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Coupled archaeological and ecological analyses reveal ancient cultivation and land use in Nuchatlaht (Nuu-chah-nulth) territories, Pacific Northwest

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ABSTRACT

Indigenous peoples' legacies of plant cultivation and management can have profound effects on contemporary forest structure and species composition long after cultivation has ceased. Despite rich ethnographic accounts of practices like orcharding and fruit tree management in the Pacific Northwest, archaeological and ecological research documenting these practises have been lacking. To investigate ancient and historical land-use and cultivation in Nuchatlaht (Nuu-chah-nulth) territory, we undertook a multidisciplinary study combining archaeological surveys on Nootka Island and ecological analyses of seven anomalous plant communities found adjacent to former village sites. Fifty-seven archaeological sites were inventoried, and 16 previously recorded sites were updated, including six notable village sites. Intensive botanical surveys were subject to indicator species analysis, NMDS, and ANOSIM analysis, which suggest that three putative orchard sites were highly enriched for culturally important and edible fruit and root plants, such as Pacific crabapple (*Malus fusca*), saskatoon berry (*Amelanchier alnifolia*), salmonberry (*Rubus spectabilis*), and wild rice root (*Fritillaria camschatcensis*), and are highly distinctive compared to nearby sites and regional floristic patterns. Four shell midden sites were characterized by plant communities distinct from both orchard sites and control sites. Our archaeological and ecological analyses, alongside ethnohistorical data, strongly suggest a pattern of ancient and/or historical cultural landscape modification by Nuchatlaht peoples to produce food-bearing plant communities in their territories. This compliments findings in other literature, and what Indigenous peoples have long told researchers, that plant resources were routinely encouraged and harvested across their inhabited landscapes.

1. Introduction & background

For the better part of a century, early colonial settlers and anthropologists have labelled Indigenous peoples on the Northwest Coast of North America as hunter-gatherers ("complex hunter-gatherers", "affluent foragers", etc.) without any inclination towards plant cultivation or practices relating to plant food production. These assertions, perpetuated by successive generations of anthropologists and archaeologists, were based on assumptions that Indigenous peoples must have "happened upon" a naturally occurring abundance of resources like animals, fish, shellfish, other marine and riverine foods (McDonald, 2005; Ames, 2013). The assertion that people in the Pacific Northwest did not practice any form of plant cultivation became so widely circulated, that the region became a global anthropological conundrum — how could hunter-gatherers have developed such densely populated, far reaching, and stratified (non-egalitarian) societies without plant cultivation? The answer, of course, is that there *was* plant food production and cultivation.

Indigenous scholars and community members have been steadfast in their knowledge and assertions that their homelands have been cared for and managed for millennia. This localized knowledge has informed scholarly investigations over the last five decades. In particular, ethnobotanical and ethnographic research has shown the extent to which many communities in the Pacific Northwest cultivated a range of terrestrial plant foods in diverse and highly localized ways (Hunn, 1990; Turner, 1999, 2014; Deur, 2000, 2002; Deur and Turner, 2005; Anderson, 2013, 2014; Turner et al., 2013; Armstrong et al., 2018).

Indigenous peoples' land-use and plant management activities have materialized archaeologically in recognizable ways (Lyons et al., 2021). Such findings have been the result of rare and lucky excavations, such as

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the preservation of a 3500-year-old waterlogged and intact wapato (*Sagittaria latifolia* Willd.) garden in Katzi territory near the city of Vancouver (Hoffmann et al., 2016), while other archaeological signatures of cultivation and management have been the result of highly targeted and concerted multidisciplinary efforts (Lepofsky and Lertzman, 2008; Lepofsky and Armstrong, 2018). The identification of Indigenous forest gardens throughout the province of British Columbia (BC, Canada) is one recent example, where the relicts of plant use and cultivation have been identified using archaeological, ecological, and ethnobotanical methods (Armstrong et al., 2021). Forest gardens are ecosystems dominated by edible fruit and nut trees and shrubs, berries, and roots. They are dynamic systems composed of wetland crops, berry patches, and orchards, and continue to grow near archaeological village sites today.

Nuu-chah-nulth people on the northwest coast of Vancouver Island are one of the many Indigenous communities in British Columbia known to have harvested a broad range of plant species for food and medicines (Turner and Efrat, 1982; Turner et al., 1983; Clayoquot Sound Scientific Panel, 1995). Ethnographic, linguistic, and historical records, while heavily focused on fish and sea mammal foods, support the fact that plants played a crucial role in Nuu-chah-nulth diets and trade economies and that some plant species were actively managed across their territories (Turner et al., 1983; Deur, 2002). One of the earliest European accounts of cultivation among Indigenous peoples in the entire province comes from Tahsis Inlet—immediately adjacent to our Nuchatlaht study area, and was historically a former territory of the Nuchatlaht (Menzies, 1792; Drucker, 1951). In September 1792, Cpt. George Vancouver's surgeon and naturalist, Archibald Menzies, noted peoples' intensive cultivation of root crops, "with as much care & assiduity as if it had been a potato field" (Menzies, 1792:116–117). Menzies is referring to intertidal root gardens; cultivated ecosystems at the intersection of tidal and terrestrial environments, managed to encourage "wild" root crops like Pacific silverweed (*Potentilla anserina* L.), rice root lily [*Fritillaria camschatcensis* (L.) Ker Gawl.], and springbank clover (*Trifolium wormskioldii* Lehm.). Botanical and archaeological surveys were used to identify the remnants of these gardens, where associated rockwork structures are still visible throughout Nuu-chah-nulth territories today (Deur, 2002). In fact, during Deur's fieldwork, he noted that for almost a century, archaeologists interpreted all intertidal rockwork as fish traps, and thus missed this key feature of cultivation and plant management (Deur, 2000:186–189). Other ethnographic accounts make mention of intensified berry use and transplanting, especially in the context of strict Nuu-chah-nulth ownership rights and harvesting protocols (Drucker, 1951). Specifically, early colonizer accounts by Moziño (1793), Jewitt (1824), Sproat (1868) and ethnographer Phillip Drucker (1951) mention the intensive use, trade, and tenure over patches of salmonberry (*Rubus spectabilis* Pursh), salal (*Gaultheria shallon* Pursh), blueberries (*Vaccinium* spp.), camas [*Camassia quamash* Pursh] and red elderberry (*Sambucus racemosa* L.) (See also Appendix S1).

