Living Landscapes:

A study of community composition and traditionally

managed plants across varying midden depths in the Hakai Luxvbalis Conservancy

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Abstract

Middens are the products of human activity and subsistence; in the Hakai Luxvbalis Conservancy area the middens reflect the widespread use of this area by Heiltsuk and Wuikinuxv Nations. In an effort to further understand this use and lasting impacts it has had on plant communities, this study measured the abundance of 15 targeted species and estimated percent cover. It was designed to explore how targeted species richness and diversity differs with midden depth. Results of this study showed significant difference between beach sites and forest sites (R value of 0.341, significance of 0.1%), a tantalizing difference in species abundance between shallow and deep sites, and a species richness index that increased as midden depth increased, (2.944 at shallow to 3.333 at deep sites). These results suggest a difference in the plant communities on midden sites, and m deeper sites harbour a wider variety of the specified traditionally harvested species. Additional work is needed to strengthen confidence and draw more conclusive results. These studies also uncovered potential relationships between middens calcium leaching, increased pH, and subsequent changes in plant communities.These results and proposed future studies add to the continued understanding of traditional resource management impact on plant communities in this area.

Introduction

A common misconception with Coastal First Nations in British Columbia is that they survived solely from hunting and gathering (Bruce, 2005). In reality, a holistic approach towards ecosystem management and care of natural systems is present in all Coastal First Nations groups, particularly for food, medicinal, and technology resources (Brown & Brown, 2009). These management practices and value systems are embodied in the Heiltsuk and Wuikinuxv culture. Remnants of this impact remain visible on Calvert Island and the Hakai Luxvbalis conservancy area (McLaren & Christensen, 2013). Evidence of use and management is very noticeable in the form of fish traps, clam gardens, culturally modified trees (CMTs) and middens. These are examples of physically altered landscapes and show lasting and visible evidence of the heavy use in this area. The less documented and subtler evidence of edible plant communities require a finer look to understand the ecology and tactics behind the practices of Heiltsuk and Wuikinuxv people in this area. Root and berry harvesting was not a random search for the right plants:

specific sites were managed, tended and cared for over generations much like an enormous garden. Prescribed burns to aid berry bushes' productivity were implemented. Specific tribes and families often owned these sites (Turner & Peacock, 2005). By caring for these areas, opportunities were provided for transmission of cultural values and knowledge. Taking an ecological approach to understanding the abundances, species diversity and species of these culturally important plants can strengthen the link between two knowledge systems and provide results that are both ecologically and culturally salient. This project aims to further understand the community composition and abundances of vegetative cover at midden sites in the Hakai Luxvbalis conservancy. We focus on edible plants and CMTs over sites with varying midden depths. The questions we posed to gain insight into these ecosystems through an ethnoecological lens are: (1) How do the species richness and diversity of 15 target species (13 edible plant species and 2 technology trees) differ in plant communities over midden sites with varying depths. (2) How does community composition of these sites differ with midden depth and distance inland from shore? Our null hypothesis (H_0) states that there is no difference in richness and diversity of targeted species over varying midden depths. Our alternate hypothesis (H_a) states that there is a difference in richness and diversity of targeted species over varying midden depths. Findings from this study can add to the growing understanding of how cultural management has had lasting impact on plant communities. Such information can strengthen the knowledge of how First Nations management has strongly affected living landscapes.

One way in which the aboriginal people across the world have affected the landscape is through leaving the remains of flora and fauna that were used or consumed. The term midden refers to a mound of shells, artifacts, fish bones, human remains, and other organic material left over from human inhabitation (Andrus, 2011; Kendrick & Morse, 1982). They have been found internationally, in such places as Scotland (Simpson & Barrett, 1996), Australia (Kendrick & Morse, 1982), and British Columbia's Central Coast (Lyons & Orchard, 2007). The majority of sites have been found on coastlines, but middens have been found inland from the coast if freshwater or terrestrial molluscs were available (Rabett *et al.* 2011). The key factor for the presence of a midden is the availability of some sort of shellfish. Middens ranging from 60 cm to 6000 cms have been found on Calvert Island, British Columbia (McLaren & Christensen, 2013).

Midden sites are the result of the activity on traditional village sites. Effectively a compost site, these deposits are concentrated remains of the flora and fauna that were being consumed or used, they can be a good source of proxies for paleoenvironmental data (Reitz *et al.,* 1996). An insight into the environment of the era in which the ancient community can be gleaned through sclerochronological analysis of the mollusk shells (Andrus, 2011). The extent of these sites also gives a suggestion of community site locations over time, albeit a vague one. For example, a midden accumulates as a coastal community lives in one area for an extended period of time. Dr. Rahemtullo postulates that the site on which he currently is working may be 150 meters long. The length of this site was developed over time: the northern portion of the stretch is older than the southern portion (F. Rahemtullo, personal communication, July, 2013). Such sites are not natural land formations: they are discrete areas rich in of marine-derived calcium carbonate and other organics, affecting the surrounding area's soil may chemically.

The shells that form the majority of a midden preserve biological remains through the calcium carbonate that they leach into the surrounding soil. This calcium acts to raise the pH of acidic soils (Tsakelidou, 2000), thereby preserving bones, shells and teeth. Such long lasting preservation would not be possible in surrounding highly acidic soils (Andrus, 2011). This is exemplified through fish bones found in midden sites. A second, relatively common discovery in midden sites is that of human remains. Dr. Rahemtullo has found human remains in every dig site he has worked at on the Central Coast.

The effect of midden sites on plant communities and soil chemistry has not been studied extensively (F. Rahemtullo, personal communication, July 2013). Midden sites are composed of decaying organic matter and as such may produce relatively rich soil. Current plant communities growing on these sites may be benefited by the nutrients released from the organic litter of past communities. In addition, the neutralizing effect of marine-derived calcium on soil may alter the composition of the local plant community. British Columbia's soils are relatively acidic, and so discrete area of neutral soil may support a distinct array of plant species. This is because below this threshold pH, aluminum ions (Al^{3+}) are mostly dissolved as opposed to precipitated as a solid, and toxic to many plants (Hansson et al, 2011).Despite this toxicity, the genus *Vaccinium* (blueberries) grow well in pH of 4.5 to 5.5. (Longstroth, 2012). Because decomposing organics may reduce soil's pH, the neutralizing effect of calcium may be diminished slightly (Brady & Weil, 2002). Based on the discovery of remains such as fish bones that are only preserved in neutral soils, the effect of calcium likely outweigh the possible acidification due to decomposition. In a study of the effect of the application of limestone on plant communities, Kowalenko and Ihnat (2010) found an increase in plant dry matter for 3 of 5 growing years. Although midden sites' effect on community composition of plants has not been studied extensively, their chemical composition and neutral pH undoubtedly impacts local flora.

