100	39	1,700

Gwa'ni/Nimpkish River Estuarine Root Garden (NRG) – Soil Analysis Results (Cont.)													
Sample ID	**Method**	Metals via Acid (Microwave) Digestion - ICP-MS Analysis								Compaction	Volumetric water content	Temperature	Bulk electrical conductivity
	Element	Pb	S	Se	Sn	Sr	U	V	Zn				
	Units	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	psi	%	°C	dS/m
	Estimated DL	0.05	500	0.1	0.01	0.1	0.01	0.5	1				
NRGPS2-1		54	2,700	0.91	2	120	14	80	30	N/A	43.5	18.8	0.94
NRGPS2-2		50	2,500	0.72	1.4	110	12	78	33	N/A	50	19.1	0.08
NRGPS2-3		40	2,000	0.62	2.1	110	9.6	89	37	N/A	31.5	19.1	0.96
NRGPS2-4		64	2,600	0.78	6.1	120	12	96	35	N/A	44.3	19.3	N/A
NRGPS2-5		40	2,800	0.6	2.7	100	9.9	86	32	N/A	48.5	18.8	0.83
NRGPS2-6		37	6,500	0.45	1.4	100	5.5	76	24	N/A	55	18.2	0.68
NRGPS2-7		70	2,600	0.82	1.4	120	12	84	35	N/A	46.4	18.3	0.96

2. Tl'chés soil analysis results

2.1. Tl'chés estuarine root garden (TRG) Periphery site 1 (PS1)

Tl'chés Estuarine Root Garden (TRG) Periphery Site 1 (PS1)– Soil Analysis Results																
Sample ID	**Method**	Elemental analysis via combustion		Manual meter		KCI Extraction, colometric		Bray P-1 Extraction, UV	CEC and Cations via BaCl2 Extraction, ICP-OES							
	Element	N	C	pH (1:2, soil:CaCl2)	EC (1:2 soil:water)	Available NH4 (N)	Available NO3 (N)	Available P	Exchangeable (E) Al	E Ca	E Fe	E K	E Mg	E Mn	E Na	Effective CEC
	Units	%	%	pH Units	mS/cm	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	cmol+/kg
	Estimated DL	0.01	0.01	0.1	0.05	0.1	0.1	1	0.2	0.25	0.04	0.03	0.01	0.04	0.09	
TRGPS1-1		0.56	7.0	5.4	16	<DL	1.5	29	0.17	5.9	0.016	1.4	13	0.063	25	46
TRGPS1-2		0.55	7.7	5.4	14	<DL	3.7	22	0.16	7.7	0.016	1.5	15	0.081	26	51
TRGPS1-3		0.74	11	5.8	0.49	<DL	3.2	26	0.16	20	0.021	0.74	22	0.087	11	54

Tl'chés Estuarine Root Garden (TRG) Periphery Site 1 (PS1)– Soil Analysis Results (Cont.)																				
Sample ID	**Method**	Metals via Acid (Microwave) Digestion - ICP-MS Analysis																		
	Element	Ag	Al	As	B	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	Hg	K	Mg	Mn	Mo	Na	Ni	P
	Units	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
	Estimated DL	0.05	10	0.01	10	1	0.06	10	0.02	0.01	2	1	5	0.03	20	5	1	0.5	20	0.2	5
TRGPS1-1		0.13	35,000	7.0	35	79	0.69	7,400	0.091	21	30	30	25,000	0.084	1,600	6,900	1,400	2.7	7,400	45	1,300
TRGPS1-2		0.11	35,000	6.1	33	82	0.56	7,000	0.090	21	34	30	26,000	0.078	1,800	7,200	1,200	2.0	6,800	48	1,200
TRGPS1-3		0.12	28,000	13	37	82	0.48	8,100	0.13	17	29	28	22,000	0.097	1,700	6,900	1,000	1.7	1,800	38	960