Given the express notice of plant foods and their cultivation for Nuu-chah-nulth diets and economies, it is very doubtful that they were only opportunistically gathered. In Gilbert Sproat's (1868) *The Nootka*: *Scenes and Studies of Savage* Life, despite noting that Nuu-chah-nulth people were "non-agricultural", he emphasized the use, maintenance, and importance of Pacific crabapple trees [*Malus fusca* (Raf.) C.K. Schneid] in the Barkley Sound and Tseshaht region:

> "Crabapples are wrapped in leaves and preserved in bags for the winter. The method of cooking them, when fresh plucked, is by simply boiling the apples; but, when they have lost their acidity, they are cooked by *being placed in a hole dug in the ground, over which green leaves are placed, and a fire kindled above all.* ***The natives are as careful of their crab-apples as we are of our orchards;*** *and it is a sure sign of their losing heart before intruding whites when, in the neighbourhood of settlements, they sullenly cut down their crab-apple trees, in order to gather the fruit for the last time without trouble, as the tree lies upon the ground*" (Sproat, 1868:43, bold emphasis added).

Evidently, management strategies like orcharding, root gardening, and berry tending are described as occurring near villages and peoples' habitation sites (Sproat, 1868; Drucker, 1951). This is a key indicator for archaeologists seeking to find instances of land-use and plant management as this is where the material remnants of management practices will be expected to turn up. As has been demonstrated elsewhere in the Pacific Northwest, orchards and forest gardens near archaeological village sites can persist for over a century after people have stopped cultivating there (Armstrong et al., 2021; Vanier, 2022). Notwithstanding this widespread and growing awareness among ethnobiologists and anthropologists, there is a recognizable dearth of archaeological research on Indigenous land-use and plant management in northwestern North America, despite all evidence pointing to such practices as being abundant (Lepofsky and Armstrong, 2018).

To bridge this gap, we undertake a historical-ecological approach that combines archaeological and ecological methods to test whether the remnants of Nuu-chah-nulth management, specifically orcharding, are identifiable today. Orchards and forest gardens are targeted based on ethnographic and linguistic data (Appendix S1), and based on experience successfully identifying forest garden ecosystems elsewhere in the Pacific Northwest (Armstrong et al., 2021). Here, orchards are defined as managed plant communities within forest garden complexes, where the focus of management is on the enhancement and production of fruit trees like Pacific crabapple and large edible shrubs like beaked hazelnut (*Corylus cornuta* Marshall) saskatoon berry [*Amelanchier alnifolia* (Nutt.) Nutt. ex. M. Roem], salmonberry, and red elderberry.

To test whether a framework that couples ecological and archaeological data could be useful in identifying ancient plant cultivation and land use, we selected a study region in Nuchatlaht territory, a nation within the larger Nuu-chah-nulth ethnolinguistic group. Nuchatlaht was selected based on (1) the relative frequency and intensity of culturally modified trees in the region (despite the scarcity of other archaeological surveys and research in the past), (2) the potential for identifying the material remnants of management, given the strong ethnographic records, and (3) that one of the authors has previous archaeological experience in the region.

Taken together, ethnographic and ethnobotanical evidence informs our methodological approach; by characterizing these data we are then able to construct a culturally and geographically specific methodology focusing on a coupled botanical and archaeological approach. Specifically, we hypothesize that a survey of archaeological village sites in Nuchatlaht territory, combined with a systematic study of contemporary vegetation in the vicinity of such sites, will allow us to document sites of ancient management. This hypothesis builds on global historical-ecological research, which has shown the extent to which some contemporary plant communities reflect ancient or historical management (Hammett, 1992; Keener and Kuhns, 1998; Ross, 2011; Odonne et al., 2019) especially plant communities growing near archaeological village sites (Balée, 2013; Munoz et al., 2014; Warren, 2016; Pavlik et al., 2021).

Below we present a methodological framework focused on identifying local populations of ethnobotanically salient species then test whether those aggregations are the legacies of ancient management or are merely naturally occurring plant foods. The premise is that orchards, as a component of forest gardening and unlike wild ecosystems, (1) form a definable aggregation of native fruit trees, shrubs, and root foods which can be statistically verified (using plant inventories), (2) are a recognizable feature of the immediate archaeological landscape (they typically occur within and near village sites), and (3) will produce unique structural patterns (e.g., formed canopies, linear rows, dense aggregations, cleared deadfall, no recent stumps).

2. Methods

2.1. Study sites

Nuchatlaht is one of eighteen Nuu-chah-nulth Nations [composed of historically distinct or amalgamated groups, see McMillan (1999)], whose territories span the majority of western Vancouver Island in northwestern North America. Early explorer and fur trader estimates of Nuu-chah-nulth populations following (AD 1778) contact were collectively large (Beaglehole, 1967; Meares, 1790; Boyd, 1999; Jewitt, 1824). Synthesis of several population estimates for the Nuu-chah-nulth ranges between a conservative 12,375 (Boyd 1999:264) to approximately 30, 000 people (Arima et al., 1991). Following the turmoil of introduced epidemics and conflict during and following the fur trade, populations of the region suffered a demographic loss between 70 and 90%. The first reliable census for the Nuu-chah-nulth of Vancouver Island in 1884 noted a reduced population of 3500, which continued to slip until 1939 at a population nadir of 1605 (McMillan, 1999:193).