Middens represent heavy use of an area, including traditional methods of cultivation. The lasting impacts of intensive cultivation on contemporary plant communities may be significant. For example, many species of root vegetable such as Northern Rice-root (*Fritillaria camschatcensis*) and Pacific Silverweed (*Argentina pacifica*) were cultivated by the First Nations of the Central Coast. This study seeks to examine the abundance and distribution of 12 edible and 2 technology plant species traditionally harvested by First Nations in what is now called Calvert Island and Hakai Luxvbalis conservancy (Heiltsuk and Wuikinuxv). We studied plant communities on midden sites of varying depths, because the depth of midden may act as a proxy for land use intensity. An increase in the depth of midden may correspond to an increase in the species richness of our targeted species.

Traditionally harvested plants of interest

There is no scholarly debate that Northwest Coast people cultivated plants in this region (Deur & Turner, 2005). "Garden" habitats were once maintained along the coast through a variety of techniques, often plant-specific (Peacock & Turner, 2005). Through communication with Dr. Nancy Turner we generated a list of traditionally harvested plants to inventory; in context of this project we segregated them into three categories, however in nature these communities overlap. Our target plants were selected because of their extraordinary importance to people of the Northwest Coast. The 14 edible and technology plants are found in the length of our transects from shore to forest. Our field work focused on tracking three types of traditional land management systems: root gardens, berry patches and harvested trees. From seashore to thick forest, we inventoried this specific list of plants, looking for indicators of past land cultivation. The following paragraphs describe the specific plants we inventoried and their context in an ancient landscape of management, comprehensive descriptions are available in the Table 1 of appendix.

Root gardens

In the Pacific Northwest alone, there are upwards of 25 species of edible root vegetables (Peacock & Turner 2005). Our interest focused on a group commonly found growing together in tidal wetlands and salt marshes: *Fritillaria camschatcensis* (Northern riceroot), *Lupinus nootkatensis* (Nootka lupine), *Potentilla anserine ssp. pacifica* (Pacific silverweed) and *Trifolium wormskjoldii* (Springbank clover) (Peacock & Turner, 2005). These plants are all geophytes; their nutritious organs are below the earth surface in the form of roots, corms or bulbs (Ames 2005). Each of these herbaceous perennials were selectively harvested by individuals or families for a variety of uses; anthropogenic maintenance techniques often included burning, weeding, transplanting and rotation of harvesting rounds (Peacock & Turner, 2005). Oral traditions allude to the overall importance of root vegetables as more dependable than animal sourced food in the traditional diet as well as a coveted trade item (Deur 2005). A source of carbohydrates, root vegetables were cultivated for intensification by many peoples of the Northwest Coast. Differing theories of plant food production by Thom and Peacock both agree that sedentism and root intensification are related, the sites we visited reflect this potential for a layered landscape of uses over the years (Ames, 2005).

Berry Patches

There is no better subject with which to observe the land as “an instrument of labor” than traditionally managed berry patches (McDonald, 2005). From trans-locating wild plants into village boundaries to trail maintenance for access to mountain patches, a spectrum of berry maintenance was required for predictable harvest security (McDonald, 2005). It is reported that parties of berry gatherers would spend days in the mountains harvesting or burning yields (a technique to improve future yields). Our work focused on an inventory of the following eight edible berry species: *Gaultheria shallon* (Salal), *Ribes divaricatum* (Coastal black gooseberry), *Rubus parviflorus* (Thimbleberry), *Rubus spectabilis* (Salmonberry), *Vaccinum ovalifolium* (Oval-leaved blueberry), *Vaccinum parvifolium* (Red huckleberry), *Vaccinum alaskaense* (Alaskan blueberry)*, Sambucus racemosa* (Red elderberry). From coniferous forests to rocky bluffs, these species are all found in similar woodland habitats.

Harvested Trees

The harvesting of trees was a major aspect of Northwest Coast survival and gardening practices continued well into the dense forests of this region. Depending on environmental conditions, the vertical forest was not only used for technology but cultivated for intensification. Our inventory focused on three tree species with significant cultural heritage: *Pyrus fusca* (Pacific crabapple), *Thuja plicata* (Western redcedar) and *Taxus brevifolia* (Western yew). These trees had their respective purpose, place, and management necessities within the landscape; *P. fusca* was associated with human occupied sites, whereas the majority of *T. plicata* and *T. brevifolia* were constrained to the rainforest (Peacock & Turner, 2005).