Tl'chés Estuarine Root Garden (TRG) Periphery Site 1 (PS1)– Soil Analysis Results (Cont.)												
Sample ID	**Method**	Metals via Acid (Microwave) Digestion - ICP-MS Analysis							Compaction	Volumetric water content	Temperature	Bulk electrical conductivity
	Element	Pb	S	Se	Sr	U	V	Zn				
	Units	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	psi	%	°C	dS/m
	Estimated DL	0.05	500	0.1	0.1	0.01	0.5	1				
TRGPS1-1		13	1,400	0.79	71	13	71	39	1	44.21	20.9	15.45
TRGPS1-2		11	1,300	0.65	72	10	71	45	0.25	56.4	19.4	4.8
TRGPS1-3		44	960	0.27	91	8.7	63	55	0	16.8	22.2	0.25

2.2. Tl'chés estuarine root garden (TRG) Periphery site 1 (PS2)

Tl'chés Estuarine Root Garden (TRG) Periphery Site 2 (PS2)– Soil Analysis Results																
Sample ID	**Method**	Elemental analysis via combustion		Manual meter		KCI Extraction, colometric		Bray P-1 Extraction, UV	CEC and Cations via BaCl2 Extraction, ICP-OES							
	Element	N	C	pH (1:2, soil:CaCl2)	EC (1:2 soil:water)	Available NH_4 (N)	Available NO_3 (N)	Available P	Exchangeable (E) Al	E Ca	E Fe	E K	E Mg	E Mn	E Na	Effective CEC
	Units	%	%	pH Units	mS/cm	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	cmol+/kg
	Estimated DL	0.01	0.01	0.1	0.05	0.1	0.1	1	0.2	0.25	0.04	0.03	0.01	0.04	0.09	
TRGPS2-1		2.4	30	5.4	40	<DL	1.6	19	0.16	14	0.018	5.9	46	<DL	110	180
TRGPS2-2		2.2	28	5.2	32	<DL	2.7	19	0.21	16	0.020	4.3	40	0.034	93	150
TRGPS2-3		1.2	15	4.9	13	<DL	1.0	13	0.67	6.6	0.036	1.1	13	<DL	23	44
TRGPS2-4		0.70	8.2	5.6	24	<DL	<DL	16	0.17	7.8	0.019	1.8	16	<DL	37	63

Tl'chés Estuarine Root Garden (TRG) Periphery Site 2 (PS2)– Soil Analysis Results (Cont.)																				
Sample ID	**Method**	Metals via Acid (Microwave) Digestion - ICP-MS Analysis																		
	Element	Ag	Al	As	B	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	Hg	K	Mg	Mn	Mo	Na	Ni	P
	Units	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
	Estimated DL	0.05	10	0.01	10	1	0.06	10	0.02	0.01	2	1	5	0.03	20	5	1	0.5	20	0.2	5
TRGPS1-1		0.15	18,000	4.8	79	25	0.45	6,000	0.17	3.6	8.3	23	7,700	0.12	1,700	8,900	110	3.2	45,000	13	2,500
TRGPS1-2		0.20	26,000	4.6	55	22	0.68	5,500	0.090	17	11	22	43,000	0.17	1,200	6,900	1,500	39	33,000	11	3,000
TRGPS1-3		0.17	34,000	6.6	29	66	0.76	4,800	0.064	10	23	39	19,000	0.099	1,100	5,200	190	2.1	6,500	25	1,700
TRGPS1-4		0.14	34,000	8.1	37	86	0.72	7,400	0.13	17	36	34	28,000	0.061	1,700	7,800	330	2.3	11,000	38	1,200

Tl'chés Estuarine Root Garden (TRG) Periphery Site 2 (PS2)– Soil Analysis Results (Cont.)												
Sample ID	**Method**	Metals via Acid (Microwave) Digestion - ICP-MS Analysis							Compaction	Volumetric water content	Temperature	Bulk electrical conductivity
	Element	Pb	S	Se	Sr	U	V	Zn				

	Units	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	psi	%	°C	dS/m
	Estimated DL	0.05	500	0.1	0.1	0.01	0.5	1				
TRGPS2-1		34	7,300	1.8	98	38	26	11	1.4	87.2	35.4	11.5
TRGPS2-2		35	5,400	2.9	86	35	150	8.8	0.75	46.5	40.5	6.08
TRGPS2-3		34	2,300	1.1	58	19	68	23	0.5	33.2	25.6	1.76
TRGPS2-4		12	2,000	0.65	76	12	83	34	1	101.1	31.6	16.2