The study area encompasses Nuchatlaht territory, which includes northern Nootka Island and adjacent islets (Fig. 1). The entirety of the study area is within the Coastal Western Hemlock (CWH) Biogeoclimatic Zone, the majority of which is characterized by temperate climate, hypermaritime precipitation, and highly productive and structurally complex coniferous forests (Meidinger and Pojar, 1991).

2.2. Archaeological data collection

To test whether people actively managed plant species or cultivated landscapes within the study area, we compiled a list of known archaeological sites drawn from the provincial archaeological database (RAAD, 2022), focusing specifically on sites of intensive land-use such as house depressions and shell midden sites. Shell middens reflect areas of intensive use, which typically indicate an investment in, or repeated return to, the same area sometimes over centuries but more commonly over millennia. In addition to shell midden sites, we also considered archaeological sites that reflect other recurring land-use practices such as fish traps, culturally modified trees (CMTs), and burials.

Aerial imagery from Google Earth and Bing Maps was used to identify areas near archaeological sites with anomalous or noteworthy vegetation. In areas where orchards or forest gardens have been cultivated breaks in the conifer canopy are occasionally apparent (Armstrong et al., 2021). Aerial imagery on western Vancouver Island shows relatively continuous canopies of conifer-dominant forests with multiple gaps from logging (both from recent and historical logging) and other natural phenomena (flooding, windthrows, etc.). We identified any potential sites with gaps that were characteristic of potential orchards, which tend to have less linear breaks and lower/less uniform vertical canopy height (compared to second growth from logging disturbances). Together, anomalous vegetation in proximity to archaeological shell midden sites helped narrow down our potential survey areas to a total of 12 sites. To verify whether breaks in conifer canopies were not the result of recent historical disturbances (e.g., settlements, logging, flooding, or other events) we analyzed historical air photos from our study sites dating back to 1930 (National Air Photo Library n.d.) (Fig. 2). All sites were accessed by boat, and we used this travel time to survey shorelines, noting other anomalous or noteworthy vegetation. From this additional reconnaissance, four sites were added to our study, for a total of 16 survey sites (Fig. 1).

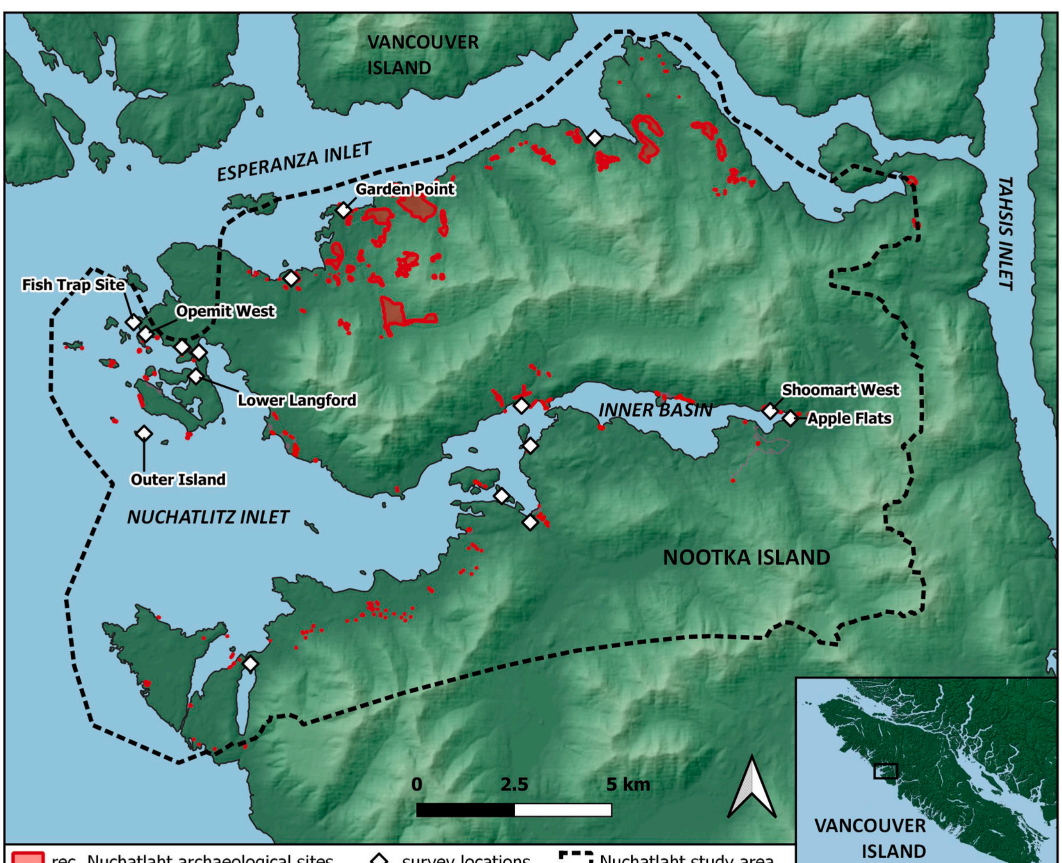

Fig. 1. Nuchatlaht study area, northern Nootka Island adjacent to Vancouver Island, British Columbia, Canada. Sixteen sites investigated for this study were chosen based on previously recorded archaeological sites, aerial imagery, and preliminary boat surveys.

