Historical Ecology of Cultural Landscapes in the Pacific Northwest

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Abstract

Historical ecology is a research program dedicated to uncovering the complex interactions between humans, their lived landscapes, and the repercussions of those relationships on contemporary social-ecological ecosystems. Cultural landscapes can exhibit multifaceted and complex elements that require a creative and novel scientific approach to be understood. A historical-ecological approach iteratively fuses scientific methods in archaeology, biology, paleoecology, and environmental history, with Indigenous research methodologies. Using the Pacific Northwest as a focus, this dissertation addresses the applicative future of historical-ecological research.

Four interrelated research contributions are compiled to represent both the broad theoretical applications of historical ecology in a global context, as well as more regionally focused and explicit methodological contributions. In two papers, results from a consensus-driven, priority-setting exercise and literature review, suggest that the future of historical ecology will have implications for policy, stewardship, and decolonizing attitudes towards resource management and climate change research. In a third paper, ethnographic interviews are used to navigate a nexus of federated knowledge surrounding the management of perennial species like hazelnut (*Corylus cornuta*) and Pacific crabapple (*Malus fusca*) in British Columbia (BC). This work shows that, while the legacy of colonialism has disorganizing effects on Indigenous communities, Indigenous people have distinct traditional ecological knowledge relating to the management of their ancestral homelands. The fourth paper builds on this work by applying a functional ecological approach to analyze anthropogenic forests from archaeological village sites in BC. This analysis illustrates how Indigenous land-use legacies lead to distinct biodiverse ecosystem functions and services. The wide range of co-authors from various fields, institutions, and Indigenous communities in all these papers exemplifies the multidisciplinary and versatile nature of the historical-ecological approach. This dissertation shows that environmental research requires the equitable consilience of multiple voices and disciplines for a future that is socially and environmentally just.

Keywords: cultural landscape; environmental archaeology; ethnoecology; functional ecology; historical ecology; traditional management

Dedication

To all those without voices,
without feet or Lords

the tendrils around my heart
are tender and tended by your heartwood
you keep me warm and curious
through every cell, hell-bound without you

at once a cleared field
thence kernels become trees
to fill a void
fulfill a purpose

tiny cotyledons break through the earth,
breaking layers of lives lived in place
your handmaidens are the ancestors
whose names are stored in rocks and wallows

winds roll, I pull you in for sweet smells
then earth swells and breaks
but peat moss protects our landing
so we colonize you once again

to you I dedicate my words and my praise
to you I dedicate grandmothers seven teachings,
your seeds are stores of kindness and resistance
your persistence a constant reminder

of movement and compassion.

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I acknowledge every one of you who has helped me along the way and will continue to teach me the Mino-Bimaadiziwin.

To all the Elders, community members and Nations who allowed me to work and study on their territories — I thank you. Because of you all, I will seek to tread lightly, humbly, respectfully, and playfully in all my work.

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To my peoples: Mom and Dad you've supported my through it all. I love and admire you both so much. Uncle Alex, Auntie Lil, Aunt Gina, Auntie Mary-Lee, Jules Armstrong, Joe Runnalls, all my 42 cousins in fact, Andrew Heneghan, Megan Cassidy, Tracy Giesz-Ramsay, Morgan Bartlett, Evan Hardy, Phillip Blundon, Rena-Marisa-Megs, Riley and Kass, and Sean P (duh), — I thank you all for your support and friendship.

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Chapter 1. Introduction

> *But sense of place is not possessed by everyone in similar manner or like configuration, and that pervasive fact is part of what makes it interesting* (Basso 1996:144).

Landscapes are the cumulative layers of lives lived in a place, whose uncountable actors move at small microscopic scales and across vast continental spaces (Heidegger 1977; Ingold and Jarowski 2012; Leopold 2004). The historical ecologist is tasked with simultaneously unravelling and entwining landscape complexities in creative and critical ways. By using the landscape as the unit of analysis, and by bringing together diverse methodological standards and practices, historical ecology is broadening its research influence in both the natural and social sciences (Balée 1998, 2006; Egan and Howell 2001; Erickson 2003; Lunt and Spooner 2005; Szabó 2010a, 2015; Szabó and Hédl 2011). This doctoral research uses a historical-ecological framework to integrate natural and social sciences and Indigenous worldviews for a more expansive, anisotropic, and relational view of the landscape. The four research articles comprising this dissertation consider various ways of researching and understanding the temporal interactions between humans and their environments. The papers address these issues at both local and regional scales, within the Pacific Northwest and beyond.

The term “historical ecology” has been used throughout the twentieth century, in both interrelated and independent ways, across disciplines such as anthropology, history, ecology and geography. Although there is no unifying method or theory, historical ecology is more than a convenient label — it has meaningful and lengthy academic roots that have connected scientists from numerous disciplines with the expectation of solving complex research questions involving both the natural and social sciences. Research involving long-term human-nature interactions has been called landscape history (Christensen 1989; Foster et al. 1999; Foster 2001), environmental history (Crosby 2000; Rymer 1979), environmental archaeology (Butzer 1964; Dincauze 2000; Evans and O’Connor 1999), forest history (Hermy 1992; Rackham 2000) or historical ecology (Balée 1998; Fairhead and Leach 1996). These, mostly sub-disciplines, have developed out of larger ones like archaeology, history, and ecology, however historical ecology is one prominent exception, which has cross-cut disciplinary boundaries since its infancy. Its development as a research program has matured independent of any one discipline in the last two decades, more researchers are using the label to self-identify, and publications using the label have more than doubled since 2000 (Szabó 2014).

Some larger research questions approached by historical ecologists are not entirely new or novel. For example, there are longstanding debates about the nature of human-environment interactions, especially in ecological or environmental anthropology (Steward 1972; Harris 1989; Kay 1994; Moran 1990; Nazarea 2006; Orlove 1980; Rappaport 1968; Townsend 2008). There have also been substantial developments by human geographers confronting the Anthropocene epoch — in which they have recently developed their own positions on the nature of human-environment interactions (Ellis 2015; Williams et al. 2016; Zalasiewicz et al. 2011). Whichever label satisfies the researcher, we are in an age where we are seeking a consilience of scientific method and theory, a conversation that is not elitist and hopefully one that can bring both longstanding theory and debates to new experimental research and fields of inquiry.

A landscape approach is purposefully fluid and can be imagined, constituted, designed, and re-designed depending on the community or audience (Tilley and Cameron-Daum 2017). Landscapes trigger acts of self-reflection, memories, reveries, and are "represented and enacted daily, seasonally, annually and [are] continually woven into the fabric of social life anchoring it to features of the landscape" (Basso 1996:57). Even seemingly a-cultural and barren spaces, like glaciers, are filled with stories and lessons that are expressed as more than merely natural (Cruikshank 2014). As Western scholars (e.g., see Atalay et al. 2014), detached from ancestral homelands, the valuation of the landscape of "others" is often less than personal or familiar. For many Indigenous people (including Indigenous scholars), landscapes or "their places", as Vine Deloria (2003:61) asserted, "have the highest possible meaning, and all their statements are made with this reference point in mind".

The Pacific Northwest, where there are detailed ethnographic and ethnohistoric records and distinct social-ecological systems, is ideal for historical-ecological research. Such research involves an appreciation and understanding of both the physical and socio-cultural constituents of the cultural landscape. This requires sound scientific research that is iterative and respectful of descendant communities, collaborative and inclusive of worldviews and realities. Although the scientific method has been associated with the proliferation of colonial interests, often to the detriment of Indigenous peoples' well-being, we are witnessing a shift in how it is used (Duran and Duran 1995; Porsanger 2004; Wilson 2008). Without strong scientific methods, historical ecologists are not necessarily able to translate their research into legislative language or contribute meaningfully to questions or concerns a community might have. However, any scientific method that is not rooted in the worldviews and/or objectives of the descendants of a specific place is without substance and is subject to greater bias, the superimposition of Western values, and perpetuating on-going colonialism. Historical-ecological research in the Pacific Northwest — as in any settler-nation context — must seek a meaningful reconciliation with Indigenous communities. This can be done with a multidisciplinary and respectful science, which is not only inclusive of different worldviews, but also reflects how those landscapes ought to be understood.

This dissertation is composed of four interrelated papers that combine natural and social scientific inquiry while deliberating on Indigenous peoples' perceptions of land, lived experiences, and place-based knowledge (e.g., Johnson and Hunn 2010). In the following pages, I introduce each paper while considering the thematic and symbolic "landscape" in which it dwells — this is more of an organizational tactic rather than mutually exclusive grouping. In Chapter 2, I define the *political landscape* as a contested place in need of attention from the perspective of social justice. The *archaeological landscape* is presented in Chapter 3 as a place where practitioners and theoreticians have long ventured to combine the physical and social elements of the places that we study. The *scientific landscape* explored in Chapter 4, uplifts science-based approaches (statistical modelling, hypothetico-deductive logic) to global problems like biodiversity loss and climate change in an age of fact-making and "alternative facts". Finally, the *peopled landscape* considers the role of ethnobiology as a longstanding field of research and pathway to better historical-ecological interpretations of the landscape and restorative justice in settler-nations. Each paper is connected to the others through these landscape themes. The landscape is not a compartmentalized place, but a heterarchical schema that operates with fluid influence and import (Crumley 1995).

1.1. The Political Landscape

Landscapes are political. They have been studied as alienable commodities (Cosgrove 1998) and landed property (Blomley 1998) and valued as the aesthetic and ideology of the modern world. It is because of this plurality of definitions and values that landscapes are often contested places, and as such, become highly politicized. For example, in neoliberal contexts, landscapes are filled with commodities and resources with both instrumental and speculative value (Taylor 1991). This means that the constituents of the landscape are conceived as having some utility or potential utility to humans and are often assigned monetary worth. In other contexts, landscapes are intrinsically valued — a fundamental presupposition of value by virtue of something simply being. Intrinsic value explains, in part, initiatives like government-sanctioned conservation areas (e.g., Provincial parks and State forests), where resource extraction and commodification are not the sole objective. In Western society, the trade-offs between instrumental and intrinsic valuation of landscapes are constantly contested (Naess 1989; Bookchin 1993; Pister 1995). In many Indigenous communities worldwide, however, the presupposition to value all life often supersedes the commodification of resources and lands (Blaser et al. 2004; Escobar 2011; O'Faircheallaigh 2012; Willow 2016). For these communities, the intrinsic valuation of biota, landscapes, and homelands is at the centre of many religions, resource management, social order, and governance (Anderson 1996; 2014; Thornton 1997).

The *remnants* of lives lived on a landscape are also highly politicized. Consequently, archaeological heritage has long been used as a political tool (e.g., Trigger 1984; Silverman 2010). The legal process behind cultural and heritage resource management, mandated provincially in Canada, is flawed and tends to downplay how First Nations value their own heritage and cultural landscapes (Ferris and Welch 2014). For example, cultural depressions are legislated as potentially high-impact archaeological sites worth protecting, whereas subtler or ephemeral sites such as a cliff face associated with an oral story, berry harvest sites, or a grove of trees used for women's puberty rituals, are difficult or impossible to protect under current legislation (Turner 2014; Wickwire 1991).

The first paper in this dissertation (Chapter 2: *Historical Ecology and Ethnobiology: Applied Research for Environmental Conservation and Social Justice*), considers the role of historical ecology in social and environmental justice movements. The review reflects on how historical ecology can contribute data and narratives to local socio-ecological issues. In settler-nations like Canada, where environmental issues disproportionately affect Indigenous communities (Dhillon and Young 2010; Mascarenhas 2007), environmental initiatives cannot be separated or isolated from social ones. In this sense, it might be argued that archaeologists working with First Nations (who are in conflict with government/industry development — oil and gas, mining, etc.) cannot remain neutral (e.g., Kirsch 2002). By reviewing the social and political constituents of a given place, Chapter 2 evaluates how historical-ecological research can bypass entrenched institutional barriers and promote a more informed and just interpretation of the landscape.