2.3. Tl’chés estuarine root garden (TRG) Periphery site 1 (PS3)

Tl’chés Estuarine Root Garden (TRG) Periphery Site 3 (PS3)– Soil Analysis Results																
Sample ID	**Method**	Elemental analysis via combustion		Manual meter		KCI Extraction, colometric		Bray P-1 Extraction, UV	CEC and Cations via BaCl2 Extraction, ICP-OES							
	Element	N	C	pH (1:2, soil:CaCl2)	EC (1:2 soil:water)	Available NH_4 (N)	Available NO_3 (N)	Available P	Exchangeable (E) Al	E Ca	E Fe	E K	E Mg	E Mn	E Na	Effective CEC
	Units	%	%	pH Units	mS/cm	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	cmol+/kg
	Estimated DL	0.01	0.01	0.1	0.05	0.1	0.1	1	0.2	0.25	0.04	0.03	0.01	0.04	0.09	
TRGPS3-1		0.35	4.1	5.8	2.3	<DL	<DL	32	0.23	5.1	0.016	0.68	5.1	<DL	7.4	19
TRGPS3-2		1.1	13	5.8	5.9	0.47	3.8	48	0.13	9.8	0.017	0.75	14	0.039	4.3	29
TRGPS3-3		0.73	8.4	5.6	0.74	0.24	2.1	29	0.14	12	0.017	0.85	18	<DL	15	46
TRGPS3-4		0.61	6.8	5.3	0.57	0.65	1.8	89	0.17	8.3	0.020	0.60	11	<DL	5.4	25

Tl’chés Estuarine Root Garden (TRG) Periphery Site 3 (PS3)– Soil Analysis Results (Cont.)																				
Sample ID	**Method**	Metals via Acid (Microwave) Digestion - ICP-MS Analysis																		
	Element	Ag	Al	As	B	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	Hg	K	Mg	Mn	Mo	Na	Ni	P
	Units	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
	Estimated DL	0.05	10	0.01	10	1	0.06	10	0.02	0.01	2	1	5	0.03	20	5	1	0.5	20	0.2	5
TRGPS3-1		<DL	27,000	3.6	29	62	0.25	8,800	0.13	14	27	18	19,000	<DL	1,500	6,700	270	0.67	2,500	25	880
TRGPS3-2		0.098	22,000	4.1	46	53	0.36	9,000	0.13	12	17	20	16,000	0.060	1,600	7,100	210	0.82	4,300	16	1,600
TRGPS3-3		0.057	22,000	4.3	55	55	0.38	7,600	0.095	13	19	18	18,000	0.033	1,500	6,300	200	1.2	1,800	17	1,100
TRGPS3-4		0.067	24,000	3.4	62	62	0.41	7,800	0.099	12	22	19	19,000	0.032	1,600	6,100	220	<DL	1,700	19	1,500

Tl’chés Estuarine Root Garden (TRG) Periphery Site 3 (PS3)– Soil Analysis Results (Cont.)												
Sample ID	**Method**	Metals via Acid (Microwave) Digestion - ICP-MS Analysis							Compaction	Volumetric water content	Temperature	Bulk electrical conductivity
	Element	Pb	S	Se	Sr	U	V	Zn				
	Units	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	psi	%	°C	dS/m
	Estimated DL	0.05	500	0.1	0.1	0.01	0.5	1				
TRGPS3-1		4.1	1,400	0.33	85	5.3	62	46	3.2	27.8	17.7	1.23
TRGPS3-2		19	2,400	0.47	110	12	51	33	1	5.4	20	0.05