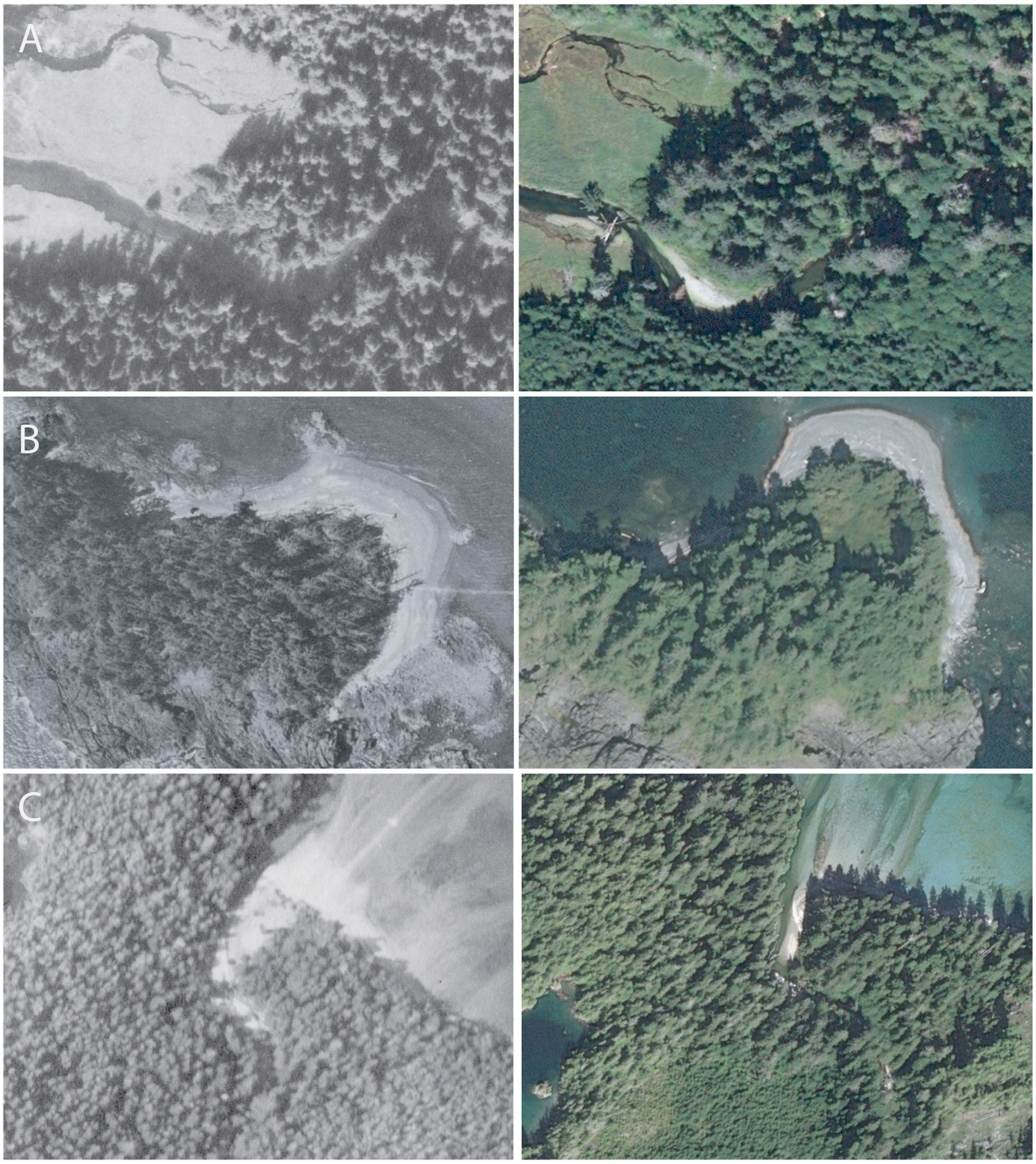

Fig. 2. Sample historic air photos (1930) and aerial imagery from study sites: (A) Apple Flats, (B) Outer Island (note anomalous vegetation), and (C) Garden Point.

2.3. Botanical data collection

At all 16 study sites, vascular plant species were inventoried by employing transects, walking a set distance across the site and recording all plants within a 2 m buffer of the recorder. Of the original 16 sites of interest, 7 were determined to be potential orchards based on the frequency of ethnobotanically important food plants, their proximity to archaeological sites, and in some cases, the curvilinear arrangement of large fruit trees. A geographical and archaeological overview of sites is provided below (Appendix S2).

To characterize the occurrence and frequency of plant species, higher resolution botanical inventories were then employed at all 7 sites (Appendix S3). Inventories were conducted in accordance with the BC Field Manual for Describing Terrestrial Ecosystems (BC Ministry of Forests, 2010) and based on previous research methodologies developed for BC-specific studies on anthropogenic vegetation (Armstrong et al., 2021; Lepofsky and Armstrong, 2018). Botanical nomenclature followed the *Electronic Atlas of the Flora of British Columbia* (Klinkenberg, 2020). All nearby archaeological sites and features (within 300 m of transects) were recorded.

A boundary marker was set by walking the perimeter of each site with GPS tracks, or by outlining the potential site area using aerial imagery. Using that boundary marker or polygon as the extent of the site, we divided the sample area into 5 × 5 m plots. Within each plot, tree, shrub, and herbaceous species were recorded. A mean of 6 plots were recorded at each site. In order to characterize the ambient conifer ecosystems of the region control plots (5 × 5 m, 3 per site) were recorded in adjacent conifer forests, where a clear break in the broadleaf vegetation was present. Control plots were randomly selected outside of the potential orchard and averaged ~30 m from the boundary marker. All control plots were in conifer-dominant forests, but do not necessarily reflect the absence of human land-use (in one case, at Apple Flats, there was evidence of recent logging).