1.2. The Archaeological Landscape

Historical ecology has deep roots and overlapping field methods and theoretical aspects with landscape archaeology and landscape ecology (Crumley 2002; Lindborg and Eriksson 2004; Swetnam et al. 1999; Lane 2010; Szabó and Heidl 2011). Since historical ecology is interested in both the physical and socio-cultural aspects of the landscape, this section considers developments in landscape archaeology (rather than the typically a-cultural landscape ecology — see Rhemtulla and Mladenoff 2007) and sets up Chapter 3 of this dissertation: *Anthropological Contributions to Historical Ecology: 50 Questions, Infinite Prospects*.

"Conventional" landscape archaeology employs Cartesian-based frameworks to form heuristic arguments and testable hypotheses that combine landscape history and field archaeology (Aston and Rowley 1974; Layton and Ucko 2003). Landscape archaeology, which focuses on landforms and ecosystems, has largely been considered as a scientific outlook, or a natural science-based consideration of the landscape (e.g., Binford 1980; Butzer 1990). In both academic and CHRM contexts, the methods for employing a landscape archaeological approach are now highly refined and technical, making use of aerial photographs, aerial laser scanning, ground-penetrating radar, and envisaging metadata with sophisticated models and statistical procedures.

An archaeological site is, of course, more than a set of relationships among physical features. Building on postmodern developments of the 1980s, an archaeological site was constituted as a much more intricate entity. The “landscape”, in this context, was regarded simply as a generic term for something much more disorganizing and complex, and developments in social theory, human geography, and ethno-archaeology broadened our sense of the social and cultural landscape (Casella 2001; Cosgrove 1998; Hunn and Meilleur 2010; Johnson 2010; Johnson and Hunn 2010). The archaeological landscape might imply a location or a specific site, but for many people such places can also be connected to thought, survival, and culture, and should be treated as subjects rather than objects (Darvill 1999; Lekson et al. 1996). Tilley (1994, 2004) and Edmonds (2002) criticize conventional landscape archaeology for being over-empirical, focused too much on Cartesian approaches, and as Bender and Aitken (1998) note, pointless objectivity.

A more useful treatment of the archaeological landscape requires a consilience between people and place, wherein human agency is not necessarily at the forefront, nor in the background, of landscape history and landscape archaeology. In this regard, the primacy of the physical dimensions of the landscape is challenged by the *relationships* constructed between actors in the physical realm. For example, understanding how vegetation, soil cover, and climate form the contemporary landscape is as much a natural science as a social science, and each informs the other. Davies (2014) studied agricultural landscape transformations (terraces, irrigations canals) among the Pokot in Kenya’s Rift Valley. These changes were the result of both cumulative social practices (daily maintenance and gradual “build up”), large-scale singular discrete acts (large-scale clearing), small-scale weather patterns, and larger geological events. Davies’ concern with the temporality of landesque capital (land-like capital such as terracing, Håkansson and Widgren 2016) considered a fine-grained, social-ecological valuation over time. His focus on small changes, like daily maintenance, gives a clearer understanding of the landscape and human experience, rather than focusing only on finalized large-scale features which overshadow more subtle social-ecological processes.

Chapter 3: *Anthropological Contributions to Historical Ecology: 50 Questions, Infinite Prospects*, presents a two-year international and multi-disciplinary effort to outline how archaeology and anthropology can contribute to earth sciences, ecology, and larger questions about climate change, resource management, and biodiversity and community ecology. Archaeologists have internally struggled to balance the physical/natural with the social/cultural in their work for decades. As a group of predominately archaeologists, the *50 Questions* research project sought to bring what we know and have learned about social-ecological landscapes, and bring that knowledge to the burgeoning field of historical ecology. To accomplish this, 50 questions were edited down from over 300 research questions crowd-sourced from scholars around the world. In addition to the anthropological contributions to ecological questions, the results of our research also focused on issues of scales in interdisciplinarity, as well as communication and policy. Landscape archaeology can contribute to the challenge of historical ecologists to adequately evaluate the coupled social-ecological dynamics of a given landscape.

1.3. The Scientific Landscape

The third paper in this dissertation, Chapter 4: *Functional Traits and Biodiversity Reflect Ancient Forest Gardens in the Pacific Northwest*, used functional-ecological methods to study Indigenous forest gardens in British Columbia (BC). This paper illustrates the effectiveness and dynamism of a historical-ecological approach that combines archaeological and botanical surveys, ethnographic and ethnobotanical interviews, and metadata analyses to demonstrate how contemporary ecosystems are a result of ancient human activity. To understand how community composition relates to ecosystem functioning, we combine biodiversity analyses with functional diversity analyses (value and range of species traits; e.g., Díaz and Cabido 2001). This novel application of functional trait analyses to anthropogenic ecosystems resulted in new findings about social-ecological landscapes of BC.

Scientific and Indigenous land-based knowledge creation and performance are not always at odds and, taken together meaningfully (e.g., Nadasdy 1999), provide complementary insights into ecological restoration (Anderson and Barbour 2003), fill data gaps (Bennett et al. 2015), and inform policy (Cooper and Duncan 2016). Historical ecology manifests an ontological turn of many worlds (i.e., instead of "one world, many views"). However, there is still a need for empirical scientific inquiry to understand Indigenous management systems. We are currently witnessing a shift in how facts and "alternative facts" are taken and perceived by the public. To defend Indigenous rights or the environment, our authority to speak as scholars is grounded in the pursuit of "truth". Not all truths are hegemonic narratives, wherein "the truth" is controlled and supervised only by the ruling or dominant power structures. Although there may be varying paths to truth, as Hunn notes, "absent this commitment [to truth], our testimony would be dismissed as partisan advocacy" (Hunn 2002:4).

1.4. The Peopled Landscape

As Western or non-Indigenous "other" archaeologists and historical ecologists, the ability to infer meaning from the archaeological and paleoecological records relies on a grounding in the cultural and social contexts of the communities being studied. The best possible tools at our disposal are the ethnographic and ethnohistoric records we both produce and consult (Wylie 1985). In recent years, anthropologists have advocated for ontological approaches to human-nonhuman relations, the last decade of which has been termed the Age of Ontology (Daly et al. 2016). These approaches urge ethnographers to enhance their research with more "speculative wonder" (Ogden et al. 2013), to analyze cultural dynamics that shape and cultivate multispecies relations (Hartigan 2015), and offer insights into the everyday, practical experiences shaping human-nonhuman relations and how those interactions constantly come into being (Maurstad et al. 2013).

For historical ecologists who focus on eco-human dynamics, ethnobiology (or ethnoecology) has long provided specific methods and tools for catching elusive or enigmatic glimpses into human and non-human relations (Anderson 2005; Berkes 2012; Minnis 2004; Nabhan 1989). For example, by reconstructing plant and animal linguistic terms, ethnobiologists have consulted proto-languages, such as Proto-Indo-European

(Friedrich 1970), Proto-Algonquian (Siebert 1967), Proto-Numic (Fowler 1972), Proto-Oceanic (Pawley 2007) as clues to locating ancient homelands and archaeological sites. In Keith Basso's (1996) illustrative and formative work on Apache concepts of landscape, the author was constantly challenged and deeply perplexed by Apache concepts of land and space. Basso struggled endlessly with concepts of place-based wisdom and how land facilitates mental capacities to avoid harm. The classic vignette, starring a wayward Talbert asking for forgiveness from his Apache work companions, was poignantly narrated by the more steadfast Dudley who, through a careful manipulation of significant local places, was able to comment on Talbert's moral shortcomings without offense. For these Apache men, it was painfully obvious that places are more important beyond simply stating, "there are stories here". For Basso, land was deconstructed and unpacked in a beautiful and poetic prose. For his Apache friends, it meant survival.

Despite the challenges to grasp even fragments or previews into the cultural habitus of "others", there are mutually redeeming outcomes to understanding the bioregional variations of human-nonhuman relations (Hunn 2007). Ethnoecologists and their Indigenous colleagues in the Pacific Northwest have informed interpretations of archaeological features and cultural landscapes like clam gardens (Lepofsky et al. 2015), intertidal marsh gardens (Deur 2002), wapato gardens (Hoffmann et al. 2016) and other remnants of ecosystem management (Turner 2014). Martindale and Nicolas (2014) challenge the outsider archaeologist to engage with the "daunting task" of socio-cultural anthropological or ethnographic approaches to initiate a more inclusive and multivocal process of archaeological work and interpretation. I would further add that ethnoecological undertakings help the researcher co-construct decolonizing representations of the land. The descendants of those who left the archaeological record in settler-colonial nations like Canada have more than scholarly interests in their cultural landscapes; discovering the archaeology of their homelands is a nation-building exercise and a process of restorative justice.

The final chapter in this dissertation (*Chapter 5: Management and Traditional Production of Beaked Hazelnut [k̲'áp'x̲w-az', Corylus cornuta;* Betulaceae*] in British Columbia*) is a collaborative effort between an archaeologist (Chelsey Geralda Armstrong), an Nlaka'pamux Elder (Marion Wal'ceck^{w}u Dixon) and an ethnobotanist

(Nancy Turner) to describe Indigenous hazelnut management in BC. This contribution to the edited volume *Living Seeds Re-emerge from the Ashes of the Sacred Fires: Stories of Nature, Restoration of Foodways, Culture, and Health*, edited by Scott Herron, focuses on the ethnohistoric evidence of hazelnut foodways and management, stories from Marion's childhood before entering the residential school system of Canada, and how such stories are used in the community today. This contribution to the dissertation provides an ethnographic foundation on which to build an understanding of traditional plant management and cultural landscapes in BC. Furthermore, it is also an attempt to construct lateral (non-hierarchical) knowledge about the practices and experiences around plant harvesting and management. Marion's voice guides the chapter through the history, ethnobotany, and science of hazelnut, but it is her stories that overturn the academic inclination toward a single, authoritarian view on this multifaceted and dynamic plant.

1.5. Concluding Thoughts

Historical ecology is a landscape approach to social-ecological interactions and provides practitioners with a toolkit for making their research transformative and applied. The four research contributions compiled in this dissertation exemplify a historical-ecological approach to understanding and assessing cultural landscapes in the Pacific Northwest. The goal of this doctoral research was to combine natural and social sciences and Indigenous worldviews for a more expansive and relational view of the cultural landscape. This endeavour goes beyond a mere "smashing" of disciplines and evokes social-theoretical sensibilities that meaningfully intertwine multiple worldviews, akin to Ingold's meshworks (2008) and ecology of materials (2012), or Latour's actor network theory (2011). These are intuitive concepts to Indigenous worldviews, which arguably have been engaging in these types of philosophies for millennia (Anderson 2014; Coulthard 2014; Deloria et al. 1999; Haas 2007; Kirsch 2006; Wilson 2008).

Historical ecology is coming into its own as a transdisciplinary and introspective research program. However, for good transdisciplinarity, practitioners are required to be grounded in their own disciplines. This grounding assures that each researcher can come to the table with their own specialities, talents, and abilities in order to meaningfully contribute to the research question or cause (Pennington 2013; Star 2010). The journey we travel together, as archaeologist, biologist, or systems theoretician is an agreement between groups of people walking together on separate, but parallel journeys. Indigenous people have extolled this journey in important stories and covenants such as the two-row wampum (Haas 2007), or the Anishinaabe story of humans becoming with the help of Wolf.

> *The teaching of the wolf tells Anishinaabe people that Wolf was asked by the Creator to help the two-legged survive and learn how to live in Creation and how to find balance in life. When two-legged learned all that Wolf taught them, they separated and began parallel journeys. Creator reminded the humans to always respect the Wolf. Creator also told Wolf to return to the life of a wolf and leave the two-legged. This story would seem to reinforce the idea that convergence requires similar, but separate paths and that the journey is not necessarily an evolution towards sole fusion, but co-existence…* (Alex Armstrong, pers. comm., 2016)

The parallel journey taken by Wolf and human is a story of the journey of convergence and balance between two entities, such as the ecologist and anthropologist or, archaeologist and descendant community. In a similar fashion, Hunn (2002) considers the "scholar's tribe" as a community organized by clan (anthropologist, biochemist, linguist, biologist), each grouped into their own moieties (the Scientists and the Humanists), sometimes at odds, but nonetheless inseparable. As a tribe associated with our own clans and value systems, we must reflect on our ontological convictions but also the epistemic positions that bind us together for a more transformative science to succeed (Pennington et al. 2013).