Site Profiles

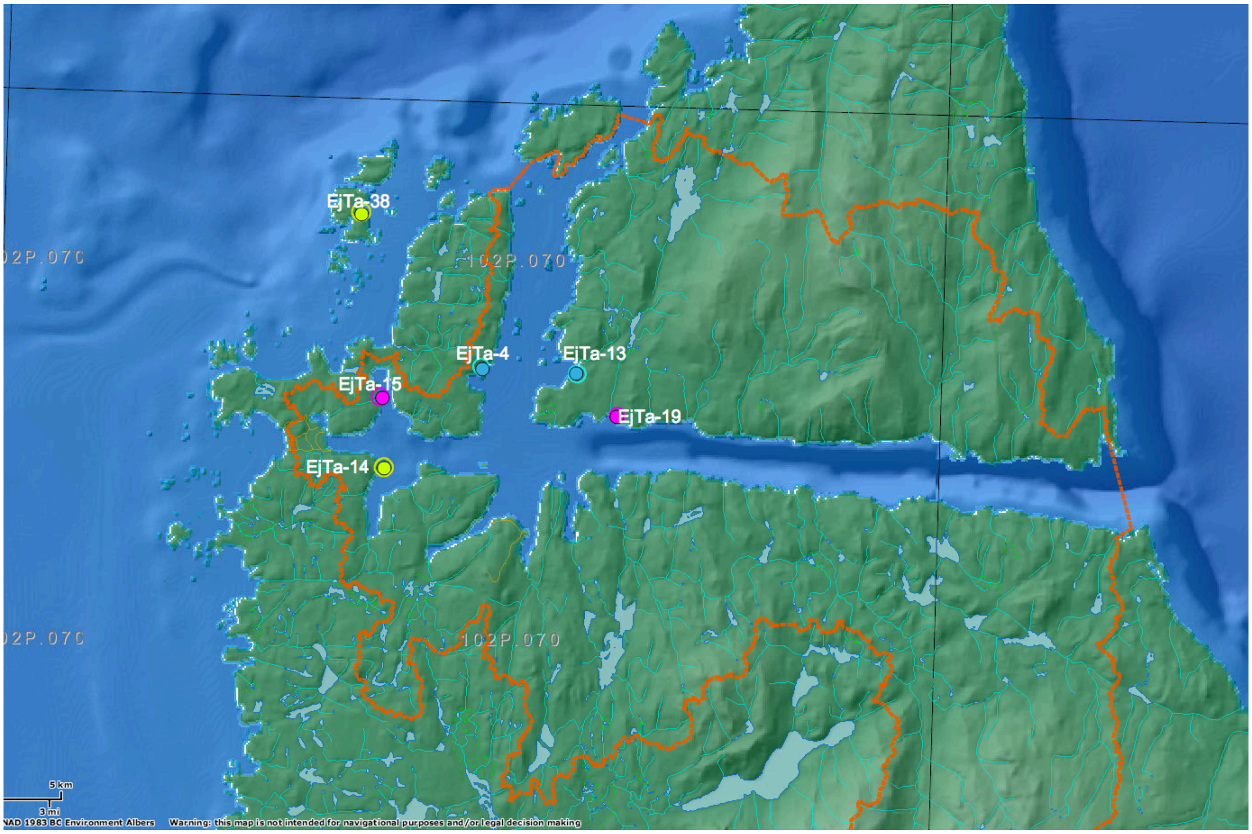

Fig. 1. Map of all sites: EjTa-15 (shallow), EjTa-19 (shallow), EjTa-14 (medium), EkTa-38 (medium), EjTa-4 (deep), EjTa-13. Pink represents shallow sites, yellow represents medium sites, and blue represents deep sites. UTM zone 9, Hakai Luxvbalis Conservancy.

Six sites were selected for this project based on a range of exposed middens from 60 cm to 600 cm depth below surface (dbs). These specific sites (Fig. 1) were chosen from the Report for the Hakai Ancient Landscapes Archaeology Project based on the following factors: accessibility, proximity to Hakai and recorded depth of midden. The environmental conditions were consistent across all sites: shoreline, midden and forest. Each site has a long history of human occupation; this is physically visible by today's exposed middens and growing list of mapped CMTs. Additionally, the sites we surveyed host a variety of well documented cultural features beyond shell middens. Canoe runs, clam gardens, fish traps and terraces are all recorded respectively across these sites.

Shallow Depth Sites:

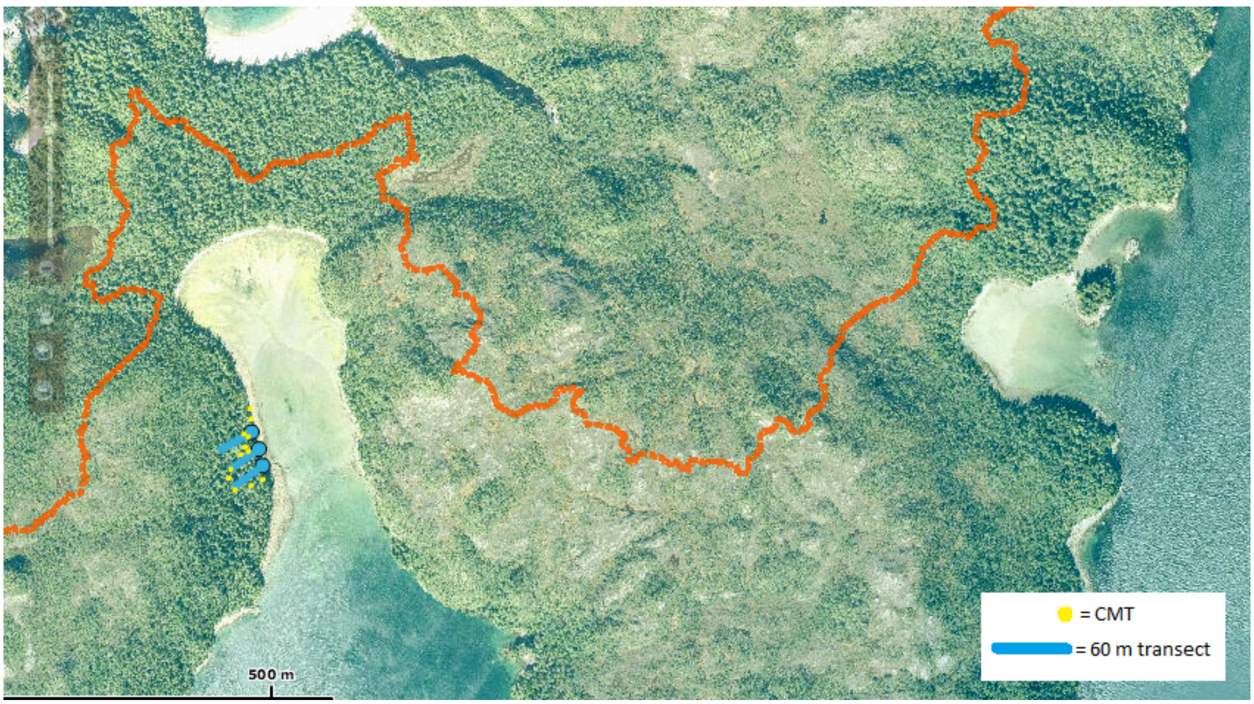

Fig. 2. EjTa-15, shallow site of 160 cm depth below surface.

EjTa-15 (Fig. 2) is located at the head of Kwakshua Channel with a relatively shallow shell midden exposure of 160 cm dbs. This site also hosts a canoe run, recorded surface lithics and a rock and boulder feature that may be an unconfirmed fish trap. Chipped stone recovered from the intertidal zone may date back to the early Holocene; the Report for the Hakai Ancient Landscapes Archaeology Project suggests that sea-level sampling is warranted in this area (McLaren & Christensen, 2013). EjTa-15 was reached by canoe in overcast weather on June 22, 2013 by Chris, Audrey and Amanda. Fieldwork was conducted from 9:10 am to 3:45pm with a break to paddle back to the institute for lunch. 12 CMTs were recorded by GPS waypoint and plotted onto a map with site boundary. An especially large red huckleberry bush was found between 20-40 m on the second transect at this site.

Fig. 3. EjTa-19 at bottom right, shallow site of 120 cm depth below surface. EjTa-13 at center, deep site of 4 m depth below surface.