2.4. Ecological analysis

To compare plant community composition between sites, we carried out indicator species analyses, non-metric multidimensional scaling (NMDS), and analysis of similarities (ANOSIM) across all 7 sites. To identify species that were strongly associated with specific types of plots ("indicator species") and statistically differentiate between ecosystems, 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. To further understand differences between plots, we conducted an NMDS analysis with the R package *vegan* ver. 2.5–7 (Oksanen et al., 2020) using the Jaccard dissimilarity index and visualized the results with the R package *ggplot2* ver. 3.3.3 (Wickham, 2011). To test for statistically significant differences between the plots at each site and across all sites, we conducted an analysis of similarities (ANOSIM) with *vegan* using the Jaccard dissimilarity index and 9999 permutations.

3. Results

3.1. Archaeological data

Archaeological data and analyses within the Nootka Island study area is notably lacking and incomplete compared to other nearby Nuu-chah-nulth communities (McMillan, 1969; Dewhirst, 1978, 1980; Calvert, 1980; Haggarty, 1982; Marshall, 1992, 1993; Ogden, 2015). Most archaeological sites recorded in the study area were the result of (1) cultural resource management surveys ahead of logging and (2) surveys by Haggarty and Inglis (1984, 1987) along the northern Nuu-chah-nulth coast in 1984 and for the Nuchatlaht Ethnography project in 1987. The Inglis and Haggerty surveys focused on locating shoreline villages, middens, fish traps, and burials of which there was some local knowledge. While they recorded dozens of sites in a matter of days (which is rather exceptional), no sites were described in detail or mapped. Similarly, inland surveys focusing on the expedient identification of culturally modified trees in advance of logging have not resulted in any significant research or analyses outside of government permit reports.

Notwithstanding the limited archaeological research within Nuchatlaht Territory, we were able to conclude that the study area was a relatively densely occupied landscape. Cultural resource management surveys associated with logging have assessed approximately 5% or less of the land base in the Nuchatlaht study area and yet over 8000 CMTs, deep within Nootka Island's forests, including two significantly large cultural forests containing over 2500 CMTs, have been recorded to date (PARL, 2022; RAAD, 2022). Several Nuchatlaht archaeological surveys between 2017 and 2021 have resulted in the identification of 45 CMT sites, 11 middens, and a large burial site. Additionally, 16 previously recorded sites were updated within the study area (RAAD, 2022). During our 2021 fieldwork, we determined six of the originally identified middens (Haggarty and Inglis, 1984, 1987; RAAD, 2022) to be larger than previously recorded and are notable Nuchatlaht village sites with terracing, house depressions, and extensive midden deposits (Fig. 3). Due to time constraints, we were unable to visit several more village and defensive sites identified by Haggarty and Inglis in the 1980s. Notably, almost every botanical survey site (n= 7) visited during our study resulted in the identification of dense clusters of unrecorded or under-recorded archaeological sites. These recent findings suggest the Nuchatlaht study area is just as archaeologically rich and diverse as other more studied regions and territories on the west coast of Vancouver Island.

3.2. Botanical data

Of the 16 sites of interest, 7 sites were chosen for higher resolution inventories, based on the frequency of ethnobotanically important plants and their proximity to archaeological sites. Sites dominated by red alder (*Alnus rubra*), willows (*Salix* spp.) and other seral species without a history of management were disregarded. Although both willows and red alder have notable ethnobotanical uses for Nuu-chah-nulth (e.g., Turner and Efrat, 1982), these environments, dominated by broadleaf trees and which produce a noteworthy break in the aerial imagery, were determined to be the result of recent logging disturbances

Fig. 3. Archaeological inventory of aboriginal logging and bark harvesting sites (A), recorded terraces and house depressions at village sites (B), shell midden sites, in this photo, exposed by upturned tree (C). Photography J. Earnshaw (A), Troy Moth (B,C).

(e.g., red alder growing in homogenous stands among conifer stumps), or natural openings along wet sites like creeks and seepages (a minor component of the forest and too small and inadequate for sampling). Final survey sites included: Garden Point, Outer Island, Apple Flats, Shoomart West, Opemit West, Fish Trap Site, and Lower Langford. At the latter four sites, the inventoried vegetation grew directly on top of shell midden. The remaining three sites were within 100 m of a midden site or burial, but not directly on top of shell middens.

Vegetation inventories of the 7 sites of interest revealed a clear pattern of plant community composition resulting in three distinct site types: orchard sites, shell midden sites, and control sites (Table 1). ANOSIM tests, which can compare complex plant communities, showed that midden and orchard sites were significantly different from one another ($p > 0.0001$; $R = 0.5395$). As expected, test sites (orchards and shell middens) were significantly different from their nearby controls ($p < 0.0001$). All control sites were not significantly different from one another (i.e., between midden controls and orchard controls; $p = 0.0619$; $R = 0.09936$). The NMDS visualization illustrates clear differentiation between orchard and midden plots (Fig. 4).

Both site types' controls appear to meaningfully aggregate, that is, regardless of whether the site was an orchard or a midden, their controls reflect similar ecosystems characterized by the same aggregation of species. Although false-lily-of-the-valley [*Maianthemum dilatatum* (Alph. Wood) A. Nelson & J.F. Macbr.] and false azalea (*Menziesia ferruginea* Sm.) were most closely associated with midden control sites, further soil analyses may indicate why this was the case. The control plots for both orchard and midden site types were characterised by typical primary forest species for this Biogeoclimatic Zone, such as sword fern [*Polystichum munitum* (Kaulf.) C. Presl] and western redcedar (*Thuja plicata* Donn ex D. Don), reflecting a similar conifer-dominant forest on the edge of both site types. While these species are ethnobotanically salient — indeed, western redcedar is considered a cultural keystone species for many Northwest Coast communities (Garibaldi and Turner, 2004) the significance here is that paired sample/control sites accurately represent the ambient conifer-dominated landscape. This tactic is useful when experimental conditions are complex or difficult to isolate.