In an age of accelerated climate change, on-going colonial oppression, and hyper-capitalist expansionism, the journeys we take as scholars will converge, not only out of desire, but out of necessity. Anthropological research can no longer operate in isolation of political-ecological issues; otherwise, it is unethical and unjust (Veteto and Lockyear 2015), and in some cases may lead to bad practice (Escobar 2011). Historical-ecological research organizes itself around its strong scientific method, the political-ecological contexts in which it operates, and strives to bridge the social and the natural in critical and meaningful ways (Armstrong chapter 2 in this dissertation). As such, this collection of research contributions uses the historical-ecological research program to understand the landscape in a way that is critical, compassionate, and just.

Chapter 2. Historical Ecology and Ethnobiology: Applied Research for Environmental Conservation and Social Justice

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2.1. Abstract

Historical ecology provides a research program and toolkit for applied interdisciplinary research in ethnobiology. With a focus on long-term changes in built environments and cultural landscapes, historical ecology emphasizes the need for scientific collaboration on between disciplines for more relevant and applied academic research — particularly in service to environmental conservation and social justice.

2.2. Historical Ecology Research Program

Historical ecology is a research program that focuses primarily on landscape as the unit of analysis and emphasizes the understanding of environmental change through deep time with an eye toward application in the present. By extending the timescale of landscape change, it is possible to create a more historically situated understanding of socio-environmental interactions and patterns. Such patterns can be used to help inform and initiate environmental conservation and social justice.

Since the early 1990s, historical ecology has been undertaken in various global contexts by ecologists, biologists, archaeologists, and anthropologists. Crumley and Balée have been the most visible advocates of historical ecology through their respective work in France and the Amazon (Balée 2013; Crumley 1994). Their unique but complimentary approaches to historical ecology — Crumley trained in archaeology and Balée in cultural anthropology — argue: (1) nearly all landscapes on earth have been affected by humans to differing degrees; (2) both human and natural phenomena that physically manifest in landscapes or immaterially in cultural memory can be studied as an integrative whole; and

(3) knowledge of human-land use and change through time can and should be applied to contemporary issues (e.g., global climate change, Indigenous sovereignty). These foci contribute to and reinforce two interrelated paradigm shifts in contemporary anthropology and geology: the “ontological turn” in the social sciences that challenges Western nature-culture dualisms and sees humans and landscapes as inseparable and interrelated wholes (Latour 2014); and increasing support for geological re-classification of the current epoch as the “Anthropocene” in recognition of the keystone role that humans play in socioecological earth systems (e.g. Zalasiewicz et al. 2011).

The applied focus is likely the most broadly relevant aspect of historical ecology and provides fertile cross-linkages with ethnobiology. In Wolverton’s (2013) conceptualization of “Ethnobiology 5”, he calls for ethnobiologists to communicate the relevance of their research to help solve contemporary socioenvironmental issues. In the historical ecology research program, anthropologists are encouraged to broaden their research of local or Indigenous knowledge by including ethnohistoric data (e.g., Nabhan 2007); or by showing cultural memory, symbolism, and culinary practices are as important to agrobiodiversity conservation as official programs (e.g., Veteto and Welch 2013). In the field of archaeology, historical ecology allows scholars to make their research more relevant by contributing to contemporary environmental issues (Balée and Erickson 2006) and providing, for example, long-term zooarchaeological data for the reassessment of ecological baselines (McKechnie et al. 2014).

Ongoing and more classic research demonstrates how ethnobiologists, environmental anthropologists and archaeologists are applying historical ecology to contemporary environmental issues. Fairhead and Leach’s (1996) groundbreaking work showed that Indigenous land-use strategies in a West African forest-savannah mosaic create forest islands rather than furthering deforestation (as previously assumed by scientists, forest ecologists, and conservationists), contributing policy recommendations of significant importance to both environmental conservation and social justice. Welch et al. (2013) have provided evidence for reversing assumptions of both development practitioners and conservationists in Central Brazil, using combined ethnographic and historical-ecological data to show that Indigenous burning practices in a fire-adapted cerrado biome are significantly more conducive to forest stability and vegetation recovery than fire suppression and agribusiness expansion. A historical ecology research program in Peru utilized archaeological methods (pollen and soil analyses) to document relict agricultural features such as terraces, canals, and raised fields that exhibited excellent soil quality, good drainage, and buffers to frost risk (Erickson 1998). Archaeologists, agronomists, and communications experts subsequently worked with descendant communities to rehabilitate farming practices — based on insights from ancient agriculture — and their results proved to be more sustainable compared to contemporary European style farms after only a few seasons. In another important case study, archaeologists and paleoecologists (Szpak et al. 2012) have used isotopic and zooarchaeological data (ca. 5,200 years BP–AD 1900) to better understand the foraging ecology and historical range of locally extinct sea otters and help inform re-introduction programs on the Pacific Northwest Coast of North America.

Human health in Indigenous and local communities is intimately connected to the health of the environment and is another domain where historical ecology and ethnobiology are making significant contributions. The restoration or reinvigoration of sustainable cultural landscapes has had positive impacts on social well-being worldwide. Barthel et al. (2013) combine social memory, traditional ecological knowledge, landscape features, and local environmental fluctuations to argue that land-sharing (instead of land-sparing) is a key variable for preserving biocultural diversity and promoting food sovereignty in communities across Europe. A historical ecology orientation also informed experimental research that shows how anthropogenic non-Western management in ancient intertidal terraces and clam gardens resulted in clam density and overall biomass increases (Groesbeck et al. 2014). This work effectively demonstrates that viable food production and sustainable ecosystems can be simultaneously achieved, both in the past and (hopefully) in the present and future. Furthermore, such research demonstrates that First Nations communities have had long-term positive dialectical effects on contemporary (previously considered 'wild') ecosystems, providing evidence that can help Indigenous people assert rights and access to traditional landscapes in the context of current sociopolitical realities.

To date, historical ecology has been underutilized by ethnobiologists as a productive research program with notable exceptions (e.g. Balée 2013). This may be a result of the lack of exposure historical ecology receives in academia (it is often taught, if at all, as a segment or sub-unit of advanced courses in geography, anthropology, and ecology). We can envision future and ongoing (e.g. Human Ecodynamics Research Center — HERC; Integrated History and Future of People on Earth — IHOPE; Resilience in East African Landscapes — REAL) long-term historical ecology projects that combine the strengths of cultural anthropology, archaeology, and biology/ecology in a unifying ethnobiological approach. This approach has the potential to further expand our research into the applied realm, contributing to a future that is more environmentally sustainable and socially just.

Chapter 3. Anthropological Contributions to Historical Ecology: 50 Questions, Infinite Prospects

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3.1. Abstract

This paper presents the results of a consensus-driven process identifying 50 priority research questions for historical ecology obtained through crowdsourcing, literature reviews, and in-person workshopping. A deliberative approach was designed to maximize discussion and debate with defined outcomes. Two in-person workshops (in Sweden and Canada) over the course of two years and online discussions were peer facilitated to define specific key questions for historical ecology from anthropological and archaeological perspectives. The aim of this research is to showcase the variety of questions that reflect the broad scope for historical-ecological research trajectories across scientific disciplines. Historical ecology encompasses research concerned with decadal, centennial, and millennial human-environmental interactions, and the consequences that those relationships have in the formation of contemporary landscapes. Six interrelated themes arose from our consensus-building workshop model: (1) climate and environmental change and variability; (2) multi-scalar, multi-disciplinary; (3) biodiversity and community ecology; (4) resource and environmental management and governance; (5) methods and applications; and (6) communication and policy. The 50 questions represented by these themes highlight meaningful trends in historical ecology that distill the field down to three explicit findings. First, historical ecology is fundamentally an applied research program. Second, this program seeks to understand long-term human-environment interactions with a focus on avoiding, mitigating, and reversing adverse ecological effects. Third, historical ecology is part of convergent trends toward

transdisciplinary research science, which erodes scientific boundaries between the cultural and natural.

3.2. Introduction

Historical ecology is a field of inquiry that has come of age and currently finds itself at a crossroads. After decades of interrelated developments in both ecology and archaeology, historical ecology is increasingly recognized as an inclusive intellectual hub for exploring a range of fundamental questions in disciplines such as ecology, biology, archaeology, anthropology, history, geography, and ethnobiology. The term is increasingly cited in academic literature and researchers are beginning to use the label to identify themselves (Balée 1998; Isendahl and Stump 2015; Russell 1997; Szabó 2015; Thompson and Waggoner 2013). The appeal of historical-ecological research is that it operates on multiple temporal scales and across disciplinary boundaries that have long separated the social and natural sciences (Crumley 2007; Russell 1997;). It also generates applied research questions and data for historically grounded and socially just conservation programs, in which environmental initiatives consider the totality of human-environment interactions and foster a critical awareness of the imposition of "green" policy on communities, many of whom may be marginalized (Armstrong chapter 2 this dissertation; Balée 1998; Levin and Anderson 2016; Szabö and Hédl 2011).

Historical ecology, however, is not organized around a single unified methodology or theory, and there are no dedicated publication venues. Indeed, most publications in historical ecology showcase the crossover potential of ecologically and socially engaged historical research. There are many points of departure that lead researchers to engage with historical ecology. At the core of many historical-ecological research initiatives is a recognition of the interpretive potential of combining archaeological, historical, and ecological data and expertise (Briggs et al. 2006; Rick and Lockwood 2013). Based on our research focus, two "types" of historical ecology appear to have formed, primarily associated with either archaeology or ecology, and resulting in a parallel but largely non-overlapping literature (Crumley 2015; Ellis 2015; Gimmi and Bürgi 2007; Lotze and McClenachan 2013; Pennings 2013; Szabó 2015).

Szabó (2015) contends that historical ecology is in a third scholarly iteration, which will either stay nestled under a multidisciplinary umbrella or emerge as a conventional (institutionalized) academic discipline. Whether or not the concept is bound to either trajectory, this moment is cause for reflection on past, present, and future research questions of its practitioners. Rather than struggle with the circuitous task of defining historical ecology, we instead employed crowdsourcing and consensus-building methods to identify research questions guiding current historical-ecological research, as well as questions which may become more important in years to come.

This research initiative grew out of a symposium held at Uppsala University in 2014. Researchers identifying as historical ecologists presented their work, and while seeking to frame a discussion about the future of historical ecology, realized that there were gaps in our cumulative perceptions on the current state of the research program. In order to better understand who historical ecologists are and what they do, we crowd-sourced over 300 questions in a priority-setting initiative between November 2014-November 2015. Questions were edited down to 50, which we determined was a suitable and unconstrained number and comprised a representative subset of the total pool of submissions.

3.3. Methods

For identifying and ranking important questions in historical ecology, an open, inclusive, and consensus-driven four-stage group process was followed. This process builds on similar methods used by Sutherland and colleagues' numerous priority-setting research works (Sutherland et al. 2006; Sutherland et al. 2009; Sutherland et al. 2011; Sutherland 2013) as well as the research of Seddon et al. (2014) Kintigh et al. (2014), and Parsons et al. 2014 in paleoecology, archaeology, and marine biodiversity, respectively. Social justice organizing tactics, in which challenging conversations are facilitated to catalyze breakthrough thinking and lasting agreements, also inspired the process.

In 2014, an international meeting was convened in Uppsala (Sweden), focusing on early-career researchers working in historical ecology. Twenty-eight participants came together to generate discussion on key topics and share perspectives on the various “types” of historical ecology. A global survey was then circulated online to further crowdsource research questions from academics working broadly under the historical ecology umbrella. Over 300 questions were submitted and sorted into two or more of the following nodes: (1) climate and environmental change and variability; (2) multi-scalar, multi-disciplinary; (3) biodiversity and community ecology; (4) resource and environmental management and governance; (5) methods and applications; and (6) communication and policy.