EjTa-19 (Fig. 3) is located in a south facing bay on Hecate Island with a relatively shallow midden of over 120 cm dbs. No lithics were found on this gravel beach but more midden is thought to likely extend 50 m to the west of auger tested site (McLaren & Christensen, 2013).

EjTa-19 was reached by canoe and kayak in the rain on June 24, 2013 by Chris, Audrey and Amanda, all work conducted between 2:30 and 6:30 pm. All transects at this site were conducted on the east side of the creek, above the exposed midden. Of note outside of our transect, is the variety of edible plants along the creek: crab apple trees, large red huckleberry shrubs and Labrador tea. A lot of burnt snags, cedars and possible CMTs were observed at this site, especially near the creek. Section 20-40 m of transect 3 crossed many small cedars and burnt snags.

Medium Depth Sites

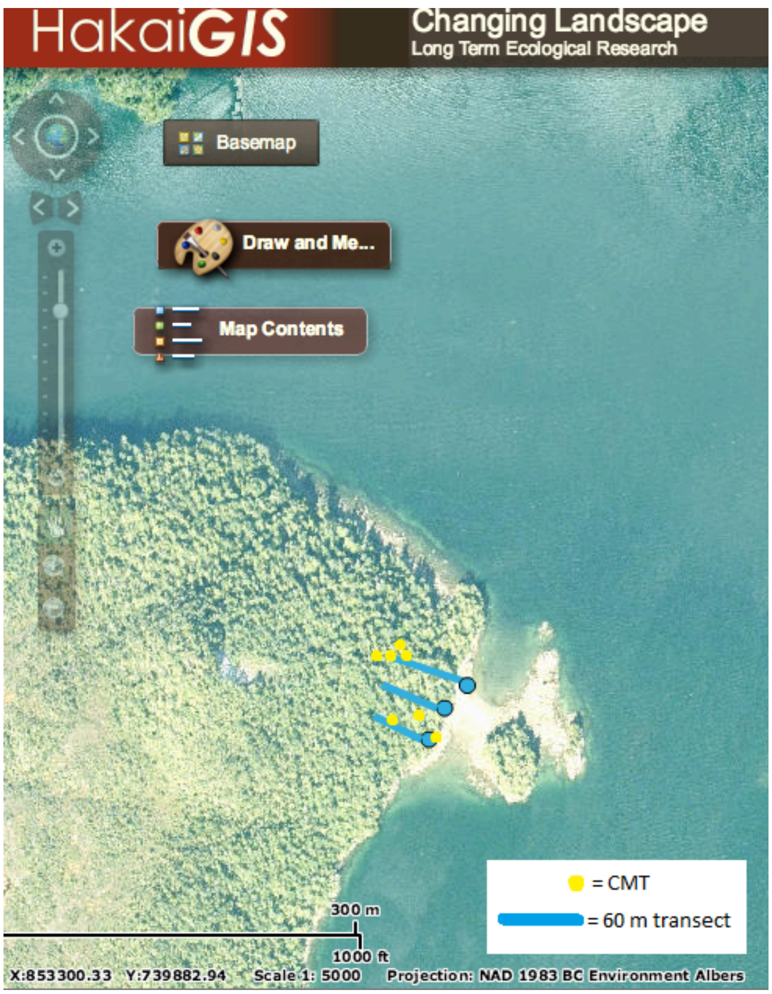

Fig. 4. EjTa-14, medium site of 3 m depth below surface.

EjTa-14 (Fig. 4) is located at the head of Kwakshua channel, on the south side, marked with a distinctive islet and tombolo feature. This site has a relatively medium midden at 3 meters dbs. Intertidal lithics of chipped and ground stone were found here as well as fauna remains, a terrace, many CMTs (including at least one on the islet), a possible clam garden and canoe run (McLaren & Christensen, 2013). EjTa-14 was reached by canoe on June 20 2013 in overcast weather; fieldwork was conducted from 1:45 to 5:30 pm by Chris, Audrey and Amanda. An abundance of silverweed and crab apple trees near exposed midden are recorded in transect data, a large depression in the earth and extensive red huckleberry at the end of transect 2. This large depression is similar in appearance to village sites at Kvai and in archaeology pictures (A. Cockett, A. Cook, & C. Madsen, personal observation, June 2013).

Fig. 5. EkTa-38, medium site of 2.5 m depth below surface.

EkTa-38 (Fig. 5) is located on the east side of Starfish Island in a protected bay with a relatively medium midden up to 2.5 meters dbs. A wet site component is suggested being at this site at 180 cm dbs is recorded as wet and "smelly". A pictograph, canoe run and many CMTs have been recorded as well. Interestingly, this site was located by Abe Lloyd in 2011 because of the edible food plants growing onshore: *P. pacifica, F. camschatcensis, P. anserine spp. Pacifica* (McLaren & Christensen, 2013). EkTa-38 was reached by power boat in overcast weather on June 17 2013. Field work began at the north end of the rocky beach beneath 7 crabapple trees, conducted from 9 am to 12:30 pm by Chris, Audrey and Amanda. A dense patch of springbank clover, Pacific silverweed and Pacific hemlock parsley was present at the start of transect 1. A cascara tree, Pacific yew, mountain ash, Labrador tea and Saskatoon berry were observed off transect. All tree species were relatively small at this site. An interesting circle shaped depression was crossed in 20-40 m of transect 2 in the vicinity of an extensive patch of red huckleberry shrubs. Brian Starzomski (June, 2013) remarked on the richness of the marine environment at this site.

Deep Sites

Fig. 6. EjTa-4, deep site of 6 m depth below surface.

EjTa-4 (Fig. 6) is located on a south-east facing bay on Calvert Island. This relatively deep midden extends at least 6 meters dbs. The site of recent UNBC archaeology field schools, EjTa-4 is host to many intertidal lithics, burials, CMTs, house platforms and a rockshelter. Dr. Farid Rahemtullo suggests that this site warrants further testing as it may be one of the most extensive village sites in the region (McLaren & Christensen, 2013). EjTa-4 was reached by canoe and kayak in initially overcast to deteriorating weather on June 26 2013. Fieldwork was conducted from 11 am to 3:15 pm by Chris, Audrey and Amanda. Extensive thimbleberry covers the bank of the midden along this site, salmonberry was also found and recorded in transect 1. The big rock off shore of this site is habitat to a community of rice root, silverweed, twinberry, monkey flower, licorice fern and Pacific hemlock parsley. The island hosts at least 10 CMTs, a yew tree and patch of Pacific hemlock parsley.