The orchard, midden, and control sites also contained characteristic indicator species that distinguish them (Table 2). The first site type, orchard sites (Garden Point, Outer Island, and Apple Flats), are characterized by culturally important plants with berries and other fleshy fruits and edible underground structures like rhizomes and bulbs. Six plant species (Pacific crabapple, salmonberry, saskatoon berry, rice root lily, salal, and Pacific silverweed) are strongly associated with these sites, one being either exclusively associated with orchard site types (saskatoon berry) or occurring more frequently and intensely at the sites (salal). All the species in the orchard sites were once highly important foods and trade products for Nuu-chah-nulth people (Turner and Efrat, 1982).

Pacific crabapple was strongly associated with orchard sites in the Nuchatlaht study area (indicator analysis $p < 0.0001$). This is unsurprising given the ethnobotanical importance of Pacific crabapples for food, the strong ethnographic evidence of management and cultivation, and the predominance of apples at each of the three forest garden sites. This pattern is also seen elsewhere on the coast, as relict apple orchards occur in Heiltsuk and Ts'msyen territory (Lepofsky et al., 2017; White et al., 2021), and in Coast Salish territory (Stapp and Walker, 2018; Armstrong et al., 2021; Vanier, 2022). There is no doubt that Pacific crabapples grow in the region without any human intervention, but they tend to be young-growing, sparse, and occur on the edge of islets, backed by conifer forests (Routson et al., 2012) — they do not occur in such frequency and size as is found at Outer Island, Garden Point, and Apple Flats.

Table 1
Results of analysis of similarities test comparing midden and midden control plots as well as orchard and orchard control plots.

Plot types tested	R-value	P-value
Orchard vs. orchard control	0.8201	0.0001
Midden vs. midden control	0.5423	0.0001
Orchard vs. midden	0.5395	0.0001
Orchard control vs. midden control	0.09936	0.0619

The second site type is associated with (growing on top of) shell middens at Opemit West, Fish Trap Site, Lower Langford, and Shoomart West, and is characterised (with significant p-values at $\alpha = 0.05$) by two edible species, cow parsnip (*Heracleum maximum* W. Bartram) and thimbleberry (*Rubus parviflorus* Nutt.) — both of which were eaten in large quantities but not stored over the long-term. Additional species included (at $\alpha = 0.10$) include giant vetch (*Vicia gigantea*), hedge nettle [*Stachys cooleyae* Benth. (A. Heller) G. Mulligan & D. Munro], and wild raspberry/nagoonberry (*Rubus idaeus* L.). Shell midden plant species, although still different from naturally occurring forests, are likely the result of a natural succession of plants after people departed from the village (plants would not have been growing there at the height of occupation (Fig. 5).

3.3. Archaeological and ecological syntheses

The cultivation and management of plant species has resulted in unique plant communities in the study area, which likely would not have occurred naturally (without human interference). Based on botanical inventories, we determined plant communities at Outer Island, Garden Point, and Apple Flats are statistically unique from other plant communities, and that indicator species of the orchard site type are dominated by edible fleshy fruits and root foods that can be harvested and stored over the long term. Uncoincidentally, all the sites are associated with rich archaeological landscapes (Fig. 6).

At Apple Flats, the orchard site is located at the end of a large inlet, adjacent to a historical habitation site (Indian Reserve 5) and an archaeological shell midden site (Shoomart West). Outside of these habitation sites are an archaeological fish trap site and multiple culturally modified tree sites — indicating varied and widespread use of the immediate landscape. Clear-cut logging disturbances from 1980 have altered the southern half of the estuary; large stumps and scrubby second growth of western hemlock and spruce are concentrated to the south of the orchard site. The orchard itself does not have visible stumps or deadfall and historic air photos (from 1930) show that the canopy of the orchard has remained intact over the last century (Fig. 2). Taken together, and with the ethnographic evidence, we conclude that the Apple Flats orchard is not the result of recent or natural succession, and that it is a previously managed orchard — similar to others identified north of the study area (Lepofsky et al., 2017).

At Garden Point, an exposed shell midden along the beach was identified by Haggarty and Inglis (1984). The site was re-visited and we identified a flat mound of midden along the waterfront, likely representing one large, or multiple smaller, house platforms (11 × 15 m). Additional house platforms were visible behind the beach on a promontory overlooking the river and the midden site was extended roughly 40 m. Future archaeological work will ascertain the full extent of this impressive Nuchatlaht village. On the opposite side of the creek, flowing against the southeastern edge of the midden site, more than 90 individual crab apple trees and other edible fruit trees and shrubs were identified. Interspersed throughout the boundaries of the orchard site are sparsely growing (likely old-growth) conifer trees, which made it difficult to characterize the orchard through aerial imagery alone (older conifers form dense canopies). Several western redcedar and Douglas fir [*Pseudotsuga menziesii* (Mirb.) Franco] trees exhibited cultural modifications (i.e., CMTs) that were not previously recorded. Given the association of edible fruit trees and shrubs, verifiably distinct from other plant communities in the study area, and that these occur adjacent to a freshwater source, an extensive shell mound site, exposed beach midden, and numerous culturally modified trees, we conclude that