TRGPS3-3		20	1,400	0.25	85	7.0	53	37	0	2	25.1	0
TRGPS3-4		11	1,200	0.23	83	5.3	52	44	1.2	9.1	26.5	0.01

2.4. Tl’chés estuarine root garden (TRG)

Tl’chés Estuarine Root Garden (RG) – Soil Analysis Results																
Sample ID	**Method**	Elemental analysis via combustion		Manual meter		KCI Extraction, colometric		Bray P-1 Extraction, UV	CEC and Cations via BaCl2 Extraction, ICP-OES							
	Element	N	C	pH (1:2, soil:CaCl2)	EC (1:2 soil:water)	Available NH_4 (N)	Available NO_3 (N)	Available P	Exchangeable (E) Al	E Ca	E Fe	E K	E Mg	E Mn	E Na	Effective CEC
	Units	%	%	pH Units	mS/cm	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	cmol+/kg
	Estimated DL	0.01	0.01	0.1	0.05	0.1	0.1	1	0.2	0.25	0.04	0.03	0.01	0.04	0.09	
TRG-1		0.63	7.8	5.3	19	0.59	0.19	140	0.30	6.5	0.023	0.53	8.3	<DL	4.2	20
TRG-2		1.2	14	5.2	12	0.41	2.5	110	0.17	5.8	0.020	1.5	13	<DL	32	53
TRG-3		1.5	20	5.4	4.2	0.23	0.52	130	0.17	15	0.019	0.96	20	0.11	20	56
TRG-4		0.70	8.8	5.3	2.3	0.11	0.16	230	0.21	9.6	0.027	0.49	12	0.028	6.6	29

Tl’chés Estuarine Root Garden (TRG) – Soil Analysis Results (Cont.)																					
Sample ID	**Method**	Metals via Acid (Microwave) Digestion - ICP-MS Analysis																			
	Element	Ag	Al	As	B	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	Hg	K	Mg	Mn	Mo	Na	Ni	P
	Units	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
	Estimated DL	0.05	10	0.01	10	1	0.06	10	0.02	0.01	2	1	5	0.03	20	5	1	0.5	20	0.2	5
TRG-1		0.059	30,000	3.8	41	67	0.41	7,300	0.063	16	31	18	22,000	0.038	1,700	7,600	310	0.73	9,500	31	2,200
TRG-2		0.13	28,000	9.1	46	55	0.59	8,500	0.099	21	20	23	27,000	0.092	1,100	7,300	1,000	3.1	5,900	23	3,600
TRG-3		0.17	27,000	1.1	46	65	0.66	16,000	0.22	26	23	53	30,000	0.12	1,200	7,400	1,400	4.4	3,600	32	7,200
TRG-4		0.11	34,000	9.8	27	70	1.0	9,600	0.14	32	27	32	43,000	0.063	1,200	7,100	1,300	2.5	2,500	31	4,900

Tl’chés Estuarine Root Garden (TRG) – Soil Analysis Results (Cont.)												
Sample ID	**Method**	Metals via Acid (Microwave) Digestion - ICP-MS Analysis							Compaction	Volumetric water content	Temperature	Bulk electrical conductivity
	Element	Pb	S	Se	Sr	U	V	Zn				
	Units	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	psi	%	°C	dS/m
	Estimated DL	0.05	500	0.1	0.1	0.01	0.5	1				
TRG-1		32	2,000	0.41	73	7.9	61	46	2	96.3	23.8	17.15
TRG-2		70	2,800	0.77	100	8.6	71	63	1	44.5	30	5.33
TRG-3		60	2,400	0.91	170	11	77	96	0.5	20.4	40	0.05
TRG-4		31	1,300	0.45	95	4.7	110	100	1	16.7	38.3	0.11

Tl'chés Estuarine Root Garden (TRG) – Loss of Ignition (LOI) Soil Analysis Results			
Sample ID	**Method**	Muffle Furnace	Gravimetric(*)
			Dry weight
		LOI	
	Units	%	g
	Estimated DL	0.1	
TRGU4A–S1 (14cm DBS)		2.9	336.5
TRGU4A-S2 (30cm DBS)		9.5	474.8
TRGU4A-S3 (33cm DBS)		8.0	451.7
TRGU4A-S4 (40cm DBS)		4.6	989.0
TRGP1-S1 (16cm DBS)		14	574.4
TRGP1-S2 (26cm DBS)		13	791.5
TRGP1-S3 (30cm DBS)		9.7	758.1
TRGP1-S4 (33cm DBS)		7.2	804.9
TRGP1-S5 (40cmDBS)		7.1	830.4