EjTa13 (Fig. 3) is located on the west side of Hecate Island in a sand/gravel bay with a small island. This relatively deep site has a midden recorded at over 4 meters dbs. A significant habitation site, there are many intertidal lithics, a rock shelter burial and intact Olivella shell bead found here. This multi component site warrants further testing as it also has deposits that date back to early Holocene (McLaren & Christensen, 2013). EjTa-13 was reached by canoe and kayak on June 25 2013 by Chris, Audrey and Amanda. Fieldwork was completed between 12:45 and 4:45 pm in rainy and windy weather. Access to transect 1 was an extensive patch of coastal black gooseberry, followed by an exceptionally large patch of red huckleberry. Cascara and Yew trees, along with big cedars were crossed in all transects at this site.

Methods

To conduct field work we used the following materials: reel tape measure, compass, Garmin GPS, m^2 plastic quadrat, 3 outdoor journals, pen, pencils, and *Plants of Coastal British Columbia* by Pojar and Mackinnon. Chris Madsen paced along the transect with a bearing while Audrey Cockett identified target species and Amanda Cook recorded. All three group members shared the task of quadrats: identifying and recording percent cover. Selection of the 14 identified species was based on accurately representing a cross section of this region.6 sites were selected from the SFU archaeology report 2012 based on the depth of midden and accessibility (McLaren & Christensen, 2013).

We chose 2 shallow (0.9 m to 1.2 m: EjTa15 and EjTa19), 2 medium (2.5 m to 3 m: EkTa38 and EjTa14), and 2 deep (4 m to 6 m: EjTa13 and EjTa4) midden sites to survey. Various modes of transportation were used: canoe, kayak and motorized boat got us to the shore and from there we bushwhacked on foot. At every site 3 belt transects with a 2m wide scope and 60 m length were taken using a measured pacing technique. 60 m was chosen based on elevation profiles drawn in Hakai GIS with the aim to yield a data set that included coastal, nearshore, and backshore environments. 60 m long transects end prior to the transition into bog forests, which are inhospitable environments for our target species. The belt transects were designed to gather data on the abundance of 15 species of harvested plants. A control of access was used to select transect location, delicate middens were avoided as to not disrupt cultural remains. The three transects were spaced by at least 20 m to avoid replication in our data collection and used the same bearing unless adjustments were required due to shoreline variation.

Transects and quadrats began at the first presence of defined shoreline vegetation and ran near perpendicular to the tideline. To gather baseline and reference information on community composition four pairs of 1 m^2 quadrats were set on either side of the transect at 0 m, 20 m, 40 m and 60 m. The quadrats were used between knee-height to ground level depending on density of vegetation. Within the quadrats, percent cover estimates of functional groups and specific species were taken. Functional groups such as moss, lichen, litter and fungi were used, however most plants were identified to the species level, regardless of whether or not they were one of the 14 species of interest.

Western Redcedar within usable circumference were recorded on transect, more than one can hug defines a “usable” circumference when considering CMTs (J. Housty, personal communication, May 2013). A separate category for CMTs was used to record their GPS waypoint and circumference measurement with reel tape. Every CMT identified within 20 m from the transect was marked with a GPS waypoint to increase data on the cultural use of these sites, the exact CMT locations were mapped by site. Transect start, end, and time were also recorded using GPS waypoints. The full collection of way points has been formatted onto

HAKAI GIS for an overview of our field site scope. The Garmin GPS e-trex we used is subject to <15 m position accuracy as of 2003 with subject to change (Garmin).

Data Manipulation

We used Primer 6 to perform one-way and two-way analyses of similarities (ANOSIMs) with factors of site and distance. Further, Primer 6 was used to create two nMDS (nonmetric multidimensional scaling) graphs. Lastly, the same program was used to perform one-way and two-way percent similarities (SIMPER) with the same factors as the ANOSIMs (see Tables 1 and 2).

Test Factor	Groups	R Statistic	Significance level %
Depth	Shallow, Medium	0.019	22.4
Depth	Shallow, Deep	0.117	0.9
Depth	Medium, Deep	0.075	1.2

Table 1. One-way analysis of similarities (ANOSIM) for transect data comparing sites by depth (shallow, medium, deep). This test was used to compare similarities between depths to determine if a difference exists.

Test	Groups	R Statistic	Significance Level %
One way ANOSIM	Medium, Deep	0.033	1.4
One way ANOSIM	Medium, Shallow	0.009	16.7
One way ANOSIM	Deep, Shallow	0.045	0.3
One way ANOSIM	0, 20	0.637	0.1
One way ANOSIM	0, 40	0.702	0.1
One way ANOSIM	0, 60	0.706	0.1
One way ANOSIM	20, 40	0.081	0.1
One way ANOSIM	20, 60	0.07	0.4
One way ANOSIM	40, 60	0.014	18.4
Two way nested Dist(Site)	EjTa14, EjTa13	0.063	28.6
Two way nested Dist(Site)	EjTa14, EjTa4	-0.052	65.7
Two way nested Dist(Site)	EjTa14, EjTa15	-0.104	74.3
Two way nested Dist(Site)	EjTa14, EkTa38	-0.021	57.1

Two way nested Dist(Site)	EjTa14, EjTa19	-0.094	77.1
Two way nested Dist(Site)	EjTa13, EjTa4	0.125	28.6
Two way nested Dist(Site)	EjTa13, EjTa15	0.063	34.3
Two way nested Dist(Site)	EjTa13, EkTa38	0.073	34.3
Two way nested Dist(Site)	EjTa13, EjTa19	0	45.7
Two way nested Dist(Site)	EjTa4, EjTa15	0.073	31.4
Two way nested Dist(Site)	EjTa4, EkTa38	0.052	37.1
Two way nested Dist(Site)	EjTa4, EjTa19	0.021	42.9
Two way nested Dist(Site)	EjTa15, EkTa38	-0.031	57.1
Two way nested Dist(Site)	EjTa15, EjTa19	-0.146	94.3
Two way nested Dist(Site)	EkTa38, EjTa19	0.052	42.9

Table 2. Three tests of quadrat data. Analysis of similarity (ANOSIM) tests were used to compare similarities between depths to determine if a difference exists.One-way ANOSIM compared midden sites by depth with no statistically significant result. One-way ANOSIM compared sites by distance showing distinction between 0 m beach communities and all other communities (20 m, 40 m, 60 m). Two-way nested ANOSIM compared sights by site and distance with no statistically significant result.

Factors were the site, depth, transect and distance. Variables were the edible plant species for which abundance was measured.