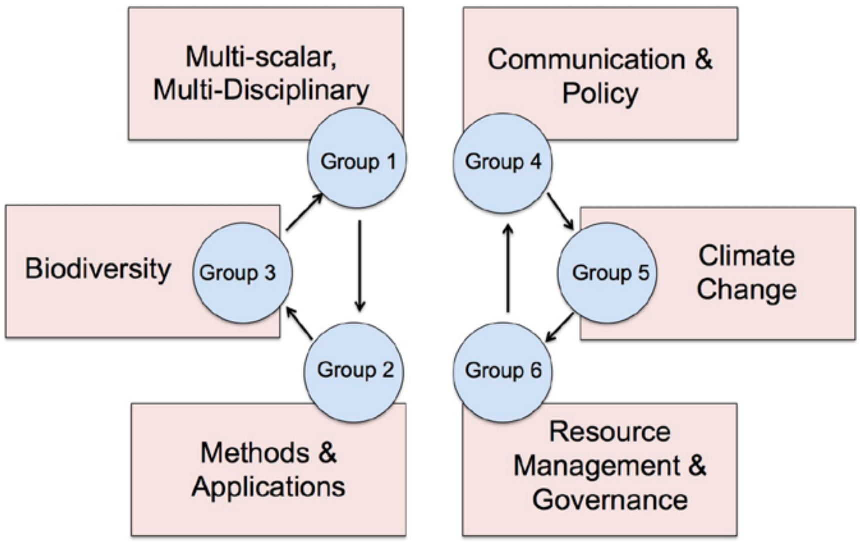

Figure 1. Consensus-Building in Second Workshop. After sorting questions into each group (10–12 participants and a facilitator) are allotted 90 minutes to select the questions most pertinent to the node. The group then rotates to the next node.

In 2015, a second-stage meeting convened in Vancouver (Canada). Initially, 47 workshop participants from various disciplinary backgrounds, all self-associated with historical ecology, broke into groups to discuss and select preferred questions from the six nodes (Fig. 1). Priority questions were identified from every theme in a consensus-based process, inspired by social justice organization in which discussion is supported by impartial peer facilitators. Rather than simply voting for questions, we used a consensus process that emphasized maximizing group intelligence through discussion and debate. The consensus method aims to eradicate a “tyranny of the majority” that occurs in democratic voting and allows for more opinions to be considered. Facilitators were chosen based on their experience in organized facilitation roles; for example, three group members had previously attended extensive facilitation-training workshops in social justice settings. These facilitators trained the other three volunteers, and after every node, would regroup to exchange techniques and group-organizing ideas. Facilitators refrained from influencing discussions, and concentrated on ensuring groups stayed on time and on topic, to maximize creative cooperation and to ensure group memory (Fig. 2). A total of 82 questions resulted from this deliberative process. In a third stage, a subset of workshop participants (53%) volunteered to edit the entire list of 82 questions that had been identified as the most important and relevant by deleting duplicates, fusing similar entries, and ensuring that the wording of the questions was adjusted to reflect the views of participants in the second stage. With 62 questions remaining, workshop participants decided to open a final editing round to our online community of scholars. In the last stage, the online community, comprising all participants from both the Uppsala and Vancouver workshops, were invited to rank the remaining short list of questions on a scale of importance (1–5) to reduce the number of questions to 50. We chose the number 50 because we found it was a large enough number to cover the depth and breadth of historical ecology, but small enough to force participants to think about the most pressing issues. In this online ranking forum, participants were invited to give feedback on the process and provide further comments on the formatting and content of questions.

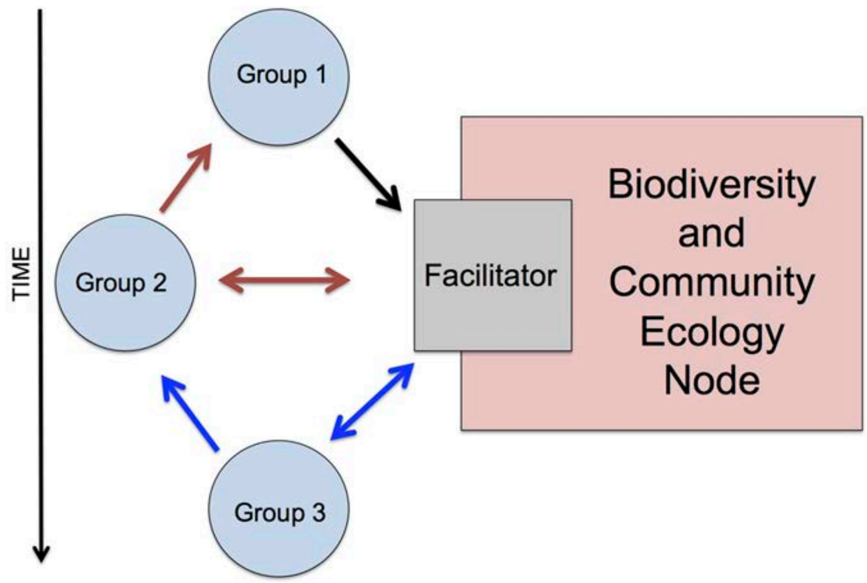

Figure 2. Facilitation Process Example. The facilitator stays with the same node throughout the day and discloses results and insights from previous groups' discussion with each new group. For example, Group 1 works through the list of biodiversity and community ecology questions with the help of a facilitator. Group 2 then works with the same question list but is able to interact with Group 1's ideas (but not vice versa) through the facilitator. Group 3 works with the original list again but is exposed to compounded ideas from Groups 1 and 2 through the facilitator, and so on until each group has an opportunity to discuss all six nodes.

A final quality-control round was a consensus-driven process amongst workshop organizers (from the New International Community of Historical Ecology — NICHE). This editing session was necessary for unanticipated outcomes that occurred throughout the online ranking exercise. For example, four questions were tied in the ranking for "last place". Using the survey output and the facilitators' minutes from the workshops (four facilitators were present in this final stage), we collapsed sufficiently similar questions, and re-organized their place in the various nodes. The wording of three questions was subsequently adjusted slightly in light of reviewers' comments on a first draft of this paper. Ethics approval was granted specifically for this study by Uppsala University Ethics Board on behalf of the State Research Council.

3.4. Limitations

The range of questions developed through this process reveal limitations in both the audience responses and the scope and scale of topics selected. During the first stage of the process, many participants preferred broad questions, seeing them as more inclusive, relatable, and relevant for defining “grand challenges” in a multi-disciplinary endeavor (c.f. Kintingh et al. 2014). However, those seeking testable hypotheses and more explicit research trajectories often preferred specific questions. The final ranking survey reflects the overwhelming participant preference for broad questions — specific questions were favored only when they were vigorously defended in-person during the workshops.

As can often be expected when attempting to generate collective knowledge, the online ranking of questions was methodologically imperfect and preliminary divisions of questions into themes are likely to have limited lateral and creative thinking, as demonstrated in other similar projects (Sutherland et al. 2011). Feedback submitted by participants in the online ranking exercise revealed frustration over the perceived similarity of some questions, vagueness of wording, and disproportionate representation of certain research topics. We therefore decided to discuss rankings and debate them in person rather than stick to the exact output (e.g., marine-based questions were ranked lower because demographically, more researchers study terrestrial ecosystems, but that does not make marine questions less important). The final version of the quantitatively ranked question list incorporates some adjustments in response to the qualitative concerns of online participants, and reflects the discourse and debates generated during the workshops.

Although the initial list of questions submitted online represented engagement with a wider variety of disciplinary and geographical backgrounds, the meetings were disproportionately attended by individuals affiliated with ecological/environmental anthropology and archaeology, and to a lesser degree with participants from ecology, biology, and geography. While calls for participation went out widely and were formulated with inclusivity in mind, the process favored English-language speakers and there was obvious and regrettable under-representation from strands of historical ecology in South

America (e.g., Arqueologia e Ecologia Histórica dos Neotrópicos), Germany (Bürgi 2008), France (Girel 2006; Mathevet 2012), Russia (Arkady et al. 2005) and Japan (Habu et al. 2011). Biases in representation reflect the limitations of the communities engaged and the challenges of networking across linguistic, geographic, and disciplinary divisions.

3.5. Results

The initial open-call for research questions led to over 300 submissions from 20 countries. The majority of respondents (71%) were affiliated with Canadian, Swedish, American, and UK institutions, with lesser representation from individuals in Brazil, Colombia, Poland, Belgium, China, Mexico, the Netherlands, France, Zimbabwe, and South Africa. The majority of respondents pursued or held PhDs (89%) and were employed by, or pursuing degrees at, academic institutions.

The goal of the exercise was to set priority or key research questions among participants, recognizing that (1) developments in historical ecology and its meanings differ across disciplines and geographical context, and (2) questions were inspired by researchers more heavily engaged on the anthropological and archaeological spectrum of historical ecology. As such, our results reflect the strong anthropological background and limited geographic scope of our participants. This does not lessen the strength of the exercise or importance of the research. Firstly, the anthropological slant will serve to address those in the natural sciences who may acknowledge that humans cannot be removed from their long-lived landscapes, but struggle with how to reconcile this influence in their research (Briggs et al. 2006; Bürgi and et al. 2016). Secondly, those working in countries that have a rich history of coupling the natural and social sciences (Egypt, India, Greece), but were not represented, can borrow, contrast, model, critique, be inspired by the diverse list of questions that can be reframed in many global contexts.

In the following sections, questions are divided by thematic node, each with a segment clarifying or detailing the relevance of the question set. There is no implied rank given to the numbered questions, but they are discussed in a logical order of applicability to each chosen topic. We conclude by highlighting three major themes that emerged from the process of this priority-setting exercise.

3.5.1. Climate and environmental change and variability

Many have advocated for a new geological epoch, the Anthropocene, on the basis that human forces, for the first time in history, now operate at a global scale comparable in effects to geophysical and climatic processes (Crutzen and Stoermer 2000; Ruddiman et al. 2016; Waters et al. 2016). It has been argued that the scale and agency behind climate change today is unique within the longue durée of huma history. However, there is a need to distinguish between large-scale climate-forcing mechanisms and inherent small-scale climate variability affecting human lives, the latter of which can be both produced and mitigated by people (Orlove 2005; Wolverton et al. 2014). Both of these concerns are reflected in the first set of questions.

1. What roles have humans played in extinction events and what can we learn about these large and small-scale changes?
2. When did human activities begin to have significant impacts/effects on the lived environments?
3. What factors allow human populations to become more decoupled from immediate environmental constraints?
4. What are the archaeological proxies of past climatic stability or instability?
5. What are the effects of climate and environmental change on human health and disease?
6. How predictable are human responses to environmental change, and how can we model such responses for future planning?
7. How is climate change affecting the management of eco-cultural and geo-cultural heritage?
8. How did past societies respond to sudden environmental shocks (e.g., extreme weather) and what can we learn from this?
9. What factors have made some communities more adaptable to environmental change than others?

At least two of these questions (8, 9) are explicitly concerned with past human experience of environmental variability and highlight the need to develop established research directions exemplified in ethnoecology (Anderson 2014; Cooper and Sheets 2012; Turner 2014), while a third question (5) lends itself implicitly to a historical approach, as illustrated by studies looking at the past interactions of climate, disease, and society (Chritz et al. 2015). Question 3 addresses the modern phenomena that allow human societies to operate, at least temporarily, beyond environmental constraints, for better or worse.

Question 2 raises the controversial issue of reclassification of the current geological epoch as the Anthropocene. The timing of the onset of this proposed epoch is widely debated (Crutzen and Stoermer 2000; Lewis and Maslin 2015; Steffen et al. 2015; Williams et al. 2015). Although some workshop participants were reluctant to use the term Anthropocene, inclusion of related questions illustrates the desire of many researchers in historical ecology to continue drawing attention to longer-term processes of human engagements with the environment and our “entry into the planetary machinery” (Crumley 2015). The formulation of Questions 3–5 was widely debated in the group. On one hand, these formulations should be seen as transitory, reflecting the problems of representing the mutual dependency of humans and environment. On the other hand, they are indicative of the challenge of interpreting and dealing with the multi-scalar interdynamics of stability and change in the archaeological, geomorphological, and paleoecological records.

Questions 1 and 6–9 emphasize how historical-ecological data can be used to address contemporary issues of climate and environmental change. It has been highlighted that historical data offer a vital contribution as we plan for and mitigate future climatic change (Anderson 2014; Cooper and Sheets 2012; Dearing et al. 2012; Gillson 2015). Question 7 takes an alternative perspective, asking how such changes might affect our ability to preserve eco-cultural and geo-cultural heritage. This drive toward applied research (Marchant and Lane 2014; Swetnam 1999) is at the heart of historical ecology’s engagement with issues of climate change.