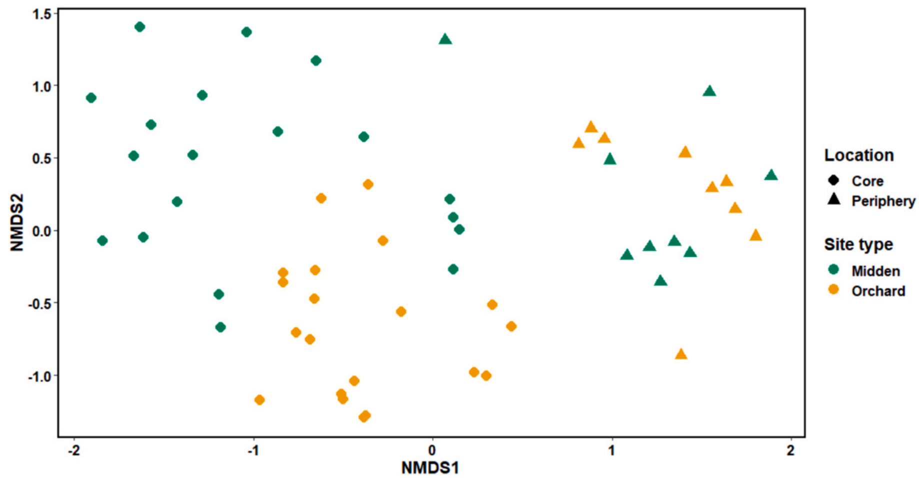

Fig. 4. Visualization of non-metric multidimensional scaling (NMDS) analysis at and adjacent to midden and orchard sites. Periphery indicates control plots and core indicates plots on middens or in putative orchards.

Table 2
Indicator plant species differed significantly between orchard, and shell midden sites as well as their respective controls. Control sites of both types were similar to each other and characteristic of the CWH dominant forest type in the region. Ethnobotanical uses are Nuu-chah-nulth specific and compiled from Turner and Efrat (1982) and Clayoquot Sound Scientific Panel (1995).

Species	Common Name	Ethnobotamcal Uses*	P-Value
Orchard			
Malus fusca	Pacific crabapple	Ed, Sr, Md, Tx	0.0001
Rubus spectabilis	Salmonberry	Ed, Md, Tx	0.0047
Amalanchier alnifolia	Saskatoon berry	Ed, Sr, Md, Tx	00389
Fritillaria camschatcensis	Rice root lily	Ed, Sr	00341
Gaultheria shallon	Salal	Ed, Sr	0.0316
Potentilla anserina	Pacific silverweed	Ed, Sr	0.0321
Periphery Control			
Thuja piicata	Western redcedar	Tx	0.0001
Polystichum munitum	Sword fern	Md, Tx	0.0109
Picea sitchensis	Sitka spruce	Ed, Tx	00337
Shell Midden			
Heracleum maximum	Cow-parsnip	Ed	00238
Rubus parviflorus	Thimbleberry	Ed, Tx	00252
Periphery Control			
Thuja plicata	Western redcedar	Tx	00003
Maiathemum dilatatum	False lily-ot-thevalley	Ed, Md	00083
Polystihum munitum	Sword fern	Md, Tx	0.009
Menziesia ferruginea	False azalea	–	0.0342
Edible = Ed Storabte Food = Sr Medicinal = Md Textile/Technology = Tx			

Garden Point was an actively cultivated and managed landscape and that future archaeological research in the area is warranted.

At Outer Island, and unlike the other orchard sites, aerial imagery shows a distinct canopy break from the contiguous conifer forest. Upon surveying the area, we found that the canopy dominated almost entirely by Pacific crabapple and historical air photos confirm the consistency in canopy cover dating back to 1930 (Fig. 1). The alignment and structure of the species is worth considering in this, and future studies; the shrub layer around the dominant canopy of Pacific crabapple was relatively cleared save for knee-high shrubs of salal, salmonberry, and sparse saskatoon berry. There were no stumps, very little deadfall, and the individual crabapple trees were extremely well-spaced — all of which may be indicators of cultivation. The orchard was more of a parkland than a forest, and it was composed of the largest Pacific apples any of us have ever observed, with trunks up to 50 cm in diameter. Outer Island is 500 m from the Nutchatl Indian Reserve (IR2) and a large archaeological site complex of villages and a Nuchatlaht fortified site (DkSr-6, DkSr-32, and DkSr-33), and was likely associated with one or both occupations. It is also worth noting that during our survey of the area multiple concealed pre-colonial bentwood box burials were located in a concealed cave on the island and a previous series of bentwood box burials were located. The orchard, together with the burials, clearly reflect a level of use, attachment, and occupancy of the island.

4. Discussion and conclusion

Coded into the Nuu-chah-nulth language is a complex knowledge base and understanding of plants and the surrounding environment (SI Appendix S1). Locally specific ethnobotanical knowledge and nomenclature not only demonstrates the importance of fruit trees and berry species for Nuu-chah-nulth communities but can be useful for archaeologists to document relict sites of land-use and plant management. While the assembly of plant species in a given ecosystem (how and where plants species grow) is in large part a response to biophysical processes (available soil nutrients, climate, etc.), in some cases, people can and have influenced these processes as well, through acts of cultivation such as weeding, tilling, pruning, and transplanting (Warren, 2016). People can influence 10 biophysical processes through direct and indirect mechanisms linked to niche-construction, efficient use of resources, and social-ecological processes like private ownership and taboos (Thomas, 2014; Turner, 2014). We determined that the vegetation associated with shell midden sites in our study may be the result of epiphenomenal impacts— Opemit West, Fish Trap Site, Lower Langford, and Shoomart West had specific and unique plant species growing directly on top of shell middens. When people live in the same area for extended periods they keep the area cleared (of conifers, for example) and by-products such as organic materials from shells create a soil substrate that is rich in phosphorus and nitrogen (Fisher et al. 2019). These biophysical and human processes interact and, over time, result in influences on the diversity, size, and complexity of plant communities (Trant et al., 2016; Schang et al., 2022).

Orchards reflect more deliberate, planned, and intentional acts of forest gardening, land-use, and management. The unique composition of plant species, their arrangement, their association with archaeological villages and other land-use sites like culturally modified trees, fish traps, and burials, and the indisputable ethnographic evidence of orcharding practices, leaves little doubt as to the characterization of cultivation of plant management sites in Nuchatlaht territory. Peoples' use and occupation areas did not start and stop at the walls of the longhouse.