Results

A range of statistical tests were performed for transect and quadrat data. For transect data, a one-way ANOSIM tested similarities between different depths of site between shallow, medium and deep sites (Table 1). A second ANOSIM compared the different depth classifications of midden site using quadrat data (Table 2). This test found no significant difference between sites, and thus no evidence for a difference in community composition between different site depths. A third one-way ANOSIM compared the community composition from distances along transects 0 m, 20 m, 40 m, and 60 m (Table 2). All comparisons involving the 0m, regardless of the site compared to, had the most statistically important results, with R statistics from 0.637 (0 m and 20 m) to 0.706 (0 m and 60 m), and all with a significance level of 0.1%. These results are displayed in Fig. 7.

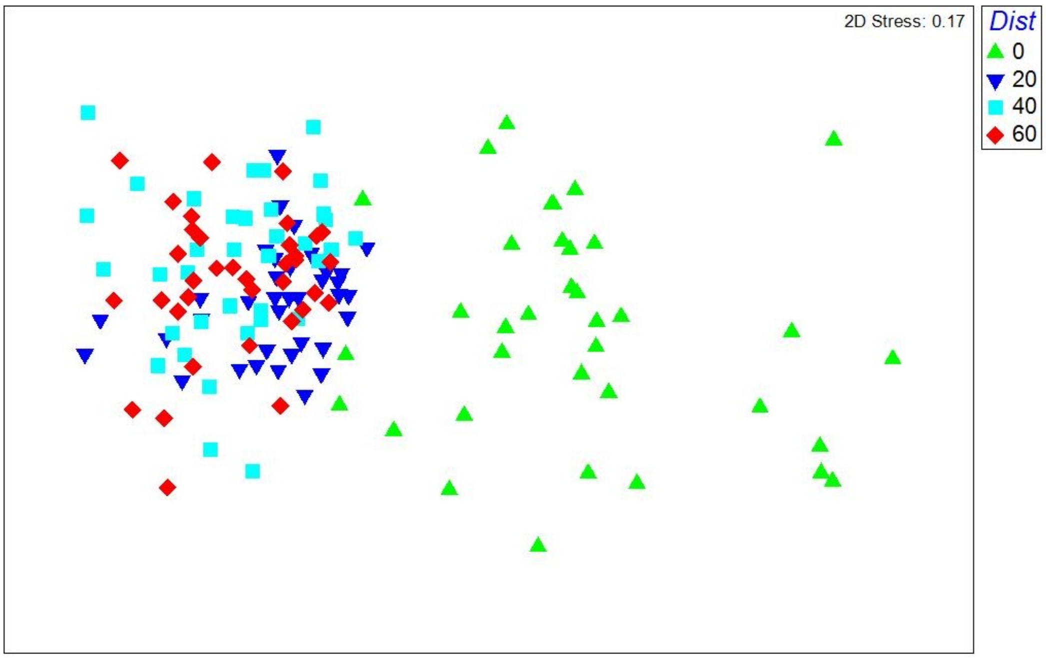

Figure 7. Comparison of community composition estimates for all sites. Nonmetric multidimensional scaling plot representing the similarities between percent cover estimates at 0 m, 20 m, 40 m and 60 m. Data points from 0 m quadrats which represent shoreline communities distinctly separate from 20 m, 40 m and 60 m distances' data points which represent forest communities. No significant difference was found between forest sites.

SIMPER analysis of quadrat data based on distance into the forest yielded an average similarity within the 0 m group of 29.60%, within the 20 m group 51.30%, within the 40 m group 44.46%, and between 60 m 49.42%. A two-way nested ANOSIM in which sites were compared first, followed by a further comparison between distances, found no significant differences (Table 2).

We performed a one-way SIMPER analysis to determine which plant species contributed the most to similarities and dissimilarities. The intragroup similarity was lowest for 0 m quadrats at 29.6%, which was fully 14.86% lower the second lowest intragroup similarity of group 40m. Dissimilarities were highest between 0 m and all other groups: 82.62% versus 20 m, 87.25% versus 40 m, and 86.68% versus 60 m. Salal and rock were the two largest contributors to the dissimilarities between 0 m and other distances, contributing nearly 25% of the difference. Of the edible plant species we looked for, Pacific Silverweed contributed the most (around 5%) to dissimilarities between 0 m and other distances. In a two-way SIMPER that first examined site and then distance, dissimilarities ranging from 52.51% (EjTa14 and EjTa19) to 62.38% (EjTa13 and EkTa38) were found. Red Huckleberry made the largest contribution to site dissimilarities of studied edible plant species, averaging around 5% and making the largest contribution in 10 site comparisons. The second largest influence was Pacific Silverweed, contributing less than 5% to site dissimilarities. Pacific Silverweed made the largest contribution of edible plant species studied in four of these dissimilarities. The largest dissimilarities between distances were between 0m and all other distances. The highest contributor to these dissimilarities from the studied edible plant species was Pacific Silverweed, averaging below 5%. Two species diversity indices were calculated for the transect data, organized by site depth. The average Shannon index for shallow sites was found to be 0.272, for medium sites as 0.220, and for deep sites as 0.331. The average Simpson index for shallow sites was found to be 0.264, for mediums sites as 0.211, and for deep sites as 0.323.

Species richness, defined in as the number of species present per site, was calculated for all sites. Only the abundance of plant species from the list of 15 traditionally harvested plants were recorded and used for the calculations. The results were then organized by the depth of the site (shallow, medium, and deep) and averaged, to yield an average species richness per depth of midden. Shallow sites were found to have an average species richness of 2.94, medium sites to have an average of 3.17, and deep sites to have an average of 3.33.

Discussion

Our results provide strong evidence for two distinct biogeographic zones: beach and forest. The data analysis which provides this evidence is the one-way ANOSIM comparing community composition at four distances along transect with quadrats (Table 2). When the 0 m quadrats are compared to the 20 m, 40 m and 60 m, the results showed strong statistical evidence for a difference between 0 m quadrats (beach) and all other quadrats (forest). The comparison of quadrats within the forest found no significant difference, suggesting that there is no large shift in community composition after the transition has been made from beach to forest habitat. This result was also important because it shows that the forest community composition was not statistically different between the sites. A one-way SIMPER analysis found that the average similarity between beach sites was around 20% lower than between forest sites. This trend gives statistical evidence to reinforce the visual impression of a difference in intra-group similarities between 0 m (beach) and 20 m and beyond (forest). If the forest communities had been found to be distinct from each other, no conclusions relating to our hypothesis could have been made based on the observation of an increased abundance of edible or technology plants. The beach plant community of each site was different from both the forest communities and the other beach sites.