3.5.2. Multi-scalar, multidisciplinary

A key strength in ecology, ethnoecology, and archaeology is an interest in multi-scalar perspectives that incorporate a wide range of data sources. Workshop participants were keen to continue integrating multi-scalar perspectives into historical-ecological research, captured in Questions 10–14, which relate to research methodologies and frames for engaging with multiple scales and the complex indices that represent them. Question 15 addresses more practical and ethical issues related to the research processes of historical ecology.

10. How do historical ecologists address different temporal and spatial scales, how do we define/communicate them, and how do we study their interactions?
11. How can archaeological and ecological methods be standardized for evidentiary and temporal comparability?
12. Does historical ecology relate exclusively to the longue durée, or "deep time" and, if so, how should those concepts be defined?
13. How do we constitute humans as integral parts of ecosystems and how do we conceptualize humans as one of many species in an ecosystem? At the same time, how can environmental history, in which humans are always regarded to be the protagonists of ecosystem change, effectively cooperate with historical ecology, which regards humans as one of the many species in an ecosystem?
14. How do we engage with the concept of sustainability in historical ecology, especially given constantly changing environmental dynamics, with or without humans?
15. What data standards should we develop to aggregate relevant information in a consolidated open-source database?

Question 10 highlights the familiar challenge of working with multi-scalar perspectives. Historical ecologists make particularly effective use of the extended spatial and temporal scales represented in paleoecological and archaeological datasets (Peterson et al. 1998; Redman and Kinzig 2003; Sayre 2005). However, practitioners also grapple with the difficulties of combining fragmented datasets of varying degrees of temporal resolution (Bailey 2007; Walker et al. 2006), and resolving localized versus regional landscape dynamics. In geography, temporal and spatial scales have long been discussed, particularly since the "spatial turn" introduced spatiality as a frame of analysis (Lefebvre 1991; Massey 2005; Soja 1989). Historical ecology can deal more competently with the spatial and temporal continuities and variability that characterize complex landscape processes by researching the connections and interdependencies of variables (similar to the concepts of pattern and process in ecology discussed below).

Question 11 addresses a concern about the perceived incompatibility of methods and temporal and spatial scales used in archaeology, anthropology, and ecology/paleoecology, as noted almost a decade ago by Bailey (2007). However, this question may reflect less of a methodological challenge than a challenge of integrating conceptual frameworks and goals of various specialized fields (Ingerson 1994). Question 13 reflects a concern for cognitive dissonance between researchers whose theoretical and epistemological frameworks may be said to align with either the social or the natural sciences. Global environmental change research was pioneered by natural scientists, yet humanities research situates people as the medium through which environmental change not only occurs, but is also experienced. Environmental humanities furthers a critical engagement with the construct of nature and examination of global power relations in which sustainable development operates (Cronon 1996; Hornborg 2016), amongst other contributions.

Multidisciplinary projects are sustained with good collaborative relationships (Ledford 2015), and communication can often be a determinant of successful multi-disciplinary work (Thurow et al. 1992). Language may be the point of divergence for those from different research traditions; for instance, we found that “longue durée”, “deep time” (Question 12), and “sustainability” (Question 14) have a multitude of associated meanings, suggesting a need for consensus building when defining our terms.

Question 15 draws attention to developing standards for merging different types of data in open and accessible ways. The tendency to prioritize data generation over data curation and publication must be addressed (Howe et al. 2008). The INTIMATE group is one example of a successful database initiative, facilitating the Integration of Ice core, Marine, and Terrestrial paleoclimatic proxy records for North Atlantic and Australasian regions (Blockley et al. 2012). However, the INTIMATE group example is noticeably lacking in collaboration with social scientists, again reflecting an exclusively quantitative focus that some workshop participants found worrisome. While model-based projections of climatic change and variability powerfully inform future environmental planning, they can inadequately incorporate smaller-scale anthropogenic activity or human political responses and governance (Lightfoot and Cuthrell 2015; Savo et al. 2016; Strandberg et al. 2014).

3.5.3. Biodiversity and community ecology

Historical ecology is uniquely poised to assess the decadal, centennial, and even longer-term landscape consequences of human activities, as well as subtler anthropogenic changes to ecological communities and populations e.g. (Ford and Nigh 2015; Nicholas 1999; Peterson et al. 2001; Rackham 2003; Rackham 2006; Szabó 2010b; Tomimatsu et al. 2009; Wyndham 2009). Insights from this research may prove valuable in future decision-making regarding the management of resources and the management of people vis-à-vis resources. For example, Anderson (1994, 2014) provides case studies of how resource management is constructed within religious and ethical codes. Such research can also be valuable for critiquing dominant narratives that continue to shape policy and management interventions based on assumptions about the causes of environmental degradation (Lane 2009). A strength of the historical-ecological research program is its ability to contextualize biodiversity as both an ecological and social concept. Biodiversity is a scientific field of inquiry, as well as a social construct, political referent, and topic of moral discourse (see Youatt 2015).

Historical-ecological research examines the interconnections between climatic and biotic variability (such as wildlife grazing, browsing, and fire) in the context of human land use and management (Capers et al. 2007; Dublin et al. 1990; Holling 1973; Lord and Norton 1990; Millington et al. 2003; Pickett and White 1985; Perrings and Walker 1997; Wu and Loucks 1995). For example, human-mediated biological invasions often initially increase local biodiversity while decreasing differences between sites (Smart et al. 2006). Over time, inclusion of invasive species in a location may lead to an ultimate decrease in local diversity (Lockwood and McKinney 2001; Strayer et al. 2006). Questions 16–21 all relate to the dynamics between plant and animal species and humans in a given landscape.

16. How does the removal or introduction of species affect landscape and seascape ecology?
17. What is the potential of evolutionary history and paleoethnobotanical knowledge for plant conservation?
18. What is the relationship between past human activities and changes in the morphology and/or phenotypic traits of plant and animal species?

19. To what degree can we use ancient and modern genetic data (e.g., genetic structure) to infer past and present management practices and human influences on other species and populations?
20. How did anthropogenic land-use practices structure vegetation patterns prior to c. AD 1500 and the commencement of European global expansion?
21. When are “invasive”, “native”, and “introduced” useful concepts? Should these terms be applied to humans as well as to other species?

Humans are conscious architects of biodiverse communities (Anderson 2005; Ford and Nigh 2015; Turner 2014), but such actions can also be interpreted as producing “epiphenomenal effects” on community ecology (Bird 2015; Codding et al. 2014; Smith and Wishnie 2000). Practices like terracing, diking, transplanting, pruning, coppicing, livestock penning, broadcast burning, and fertilizing shape landscapes and associated community compositions in intentional and unintentional ways (Turner 2014).

In addition to the more widely cited impacts of agricultural and pastoral pursuits on landscapes, human activities have also directly shaped ecosystems in intertidal and aquatic environments. For instance, some rock alignments that were once thought to be naturally occurring in intertidal marine environments now prove to be ancient remnants of large marine enhancement projects that expanded habitat and productivity and enhanced in marine resource availability (Lepofsky et al. 2015). Other human reactions to marine resource instability warrant further investigation (see Question 26) including substitution of aquatic foods for terrestrial alternatives, reduction of harvests and augmentation of resource pools (Merino et al. 2012; Young 2010), and mitigating, and seeking food sources more broadly (Berkes et al. 2006).

Smaller scale anthropogenic changes to ecological communities can be detected at the molecular level, as addressed by Questions 18–19, which acknowledge the use of phenotypic and genotypic markers for investigating past human-environment interactions. Researchers commonly use contemporary plant community assemblages to infer the presence of past human ecosystem modifications (Barlow et al. 2012; Ford and Nigh 2015; Nabhan et al. 1982; Ross N.J. 2011), but genetic and/or morphological differences are increasingly used indicators (Casas et al. 2007; Fine et al. 2013; Parker et al. 2010;

Tomimatsu et al. 2009). Mutualism, co-evolution, and hybridity are key concepts in analyzing interactions between species and landscapes that can be better utilized to predict how communities might change with anthropogenic modification. Human niche construction models offer further modes of inquiry in the study of eco-cultural dynamics (Bird et al. 2016; Ellis 2015; McClure 2015), and relate to important concepts such as landscape domestication (Erickson 2008), novel ecosystems (Hobbs 2009; Ellis 2015) and neobiotic species (Williams 2015).

Because mutualism, co-evolution, and human niche construction take place on varying timescales (Hairston et al. 2005; Palumbi 2001; Smith 2007; Thompson 1998), it is relevant to consider the temporal baselines used to understand the interplay between agents and processes in landscape formation. Question 20 refers to the use of appropriate baselines to better appreciate rates of change and scales of impact brought on by human transformations of landscapes. Such baselines are treated as transitory, rather than static, but allow us to frame important research questions that can be contingent on historical circumstances. Related to this discussion is Question 21, which asks when and if the idea of "invasive species" is a useful concept. Some would argue that the terms "invasive" and "alien" are normative and culturally freighted (Robbins and Moore 2013), imposing ideals of authenticity and stasis, or that invasive species eventually stabilize as a new normal (Hobs et al. 2009). Most workshop participants reasoned that because invasive species cause realized and measurable disturbances (changes) to otherwise diverse socio-ecological systems, such terms should remain an important frame of reference and field of inquiry (Crosby 2004; Simberloff 2011).

Worldwide, many of the most biodiverse landscapes have been produced by long-term, anthropogenic management practices (Denevan 2016). In places where local management has been discontinued, or cultural landscapes have become relict, historical-ecological research has demonstrated that the absence of humans can lead to a decline in species diversity, landscape heterogeneity, and threats to livelihood (Foster 2002; Agnoletti 2006; Ross and Rangel 2011; Bird et al. 2013; Ekblom 2015; Gillson 2015).

22. What are the ecological impacts of anthropogenic soil (and sediment) transformations?
23. How has anthropogenic broadcast fire influenced ecosystem dynamics?

24. How do we identify different cropping styles (e.g., monocropping, polycropping, perennial orcharding) in the past and their effects on ecosystems and landscapes?

Questions 22–24 are related to the anthropogenic modification of soils and vegetation through fire and/or building of soils. Much attention has been given to the formation of *terra preta* or "dark earths", created through the combination of infield and fallow burning, composting, and mulching. Anthropogenic soils have been shown to harbor important reservoirs of agro-biodiversity (Fairhead and Leach 2009; Falcão et al. 2009; Glaser 2007; Junqueira et al. 2010; Woods and Denevan 2009) and enhance forest productivity (Hoffman et al. 2016; Morin-Rivat et al. 2017; Trant et al. 2016). However, in many landscapes the customary practices that shape such soils are now discontinued. Historical ecology offers tools to understand not just the ecological dynamics of soil modifications and fire use, but also the social organization and cultural significance of these practices and the landscapes they produce (McKey et al. 2016).

Broadcast fire is an essential tool in landscape management, both to create mosaics of successional stages and to reduce wildfire spread. Seasonal fires and burning of different vegetation types creates and encourages vegetation mosaics and also protects forest patches (e.g., Erickson 2006; Fairhead and Leach 2009; Laris 2002; Trauernicht et al. 2016). Recent studies in western North America have combined paleoecological and archaeological data to examine changes in anthropogenic broadcast fire regimes and found notable changes with the onset of Spanish colonialism (Liebmann et al. 2016; Lightfoot et al. 2013). Historical anthropogenic fire regime data can also inform contemporary fire and land management policies, such as in the West Arnhem Land Fire Abatement (WALFA) project, which now incorporates and restores Indigenous fire management practices (Bowman and Murphy 2011; Russell-Smith et al. 2013).

Barthel et al. (2013) (see also Maffi 2005) referred to continuing cultural landscapes as bio-cultural refugia where local knowledge, species, techniques, and methods are crucial for both biological and agro-ecological diversity (see Question 24). Other customary settlement practices, including those relating to waste discard and manuring, may also have beneficial ecological consequences that go well beyond the epiphenomenal, and could be conceived as central to situational processes of landscape domestication (Fraser et al. 2015; Frausin et al. 2014).

While the direct effects of resource extraction, industrial pollution, and land-use change on biodiversity are often well-characterized, subtle and indirect consequences of low-impact cultural practices have yet to be investigated, prompting the following questions.