Fig. 5. Left: Shoomart shell midden site; note the obvious break in the conifer-forest in the foreground where control samples were taken. Right: Large Pacific crabapple trees at Outer Island. Photography C.G. Armstrong and Troy Moth.

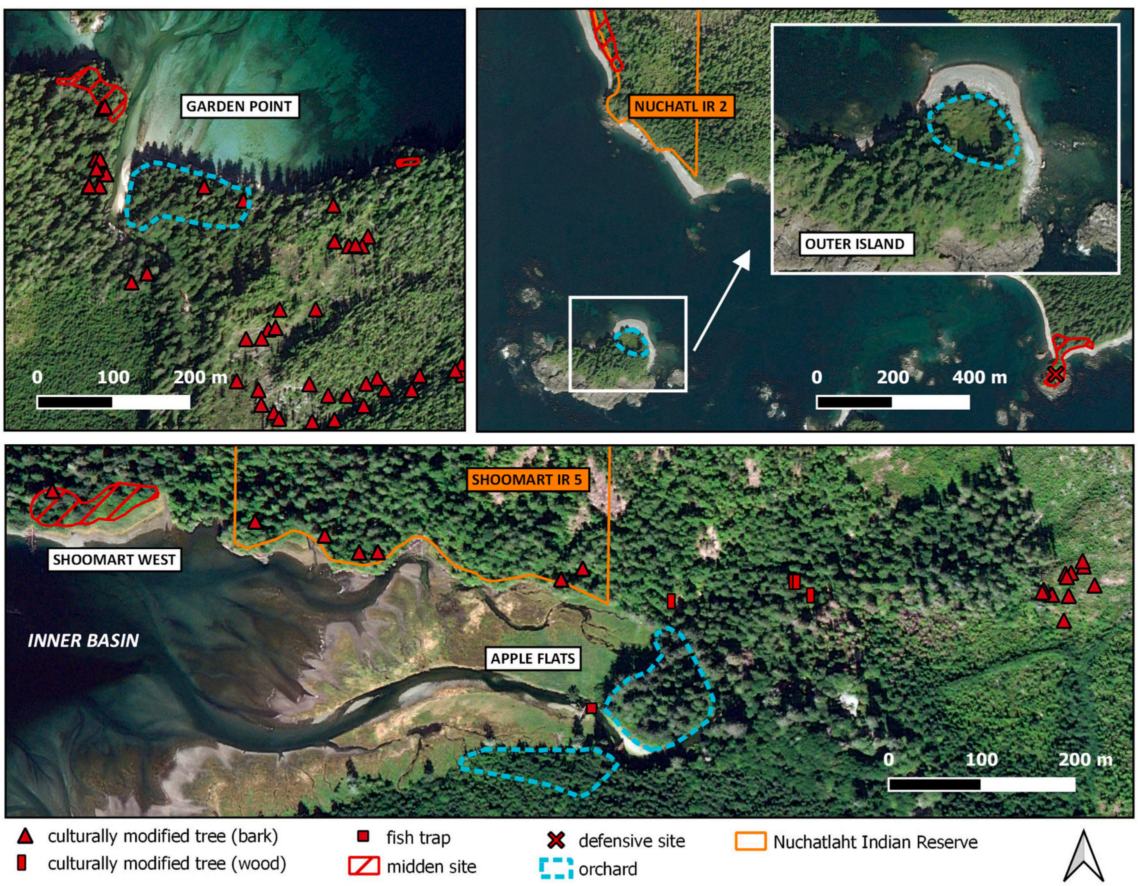

Fig. 6. Orchard sites in Nuchatlaht study area. Clockwise from top left: Garden Point, Outer Island, Apple Flats. Note associated archaeological sites and features. Orchard boundaries are not discrete and are characterized by an ecotonal gradient where vegetation from both the peripheral conifer forest and orchard site are more mixed.

And despite the often colonially charged reasons for overlooking or undermining Nuu-chah-nulth peoples' land-use practices in the past (see Deur and Turner, 2005), we know better now and should be making a more concerted effort to include such considerations in archaeological research.

Globally, the use of contemporary vegetation as markers and indicators of land-use in archaeological landscapes has resulted in productive and informative research (Ross, 2011; Ford and Nigh, 2009; Balée, 2013; Odonne et al., 2019; Pavlik et al., 2021). In North America, early anthropologists and ethnobotanists made a strong connection between anomalous vegetation and archaeological village sites, including in the works of Melvin Gilmore (1930) Volney Jones (1942), and Alex Hrdlička (1937). So, while the coupling of archaeological and ecological data is not entirely new, such work is worth better integrating in future studies. Archaeologists have made efforts to consider plant species and inventories in their research (making "plant lists"), but these are typically done without any analyses and without considering or synthesizing wider ethnobotanical or historical-ecological frameworks (Harris, 2018).

The lines of evidence presented above are informed by multidisciplinary methods and historical-ecological praxes which challenge the assumption that all plant communities *not* domesticated are the result of natural or biophysical processes alone. We are only beginning to understand the scale and impact of Indigenous land-use legacies on contemporary and native plant communities (Warren, 2016; Pavlik et al., 2021; Turner et al., 2021). As "pristine myths" (e.g., Denevan, 1992) continue to crumble under the scrutiny of methodological advancements and a critical evaluation of deeply rooted colonial narratives, we offer this methodology, that couples archaeological and ecological methods and indices, to better articulate the wide spectrum of peoples' ancient and ongoing use and modification of the lived landscape.

Declaration of competing interest

We declare no conflict of interest or competing interests.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jas.2022.105611.Acknowledgements

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