Our results may suggest that there was a positive relationship between midden depth and the abundance of the 15 edible or technology plant species that we looked for. The one way analysis of similarity using species abundance data showed little difference between shallow and medium sites and between medium and deep sites (Table 1). The comparison of shallow and deep sites suggested a difference in the abundance of the target plant species. Though a strong significance level was found, the small sample size for this test rendered this result uncertain. Because these data merely suggests a finding, further research is necessary for a stronger hypothesis. The second ANOSIM test compared sites based on depth using the quadrat data: community composition, estimated as percent cover. This test did not return a statistically significant difference between sites (Table 2).

Species richness, defined as number of distinct species at a site, was calculated for all sites and then organized by depth. This yielded average species richness for shallow, medium, and deep sites. Deep sites' average richness was highest, followed by medium sites and then shallow sites. There appears to be a positive relationship between depth of midden and the species richness of the 15 species of interest. These results lend evidence for a positive relationship between midden depth and the local variety of traditionally harvested plant species. Two species diversity indices were calculated: the Shannon index and the Simpson index. Both indices follow the pattern of increasing diversity as one moves from medium to shallow to deep sites. Because these results do not increase predictably with site depth as species richness does, they do not provide strong evidence for an effect between site depth and species diversity.

Some potential sources of error in our fieldwork were due to inconsistent pacing and GPS inaccuracy. It is difficult to quantify this because of GPS inaccuracy while under forest canopy. There is still a certain amount of uncertainty always present when pacing in a variety of conditions. Beyond fieldwork, there are other factors that led to our uncertain results. For ANOSIM tests evaluating a difference between sites based on depth, our small sample size led to an uncertain result though our significance level seemed to reject the null hypothesis with certainty. Because the window of time in which we had to conceptualize, design, and carry out this study was brief, only six days could be allocated to data collection in the field. This meant that we could only choose 6 sites to measure plant species abundance, for a total of only 2 sites per depth of midden classification. If we had surveyed more sites per depth, the statistical test results may have supported or discredited the null hypothesis more strongly. In addition to our small data set as well as a lack of proper control sites contributed to our result ambiguity. If control sites of the same environmental conditions but with no past human activity had been available to surveying, our data may have been less ambiguous. Because there is such extensive cultural history in this area, all accessible sites have history of traditional use and middens deposits. Control sites are unavailable as local archaeological work continues to find midden in more and more locations that would otherwise have been suitable sites (beaches and bays with comparable forest communities).

In order to obtain more definitive results, further rounds of data collection at different sites as well control sites are necessary. To select control sites, extensive communication with local First Nations groups would be required to ensure no history of past use, along with ensuring ecological similarity. In addition, tailoring the list of traditionally harvested plant species to the region studied may have resulted in a clearer hypothesis. For example, including Pacific Hemlock Parsley (*Conioselinum gmelinii*) or Labrador Tea (*Ledum groenlandicum*) (commonly seen at many sites) in our observations may more accurately explore the effects of past cultivation and human habitation on this part of the Central Coast.

These results were suggestive of a difference in species richness and abundance between midden depths. Specifically, there was some evidence for an increase in these biotic factors with an increase in midden depth. This may be evidence for a lasting impact of First Nations peoples on today's flora communities near historical village sites. Further research that reinforces this tentative finding could be important to strengthen the link between traditional knowledge and ecological understanding.

The pH of middens is an emergent factor, not initially considered, that possibly influenced our observations. Middens are generally located in productive forest areas, on the edges of forests and at the toe of slopes. This results in higher accumulations of nutrients and glacial tills (K. Hoffman, personal communication, July, 2013). Charcoal from campfires and the inputs of nitrogen from organic matter and calcium from shells enrich these soils and act as a buffer that raises the pH of the soils (Ok et. al, 2010; F. Rahemtullo, personal communication, July, 2013). The increased pH and combination of anthropogenic and ecological factors may combine and form ecosystems where traditionally used plants can flourish (USDA, 2013) in tandem with increased depth. The calcium from middens increased pH to neutral levels, affecting soil conditions and thereby community composition. This calcium leaching and resultant change in soil chemistry would have little effect on *Vacciniums* such blueberries and huckleberries. We noted in our field experience that most *Vacciniums* were found growing from decaying dead-wood, this was affirmed by John Reynolds' (2011) study discussing the ericoid mycorrhizal associations acting to improve nitrogen uptake in poor or acidic soil conditions for these species. At present, the extent of calcium leaching's effect on plants other than *Vacciniums* and how it would change with midden depth and size can only be speculated upon. However, based on USDA (2013) plant index, the ideal pH range for many of our target study species exceed 5.5 pH (e.g. Thimbleberry, Yew, Pacific Silverweed, Springbank Clover) (Table 4). The typical soil pH in areas similar to our study site is approximately 5.0-5.0 pH (B. Starzomski & K. Hoffman, personal communication, July 2013). This suggests that middens themselves could act to greatly improve growing conditions for many of the traditionally harvested plants, and be yet another example of the complexities of traditional management practices. Developing studies into this area could help further the understanding of how these past communities continue to have lasting impacts on the diverse contemporary landscapes.

Species	Depth	Ideal USDA pH range
Springbank Clover	M	6.2-7.0
Pacific Silverweed	SM	5.0-8.0
Northern Riceroot	M,D (out of transect)	5.5-7.0
Nootka Lupine	n/a	6.0-7.0
Salal	SMD	5.5-7.0
Coastal Black Gooseberry	SMD	5.0-7.0
Thimbleberry	MD	4.8-7.2
Salmonberry	M	5.7-7.2
Red Elderberry	n/a	5.0-8.0
Pacific Crabapple	SM, D (out of transect)	6.0-8.0
Red Cedar	SMD	5.1-7.1
Yew	D	6.2-7.5

Table 3. USDA pH ranges of targeted species and study area occurrences.

Conclusion

The Heiltsuk and Wuikinuxv peoples intensively managed the landscape within the Hakai Luxvbalis Conservancy. Physical aspects of this use have been well documented; however, interactions across this landscape can be found in subtle ecological patterns as well.

We studied this potential relationship between past human intensification of land and today's plant communities. Our results are suggestive of a difference in richness and diversity of targeted species over varying midden depths. These positive results warrant further work focused on living landscapes.