25. How and why does biological diversity (e.g., alpha and/or beta diversity) correlate with proxy indicators for cultural diversity (e.g., linguistic diversity)?
26. How have people responded to temporal-spatial fluctuations in marine resources?
27. What are the environmental impacts of political and economic restrictions to — or increases in — human mobility?
28. What are the environmental effects of past conflict and military activity?

At the core of historical-ecological research is the understanding that culture, in terms of local knowledge, customary practices, traditions, social norms, and languages, is intimately linked with landscape. Question 25 highlights an interest to further document and understand this integration (Gorenflo et al. 2012). Question 26 draws attention to the fact that human influences on marine environments also need consideration (Rick et al. 2014; Rick and Lockwood 2013;), prompted in part by concerns about the impacts of future sea-level rise (Nicholls et al. 2010) on the livelihoods of coastal people (Nunn 2013), the changes in habitat distribution and ecosystem functions that may ensue (Kirwan and Megonigal 2013), and also the likely impacts on coastal heritage (Marzeion 2014).

Changes to human mobility on different spatial scales (see Question 27) may alter population densities and thereby concentrate resource use (Adamo and Izazola 2010; Black and Sessay 1997). For example, sedentism and land loss for pastoral peoples has implications for grazing intensity and grassland composition (Fan et al. 2014; Ole Seno and Tome 2013). Constrained mobility may impact cultural practices tied to landscapes, though in other cases international and jurisdictional barriers may isolate kin networks and communities in ways that result in the discontinuation of local traditions (Werner and Barcus 2009), including resource management practices (Babai and Molnár 2014). Conversely, limited human mobility may reduce access to resources, increase exposure to pollutants, and produce other negative human impacts (Hernandez et al. 2015; Taylor 2014).

The environmental impact of warfare, political upheaval, and human conflict is also becoming a key line of historical-ecological research (Question 28). The ecological impacts of modern weaponry — including the testing and use of nuclear weapons — can be demonstrated (Harwell 1984; Sadiq and McCain 1993; Yateem 2013). However, it should be pointed out that an under- acknowledged aspect of historical warfare in the early modern period is their influence on contemporary landscapes both in environmental impact (Kuhl 2014) and heritage status commemoration.

3.5.4. Resource and environmental management and governance

Practitioners of historical ecology share an interest in resource management and governance. This concern arises from an interest in applying knowledge to the politics of conservation and sustainability and to bring this to the forefront in discussions of environmental history and resource conservation. Governance and applied policy is at the core of many of the research questions, with the growing recognition that the best paths toward resource management depend less on managing resources and more on managing people (Anderson 2014; Natcher et al. 2005). These concerns relate to a heightened understanding of the geopolitics and differential equities in which conservation and sustainable development initiatives operate (Frazier 2010).

This cluster of questions emphasizes dissolution of human-nature binaries and represents an embrace of multiple ways of knowing. Historical ecologists are aware of the ties between landscape ecologies and issues of human economy, well-being, sociality, and spirituality. The research insight provided by historical ecology to resource managers is therefore not simply an exercise in expert data exchange, but a meaningful, emergent process that aims to bring about collaboration and co-management strategies between people from different backgrounds (Vollan and Ostrom 2010). Questions 29–38 reflect the importance of a plurality of perspectives for addressing social and environmental challenges.

29. How are past relationships between centers and peripheries (e.g., urban centers and hinterlands) characterized in terms of resource management and governance?
30. Why do different cultural groups in the same bioregions utilize resources in dissimilar ways?
31. What are the correlations between the health and well-being of humans and perceived status of the ecosystems they rely upon?
32. How do traditional resource management practices of migrant human populations shape newly encountered land- and seascapes?
33. What is the role of geopolitical power in the development, maintenance, and dissolution of cultural ecosystems?
34. How has the construction of borders, boundaries, and frontiers affected land-use practices?
35. How have people altered and managed their land- and seascapes to enhance desirable resources in coastal regions?
36. What has been, and continues to be, the impact of imperialism and colonialism on cultural ecosystems?
37. How can we best engage with Indigenous and/or local communities to respectfully incorporate traditional and local knowledge into historical ecology projects that are specific to place?
38. How can historical ecology address current and future challenges of global food sovereignty and security, both in terms of geopolitical constraints and sustainable ecological practices?

This research node identified issues of human health and well-being (Question 31) and food sovereignty (Question 38) as themes that require an applied focus. Workshop participants also signalled concerns with the contested and tentative nature of human relationships with landscapes, ecosystems, or resource bases. Many wanted to see critical research into the construction and (sometimes coercive) maintenance of geopolitical borders (Question 34) and centers and peripheries (Question 29) and/or “frontiers” (Escobar 1995; Tsing 2005). The challenges of transboundary environmental management and protection have been gaining recognition in recent decades (Dallimer and Strange 2015). It is clear that cartography and socio-economic negotiations of power have relevance to local, traditional, and Indigenous governance systems and deserves research attention (Brody 1981; Thom 2009).

The legacies of imperialism and colonialism (Question 36) and global power dynamics more generally (Question 33) have ongoing ramifications for how resources are managed and governed and provide key contextual dimensions to our understanding of the recent past and present (Altamirano-Jiménez 2013). Many historical ecologists from social science backgrounds concentrate on how oppressive states, top-down management systems, or hyper-extractionist capitalism have been and are increasingly affecting global resource bases. We argue that an applied historical ecology is obligated to acknowledge and scrutinize such concerns and contribute to the mitigation of unjust practices (Veteto and Lockyer 2015). Other social scientists have developed diverse tactics and tools for evaluating the efficacy and sustainability of resource management and governance (Ostrom 2012).

Globally, the increasing commodification of biophysical resources and human labour has caused the disenfranchisement of local or Indigenous people and communities (Bodley 2014; Escobar 2008; Simpson 2001; Tsing 2005). Diminishing Indigenous and local control of, and engagement with, lands and waters, depended on for material and spiritual sustenance, has led to concomitant reductions in cultural and biological diversity (Anderson 2014; Nazarea 2006) as well as exploitative mismanagement of resources (Berkes 2012). Questions 30, 32, and 37 deal with the use of traditional knowledge and Indigenous management models to better understand the past and pursue desired futures.

Workshop participants often took issue with questions that involved the terms "traditional" or "management". For the purposes of this section we use the terms "traditional" or "Indigenous knowledge" not as static types of knowledge, but as Indigenous land-based and intergenerational knowledge (Turner 2014). Local knowledge generally refers to knowledge that has been situated in a particular landscape by typically non-Indigenous communities (Griffith 2006). Iterations of the concepts of traditional knowledge have gone through arduous critiques and many anthropologists use these terms carefully and in reflexive fashions — the commodification and obfuscation of local or Indigenous knowledge is considered in the discussion section, see also (Escobar 2008; Menzies

2006; Nadasdy 2005; Simpson 2001). Some participants also took issue with the term "management" because of the association with hierarchical state sanctioned management agencies that have generated negative connotations of the word among local or Indigenous communities. Lertzman's (2009) broadly encompassing treatment of management systems, which includes the sum of actions, goals and objectives, legitimized by social norms, institutions, and actors involved, has been adopted. Participants, particularly Indigenous scholars, challenged the use of the term "resource" (widely used both in social sciences and ecology) as its connotation leads us to think of ecological relationships as dichotomous, hierarchical, and extractive, and called for other ways of describing the world that may help us question such narratives.

3.5.5. Methods and applications

Methodological practices tend to distinguish historical ecology from other similar research programs and disciplines like environmental history and environmental anthropology. The development of historical ecology in ecology predates the anthropological trend (Szabó 2014). Ecologists have developed methods for gauging current human impacts on the environment, while archaeologists are able to reveal the timing and extent of specific human activity at the landscape scale and over deep timespans (Cooper and Sheets 2012; Harrison and Maher 2014; Szabó 2015). The triangulation of multiple kinds of sources and explorations of residual dissonance between different "archives", actors and ontologies of the natural and human world, are similarly defining characteristics of this field of scholarly endeavour, as the next set of questions highlight.

39. How can modelling of social-ecological scenarios be better developed to incorporate various datasets relating to the past (e.g., paleoenvironmental, historical, archaeological)?
40. How can historical ecology contribute to archaeological investigations of ephemeral sites? (E.g., Sites that reflect activities at a scale that is difficult to detect yet reveals fine-grained temporal records.)

41. How can we see and understand gendered relationships to foodways, past and present? (e.g., food and food systems operating in dynamic socio-cultural environments connected to issues of health and nutrition, livelihood security, labour and power divisions, and cultural and biocultural renewal).
42. What unique contributions might historical ecology make to emergent cross-disciplinary conversations about the Anthropocene?
43. How do we assess and address changes in religious/spiritual interpretations of landscapes?
44. How do land and resource management practices affect nutrient and water cycling in different ecosystems?
45. How can we differentiate between natural and human-mediated range expansions for plants, animals, and other organisms?
46. How can historical ecology engage with Indigenous and local oral traditions that may incorporate diverse spatial and temporal scales?

Questions 41 and 43 address the religious, spiritual, and engendered aspects of landscapes that affect how they are managed (Turner 2014; Vipat and Bharucha 2014). These questions could provide new insights to ecologists who may not consider the more subtle or nuanced human activities that shape landscapes (Lepofsky and Lertzman 2008; Pennings 2013; Simpson et al. 2001; Turner et al. 2013). For decades, anthropologists have wrestled with how to understand and study the relationship between cultures and their biological worlds (e.g., Balée 2006; Ingerson 1994; Ingold 2012; Young et al. 2006). In the course of this research, many have come to appreciate not only the physical remnants of these interactions, but also the cognitive and emotional experiences (Anderson 2014; Harvey and Perry 2015).

Historical-ecological research produces new insights into the relationships between people and landscapes over long time periods, but it requires a careful interlacing of research methodologies from various academic disciplines that incorporate cultural, historical, linguistic, biological, and environmental data (Hegmon et al. 2014; Meyer and Crumley 2011). Ecological principles and techniques generate strong data that can be used to test hypotheses and build rigorous models to track the subtle changes humans enact on the landscape (Heckenberger et al. 2003; Muchiru et al. 2009; Shahack-Gross et al. 2004). Question 40 recognizes the ability of historical ecology to integrate proxy markers from multiple disciplines to locate and delimit ephemeral archaeological sites (Lane 2016), the study of which can further build on understandings of human-environmental transformations.

Although Question 39 highlights the caveat of over-selling and over-representing models, these still provide valuable frameworks for interpreting data and simulating various potential outcomes and are instrumental to many research programs (Kohler and Van der Leeuw 2007; Wiens et al. 2012). Indeed, van der Leeuw and colleagues (Van der Leeuw et al. 2011) have noted that thoughtfully constructed, well-populated models of human eco-dynamics are a necessary component of understanding human-environmental systems at diverse timescales. For example, Question 45 was important for workshop participants who studied ancient transplanting and human-mediated range expansions of important plant species e.g. (Blancas et al. 2010). Kraft et al. (2014) use species-distribution models to support genetic, archaeological, and paleobiolinguistic data to track the domestication of peppers (*Capsicum annuum*). Likewise, Anderies and Hegmon (2011) have presented models for understanding human migration and resource use across multiple temporal and spatial scales in the Mimbres region of the American Southwest.

Connecting ecological data (e.g., soil nutrient levels) to anthropogenic actions (e.g., fertilizing and mulching) requires a deep cross-pollination of methodologies (Question 44). In Iceland, Adderley and others (Adderly et al. 2008) have modeled the manuring necessary for Norse settlers to achieve the desired level of home-field productivity when colonizing landscapes. Bean and Sanderson (2008) have modeled the effects of historical Indigenous fire regimes on ecosystems in Manhattan, New York.

The methods and application section reflects the broad disciplinary reach of historical-ecological research and presages our desire to connect all relevant data to understanding long-term human eco-dynamics. As Question 42 suggests, many historical ecologists are interested in contributing to broader conversations about change in contemporary human-natural systems and our arrival in the Anthropocene (Crutzen and Stoermer 2000; Zalasiewicz et al. 2010). The compelling integration of data from a multitude of historical and paleoecological research traditions remains one of the most important challenges in archaeology and historical ecology (Kintigh et al. 2014), (also see section on Multi-Scalar, Multi-Disciplinary).

3.5.6. Communication and policy

Broader outreach requires effective public communication, and it is no secret that academics and scientists are not always the best at engaging audiences outside their chosen fields. It is increasingly apparent that quantitative results do not “speak for themselves” (Baron 2010), and that practitioners need effective measures to communicate research. Workshop participants felt strongly that historical-ecological research should have an engaging approach, understanding that communication and policy is critical for applied research to be implemented. There is still a widely perceived gap between scientific data and priority information for policy makers (Sutherland et al. 2011), as explored in our last group of questions.

47. How can we develop evidence-based frameworks that highlight and overcome the problem of shifting baselines by incorporating long-term archaeological and historical data into contemporary policies and governance?
48. How can we better integrate heritage management laws and policy with those of natural resource management and conservation?
49. How can policy makers, resource managers, and researchers develop respectful, committed, and transparent partnerships with Indigenous and local communities beyond the lifespan of a typical project?
50. How ca historical ecology be made relevant for education and built into curricula?

Question 47 highlights the value of generating data of actual utility for policy makers. Two such examples are the re-assessment of ecological baselines for herring fisheries (McKechnie et al. 2014), and reviewing reference conditions in the landscapes of the North American Southwest e.g. (1999). Yet there is a caveat to Question 47; historical ecology and other “usable past” approaches can be vulnerable to reductionist narratives of the past (Menzies 2006; Blaikie and Brookfield 1987). This is as true for policy as it is for museums, education, and other curatorial approaches to history (Cameron et al. 2013). It is acknowledged that the entirety of a particular historical interpretation is not equally accessible or translatable into a policy realm (Lowenthal 2015). Recognizing this is crucial to research projects that set out to apply time-series data to advise on contemporary issues (Stump 2010, 2013). Policy should be informed by the amalgamation of diverse data sources and interpretations that are continuously iterated, with the help and consent of all communities involved (e.g., Martindale and Nicholas 2014).

Existing divisions between management of heritage and environmental resources are also particularly problematic. Historical ecology provides solid arguments for fusing heritage and environmental management policy — Question 48 was the highest-ranked question during the final survey exercise. This builds on the recognition that the erasure of humans from a landscape is not necessarily good for ecosystem conservation or associated human communities e.g. (Kittinger et al. 2011; Redford and Stearman 1993; Ross A. 2011) and that climate change and environmental management (or lack thereof) strongly impact heritage resources (Howard et al. 2016; Kearsley and Middleton 2006). Effective policy requires respectful partnerships to develop at the intersection of government, resource managers, researchers, and Indigenous and local people. The need for a commitment to bettering relations between diverse communities in a heterarchical and respectful way was recognized during the priority-setting exercise (Question 49).

Question 50 highlights a facet of communication that transmits historical-ecological knowledge through institutionalized education (e.g., the Global Environmental History MA program at Uppsala University). One potentially effective method for increasing meaningful student interest in the sciences is through project-based curricula or "teaching by phenomena", which entangles human and environmental elements in a single teachable event or landscape (Kanter 2010).

Teaching historical ecology has the potential to empower others to use knowledge of the past. It also allows for the identification of environmental problems, encourages informed discourse, and supports the development of consensus-driven policy. Participants of the priority-setting exercise all shared a desire for continued engagement with the fluid research program of historical ecology as a way of interpreting the past for the benefit of coming generations.

3.6. Discussion

3.6.1. Traditional and local knowledge

For millennia, people have been tied to their landscapes through practical experiences and complex sets of environmental and cultural knowledge (e.g., Hicks et al. 2016). As historical ecology navigates multiple iterations of time and space, and seeks to strengthen the breadth of a still-emerging field, traditional and Indigenous knowledge bases are valued as dynamic information sources that can transform or complement Western science traditions. Indeed, the role of ethnographic and ethnohistoric data and engagement with oral historical accounts was a crucial component in most participants' research tool kits. However, despite the widespread use and celebration of traditional, local, and Indigenous knowledge, many participants felt that our questions should also reflect the global power relations inherent in our work. For example, the legacies and ongoing effects of Western/European colonialism are of particular significance in considering of the complexities of global resource management.

While scholars have long recognized that multi-generational local knowledge systems are a key foundation of successful management (e.g., Bateson 1972; Berkes 1981, 1989; Rettig et al. 1989), it is also important to recognize and discuss the marginalization of Indigenous and local communities from management decisions (e.g., Tang and Gavin 2010). Traditional knowledge or, for example, traditional ecological knowledge (TEK), has long been used as anthropological currency in resource development (Nazarea 2006) and has been criticized as such (Parkes 2000). In 1984, a working group on TEK grew out of a symposium hosted by the Commission on Ecology of the International Union for Conservation of Nature and Natural Resources (IUCN), which resulted in several publications and eventual proliferation of the use of the term TEK (Freeman and Carbyn 1988; Williams and Baines 1993). Since then, TEK has been subject to extended debates in sustainable development and international conservation. The (mis)-appropriation and decontextualization of TEK, particularly in the context of mitigating facilitating industrial development has often had negative impacts, on both the purported resources targeted for management and the communities who subsist and rely on those same resources (Menzies 2006; Nadasdy 2004; Simpson 2001).

Most participants agreed with the inherent complexity of engaging with Indigenous and local knowledge and yet also agreed that these difficulties in no way negate or invalidate the benefits of doing so. These shared opinions capture insight into the long and complex political landscape to be traversed in order to achieve meaningful collaboration between Western science and local and Indigenous knowledge as a fundamental pillar of historical ecology.

3.6.2. Eroding boundaries

The results of the question-setting exercise and deliberative process reflected an increased awareness that (1) long-term eco-human dynamics have the potential to be better understood through engaging in multidisciplinary, historically oriented research; (2) there is a surge of interest in applied research; and (3) the boundaries between natural and social sciences are seemingly beginning to erode.

First, our knowledge of local and community-based resource use and landscape management practices is largely derived from ethnographic and historical data. We know relatively little about longer-term (i.e., centennial and millennial) developments of resource use and management systems and the legacies they have created for contemporary ecosystems (e.g., Anderson 2014). One reason for this lack of clarity is that traditional and locally based practices can mimic natural ecological processes (such as native plant management), and thus the histories of such interactions can often be difficult to detect in the archaeological and paleoecological records (Lepofsky and Lertzman 2008). Understanding the mosaic or meshworks of ancient burning, farming and other secondary landscape transformations (see Balée 2013), requires strong empirical methodologies. Such research focuses on generating scientific data from multiple disciplines and didactic insights about ethics, politics, conservation, science, destruction, and tradition. By tracking such variation, historical ecologists aim to create a larger picture and broader context for evaluating transformation, adaption, innovation, and social and ecological risks.

Another unifying theme among participants was that historical ecology encourages applied, change-oriented research. The motivations behind early anthropological historical ecology research were born from a context of increasing concern for understanding climate change and land-use governance. A focus emerged on tracking temporal elements of climate change and climate variability (Crumley 1994) while actively recognizing the impacts of human land-use strategies (Hjelle et al. 2012).

Historical ecology currently has many configurations, in multiple institutional and disciplinary settings, and not all research and or data collection efforts are directed toward social justice and environmental programs. However, a consensus viewpoint is that an applied historical ecology must act in service of, and consider, research that has wider socio-environmental relevance (Armstrong chapter 2 this dissertation; Veteto and Lockyer 2015).

3.7. Conclusion

The great environmental crises of the twenty-first century will require diverse knowledge sets and the cross-pollination of multiple scientific disciplines to generate innovative solutions. Anthropologists have long struggled with how to conceptualize many types of knowledge (Western, scientific, Indigenous) and have come to recognize the ontologies of “many worlds” (not “one world, many views”, e.g., Latour 2014; Daly et al. 2016), a problem also relevant for historical ecology (Crumley and Marquardt 1987; Marquardt 1992). Landscapes are constituted by individuals and their repetitive actions, where relations with other people and with nonhuman entities, including built landscapes, technology, plants, animals, and others (Deleuze 1988; Ingold 2000; Latour 2005), interact at varying spatial and temporal scales. In historical ecology, a relational landscape approach recognizes that humans live in animated and continually emergent landscapes, a recognition which opens the field for varying and inclusive perspectives, (see also Hinchliffe et al. 2005).

While the initial goal of our exercise was to identify priority research questions relating to the emergent field of historical ecology, workshop participants decided to be less insular, realizing that the developments of historical ecology and its associated expressions vary across disciplines and geographic locales of practice. However, our anthropological and archaeological focus of self-selected respondents is indicative of one aspect of the surging influence that historical-ecological research is developing across multiple academic disciplines. Taken together, these series of highlighted research questions strengthens the basis for collaborative and mindful research to better understand the interrelated entanglements of people and environment over the course of human history.

Chapter 4. Forest Garden Legacies in the Pacific Northwest: Ecological Services and Biocultural Diversity

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4.1. Abstract

Globally, archaeological sites are associated with vegetative communities that reflect both the ecological and cultural legacies of a lived landscape where people introduced, managed, harvested, processed, consumed, and disposed of important plants. However, ecologists rarely consider how the cultural legacies contribute to local and regional plant diversity and ecosystem functioning. To test how human land-use legacies affect plant community composition, functional trait distribution, and functional plant diversity, we examine the influence of two generalized land-use practices at four archaeological villages in British Columbia (<1000 BP). Species richness and functional diversity were higher at village sites, where the management of “wild” fruit, nut, and root species lead to remnant forest garden ecosystems, compared to the peripheral forests surrounding the villages which had lighter impacts from human land-use. Plants at village sites tended to have larger seeds, and more animal-mediated dispersed and pollinated species than peripheral sites. Certain groups of plants with long histories of cultural use, especially large-fruited shrubs, were associated with village sites but not seen in surrounding forests. Results indicate that Indigenous forest gardens are more functionally diverse, a measure of higher ecosystem health and resilience. This work builds on an increasing awareness that Indigenous Peoples in the Pacific Northwest actively managed their lived landscapes to increase the productivity and proclivity of desired plants, in this case, by managing forest gardens near their homes and camping areas. Functional traits and functional diversity measures have not yet been used to understand anthropogenic landscapes like forest gardens. These tools may contribute more meaningful data than species composition measures alone and enhance our understanding of ecosystem services and functioning in anthropogenic environments.

4.2. Introduction

Globally, ancient and on-going Indigenous landscape management encompasses a broad range of practices whose long-term effects have reached into almost every bioregion of the world (Balée 2013; Denevan 2016; Ellis 2016; Fairhead and Leach 2009; Levis et al. 2017; Rick et al. 2013). In recent decades, an increasing appreciation for these management practices has led to a more complex and nuanced view of how humans interact with biological communities. For instance, some studies have demonstrated that Indigenous land-use legacies tend to increase soil nutrients and species richness (Cook-Patton et al. 2014; Trant et al. 2016). This in turn can lead to a net increase in tree species (Ross N.J. 2011) and leave unique genetic signatures (e.g., fixed heterozygosity, greater population differentiation) on extant plant communities (Parker 2010, 2014; Thompson et al., 2015).

Functional diversity is increasingly used as a measure to understand ecosystem functioning and diversity (Días and Cabido 2001; Flores et al. 2014; Mouillot et al. 2013; Funk 2017). Plant traits — the physiological, phonological, and reproductive characteristics of plants — reveal more about the structure of an ecosystem and the functions of species within it, than traditional biodiversity studies which focus on species composition and richness. In order to understand how ancient Indigenous land-use practices affected ecosystem structure and functioning in the Pacific Northwest, this research uses a functional-ecological approach, which to our knowledge, has not yet been used to assess anthropogenic ecosystem services and functioning.

Research in the Pacific Northwest of North America has demonstrated many ways in which the region's "complex hunter-gatherers" intentionally managed and sustained diverse resources and ecosystems (Anderson 2005; Campbell and Butler 2010; Deur and Turner 2005; Trosper 2002; Turner 2014). Some ecosystem management practices, such as fish traps (White 2011), intertidal marsh gardens (Deur 2002), wapato gardens (Hoffmann 2016; Turner 2014), Garry oak ecosystems (McCune et al. 2013), and clam gardens (Lepofsky et al. 2015), have left lasting footprints in both the historical-ecological (subtle ecological changes) and archaeological (remnant material culture) records (Lepofsky et al. 2017).