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Appendix

Target species name	Description	Reference
Fritillaria camschatcensis (Northern riceroot)	The brown to purple bell shaped flower stands over the 3 main whorls of leaves extending from its stem. In moist and open places *F. camschatcensis* bulbs grow near the surface, easily uncovered using a digging stick or bare hands. Extracted before flowering in spring or after flowering in fall, the clusters of bulbs were either cooked immediately or dried	(Pojar & MacKinnon, 1994).

	to store in a cool location. Technology such as a cedarwood box was required to steam the roots. Alternatively, they were boiled or cooked in ash over the fire and even eaten raw with fish eggs.	
Lupinus nootkatensis (Nootka lupine)	Found in a variety of open habitats, *L. nootkatensis* has blue, pink to white coloured pea-shaped flowers in tall clusters above palmately compound leaflets. The roots of this vegetable were pit-cooked or roasted with special care as some lupines carry toxic alkaloids. ((Pojar & MacKinnon, 1994). This species was the only root vegetable on our list that we were unable to locate.	
Potentilla anserine ssp. pacifica (Pacific silverweed)	The bright yellow flower stands alone on a leafless stalk next to basal leaves of silvery and woolly textures. Cooked alongside other roots, silverweed was eaten by almost all peoples along the Northwest Coast ((Pojar & MacKinnon, 1994). *P. pacific* is a significant plant not only for subsistence, but within economic and ceremonial life (Deur, 2005). Patches of silverweed were owned by chiefs and there is discussion of entire ceremonial feast devoted to eating them (alongside *Trifolium*)	(Deur, 2005).
Trifolium wormskjoldii (Springbank clover)	This estuarine perennial has a white-tipped red to purple flower atop its compound leaflets. Found growing in dense patches along estuaries, the rhizomes of this species	(Pojar & MacKinnon, 1994)

	were harvested in the fall as the leaves died down for winter. Consistent cultivation of these perennial beds maintained growing conditions of the segregated family-owned plots. Sweet to taste like peas, the roots were often eaten with oolichan oil or dipped in fat.	
Gaultheria shallon (Salal)	Salal is common in the understorey with thick evergreen leaves and tiny pink-white urn shaped flowers. *G. shallon* produces dark purple berries of plenty. One of the most important berries of Northwest Coast people, this fruit was eaten fresh and made into dried cakes that preserved well.	(Pojar & MacKinnon, 1994)
Ribes divaricatum (Coastal black gooseberry)	Coastal black gooseberry is a tall deciduous shrub with sharp spines and prickles. Maple-leaf shape leaves and drooping clusters of reddish flowers are identifiable features of this plant. The fruit are dark purple berries with an “agreeable but inspid flavor” ((Pojar & MacKinnon, 1994). The berries were eaten ripe by most Northwest Coast people, but not stored because of their small size.	(Pojar & MacKinnon, 1994)
Rubus parviflorus (Thimbleberry)	Thimbleberry can form into dense thickets by spreading its rhizomes through the soil, usually found in open forest sites. Big, deciduous, maple-like leaves and white wrinkled flowers mark this plant. The juicy red fruit was eaten fresh by all Northwest Coast people, as well as the young shoots. Due to their course and seedy	(Pojar & MacKinnon, 1994)

	texture, these berries could also be dried and stored in cedar-bark bags.	
Rubus spectabilis (Salmonberry)	Salmonberry has three pointed leaflets and pink flowers that bloom in early spring. Juicy and coarse at once, this berry ranges from light orange to ruby red in colour; Coastal peoples have specific names for each colour form. Eaten raw, *R. spectabilis* was considered too juicy to be dried or stored.	(Turner & Hebda 2012)
Vaccinum ovalifolium (Oval-leaved blueberry)	Oval-leaved blueberry has thin oval shaped leaves and solitary pink-white urn flowers. The berries grow to a large size, blue in colour with a waxy coat that dilutes their exterior colour. Distinguished by early ripening on the coast, these berries were eaten raw and fresh or dried in cakes. Often eaten with oolichan grease and preserved in animal or fish grease.	(Pojar & MacKinnon, 1994)
Vaccinum parvifolium (Red huckleberry)	Red huckleberry can grow quite tall (4m) with sharply angled green branches and oblong green leaves ((Pojar & MacKinnon, 1994). Small urn-shaped flowers blossom before the juicy round red berries develop. Quite small and sour to taste, they were eaten raw as well as mashed into cakes. *V. parvifolium* was once gathered by means of a pack basket which was carried on the back with a tumpline over forehead	(Chambers 114)
Vaccinum alaskaense (Alaskan blueberry)	Alaskan blueberry has oval and egg shaped leaves with a hairy mid vein on the underside. Flowers are bronze	(Pojar & MacKinnon, 1994)

	to pink-green in colour and urn-shaped. The fruit is blue-black to purple-black and edible, usually slightly smaller and less sweet than *V. ovalifolium*. They were dried into cakes for preservation. This was one of two berry species we were unable to locate during field work.	
Sambucus racemosa (Red elderberry)	Red elderberry has opposite, divided leaflets with a cluster of white-creamy flowers. The red berries of *S. racemosa* are poisonous when uncooked, but an important part of Coastal people's traditional diet commonly made into make jelly and jam ((Pojar & MacKinnon, 1994). Plant remains have been found in archaeology sites hundreds of years old, according to archaeologist Farid Rahemtullo, *S. racemosa* berries were uncovered in burial remains in Northern BC. This was one of two berry species we were unable to locate during field work.	(F. Rahemtullo, personal communication, July, 2013)
Pyrus fusca (Pacific crabapple)	Pacific crabapple is a small deciduous tree with toothed egg leaves. Its flowers are white/pink blossoms that give way to tiny green/yellow/red egg-shaped apples. The fruit is tart, but considered an important food source for all Northwest Coast people. Harvested late in the summer and early fall, *P. fusca* was eaten fresh or soaked in water filled cedar boxes to become sweeter and softer over time.	(Pojar & MacKinnon, 1994)
Thuja plicata (Western	Western redcedar is a large	(Pojar & MacKinnon, 1994),

redcedar)	coniferous tree with grey-brown stringy bark and green scale-like needles. *T. plicata* was used heavily for technology; for all its gifts to humanity it was named “tree of life”. Canoes, planks, coffins, cradles, bentwood boxes, baskets, clothing, mats, rope and so much more were made from the wood, bark and roots of this tree. The Culturally Modified Trees we inventoried wear the scars of past management.	(Turner & Hebda 2012)
Taxus brevifolia (Western yew)	Western yew is a small tree with reddish papery bark and flat evenly spaced green needles. It’s hard wood was prized by all Coastal nations for its durability and trade value. Ideal for carving, *T. brevifolia* was used in the creation of much ancient technology from weapons to combs. Today, the bark of *T. brevifolia* is optimistically being tested as a cancer-fighting drug, a potential traditional use of this species.	(Pojar & MacKinnon, 1994)

Table 1. description