This study focuses on a newly re-discovered form of anthropogenic management in British Columbia (BC), Canada known as "forest gardens", concentrations of edible herbaceous roots, and fruit and nut shrub species intentionally managed near large archaeological village settlements. Forest gardens in BC differ from those in the tropics and subtropics which are characterized a by higher density of tree species that are part of a complex rotating fallow/swidden agriculture focusing on maize, beans, and squash (Ford 2008; Ross 2011). Forest gardens in the BC appear to be the result of long distance transplanting and management of predominately native perennial shrubs near the home (McDonald 2005; Turner 2014). These concentrations of plants could have resulted from the disturbance of village construction or villages were settled in such locations because of the quality of edible vegetation already present — in either scenario, people took full advantage to enhance the productivity and proclivity of desired plants, resulting in remnant forest gardens still visible today at archaeological sites throughout British Columbia.

Evidence of management like coppicing and pruning (to increase flowering, yields of fruit, promote health and vigor, control size, etc.), burning, transplanting, weeding and fertilizing are known ethnographically (Anderson 2005; Johnson 2010; Lloyd 2011; Turner 2014), but are challenging to document in the more distant past (but see Lyons and Ritchie 2017; Szpak 2014). Thus, remnant forest gardens — which persist despite over a century since large-scale population loss from colonial disease and migration led to the cessation of management — are ideal for understanding the long-term effects of social-ecological systems. A functional-ecological approach will reveal how such ecosystems may have functioned in the past (as ecosystem services), and how those legacies persist today (as unique ecosystem functions).

Despite strong evidence that archaeological settlements leave lasting biological legacies, long-term human land-use legacies on contemporary landscape composition and structure are relatively poorly understood and are unevenly considered in ecological studies. When they are acknowledged, ecologists typically regard human land-use legacies as short-lived and/or as negative and that it decreases the diversity and resilience of “natural” systems (e.g., Hermy and Verheyen 2007; Johnson et al. 2015; Mattingly et al. 2015). Neutral or positive impacts are less well recognized and studied but have been given some attention in historical-ecological research (Armstrong chapter 3, this dissertation; Ekblom 2015; Heckbert et al. 2015; Pfeiffer and Voeks 2008; Szabó 2014; Rackham 2000).

Previous studies of human land-use legacies typically focus on long-term patterns of species richness (Bellemare et al. 2002; Foster et al. 2003; Vellend et al. 2007), but these studies provide limited inferences of functional variations in plant communities and their influence on ecosystem function. An approach that considers plant functional traits (species biochemical, physical, and phenological traits) and trait syndromes (consistently co-varying plant traits) is needed to elucidate how communities that result from human land-use legacies respond to environmental factors (De Souza 2016; Mayfield 2010), affect other trophic levels (Lavorel et al. 2013), or influence ecosystem processes (Díaz et al. 2007). While functional trait data is increasingly available for plant species worldwide (e.g., TRY database, Kattge et al. 2011), there has been no known previous application of functional trait research to anthropogenic ecosystems.

To explore the ecological consequences of forest garden management adjacent to village settlements, we compare two anthropogenic ecosystem types: forest garden ecosystems and peripheral forest ecosystems. Forest gardens are characterized by unique plant communities, adjacent to large archaeological features like house depressions, raised platforms, and large concentrations of storage pits (Fig 3). The distinctive aggregation of ethnobotanically important food and medicine species near ancestral homes indicate a deliberate tending of plants, that were the result of, in the case of some species like hazelnut (*Corylus cornuta*) and northern rice-root (*Fritillaria camschatcensis*), long distance transplanting events (Lyons and Ritchie 2017; McDonald 2005; Turner 2014).

Peripheral sites consist of conifer-dominant forests with "lighter" human footprints such as bark stripped culturally modified trees (CMTs), trails, and other light resource extraction areas (Fig. 4), beginning at least 300m from the archaeological site and extending outward. This study considers how these two types of ancient human land-use practices affected the functional ecology of contemporary ecosystems. Plant inventories at four archaeological sites in BC were used to test whether species composition between two site types (village forests and peripheral forests) differed. We then examined how four plant functional traits (seed mass, shade tolerance, pollination syndrome, and dispersal syndrome) varied between the two types of human-modified ecosystems. These traits represent axes of life history variation that we hypothesize are more likely to be affected by human actions (see Funk et al. 2017 on trait selection).

Figure 3. Village site with open shrub canopy of Pacific crabapple (*Malus fusca*) and beaked hazelnut (*Corylus cornuta*) at the village site of Dałk Gyilakyaw.

Figure 4. Peripheral conifer forest roughly 300m from archaeological village of Gitsaex; note the culturally modified tree (CMT), a bark-stripped hemlock (*Tsuga heterophylla*) – although peripheral forests were not as obviously managed, they are still part of the cultural landscape and were used extensively for building materials and for fuel.

4.3. Methods

4.3.1. Study Sites

To investigate effects of human land-use legacies, we sampled plant communities in four archaeological village sites in the Pacific Northwest (Fig 3). Two Ts'msyen (Tsimshian) villages in northwest British Columbia, Canada (BC) and two Salish villages in southwest BC were chosen for their long-term (i.e., >1000 years) and consistent occupation, and their relatively recent "abandonment" (all four communities left between 1870–1890 AD). Three of the villages (Dałk Gyilakyaw, Gitsaex, and Shxwpópélem) are located in transitional ecological zones between Coastal Western Hemlock and the interior Mountain Hemlock biogeoclimatic zones (Pojar et al. 1987). Large shell-free midden deposits on major salmon-spawning rivers characterize all three sites. The fourth village, Say-mah-mit, is a shell midden site in the Coastal Douglas-fir and Coastal Western Hemlock biogeoclimatic zones on a marine inlet near the city of Vancouver. The locations of the four archaeological villages in distinct regions of BC (Fig 3), offer the possibility to study regional vegetation patterns across varying vegetation types and human land-use strategies.

Botanical inventories were conducted in 5x5m plots in both the settlement areas (directly adjacent to archaeological features), and peripheral forests (>300m from archaeological features). In each plot, trees (woody species with trunks and over 3m tall) were counted, and percent coverage was estimated for shrub (woody species under 3m with single trunk or multiple shoots) and herbaceous (non-woody species) layers. At each of the four village sites, plots were chosen at random and species richness was recorded to redundancy. This resulted in a minimum of four plots per village and five plots per periphery.

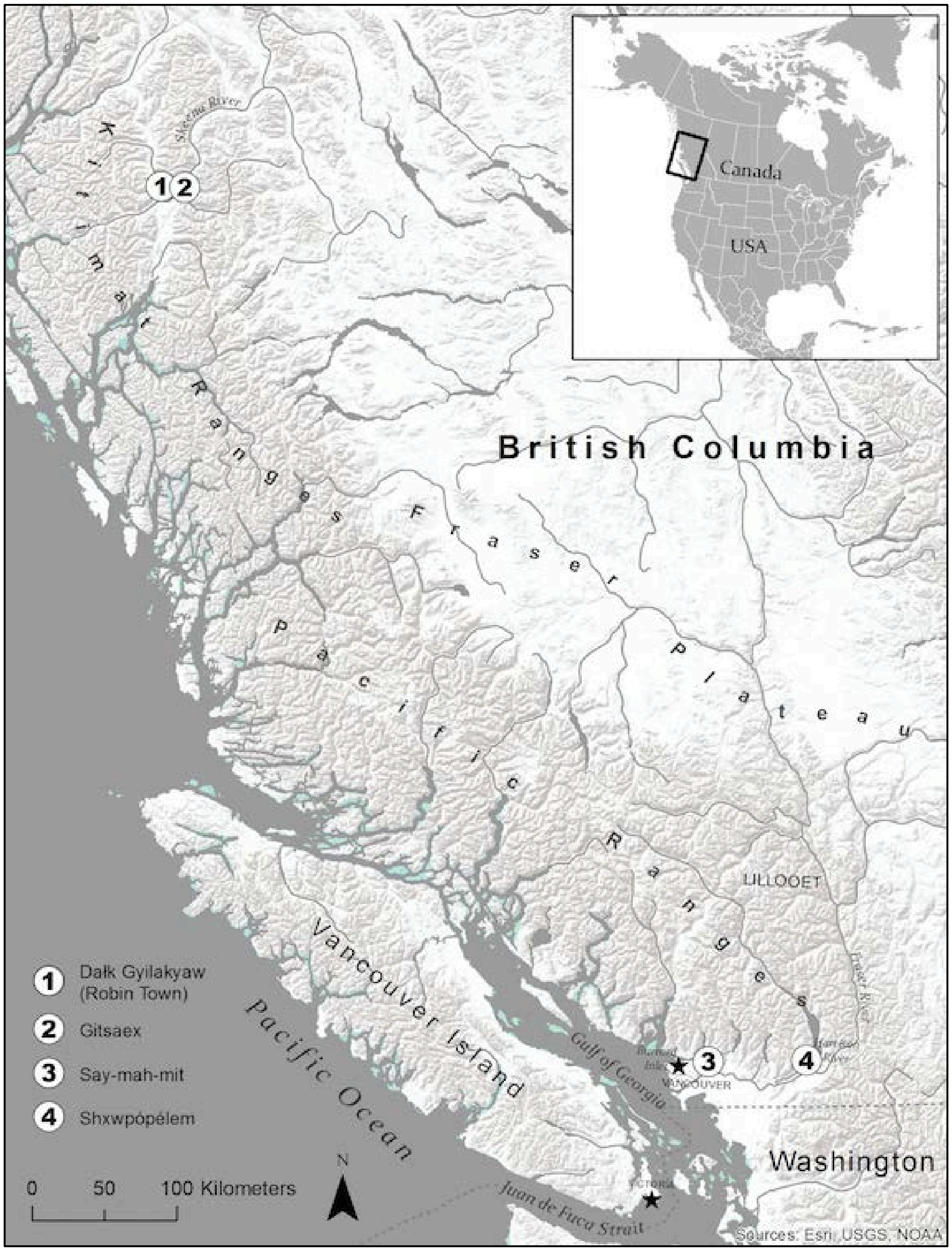

Figure 5. **Four archaeological villages in this study: (1) Dałk Gyilakyaw on the Kitsumkalum River, a tributary of the Skeena, and (2) Gitsaex on the Skeena River, (3) Say-mah-mit on the Harrison River and (4) Shxwpópélem in Burrard Inlet.**

Northern Tsimshian Villages

The Coast Tsimshian (Ts'msyen) Nations today are comprised of fourteen communities in northwest BC, located mainly around the Prince Rupert harbour, the Skeena River estuary, and up the Skeena River to the settler town of Terrace. Ancestral Tsimshianic people (including the Nisg̲a'a and Gitxsan) trace their history back to the ancestral village of Temlaxam/Temlax'aamit (where the Skeena and Bulkley Rivers meet), from whence they spread throughout the Skeena watershed and along the coast roughly 4,000 years ago (Barbeau 1928; Glavin 2000). Two of the fourteen Tsimshian communities have traditional territories throughout this region but their main reserves and villages are on either side of the settler town of Terrace, along the Skeena River and its tributaries. The ancestral villages of these two groups, the Gitsm'geelm (Kitsumkalum) and Gitselasu (Kitselas), are the focus of this study.

Gitsm'geelm village of Dałk Gyilakyaw

Dałk Gyilakyaw (Robin Town) is a complex of village clusters on the Kitsumkalum River canyon that spans roughly 2km^2 and is a cultural keystone place for the Gitsm'geelm people (Lepofsky et al. 2017). Although no absolute dating is available, based on oral histories, site formation processes, and the orientation and size of houses, the area was likely settled at least 2000 years ago. Around AD 1870, after monumental population loss from colonial diseases, the Gitsm'geelm began to leave the village for commercial (wage labour) fishing opportunities on the coast and the site was largely abandoned by 1920 (McDonald 2003).

The archaeological and ecological features at Dałk Gyilakyaw include four large clusters of house depressions and large terraces with midden deposits. Adjacent to house depressions are hundreds of cache pits, remnant orchards of hazelnut, Pacific crabapple and other fruiting trees and shrubs, and an extensive network of "grease trails" (trade routes), which connected the Gitsm'geelm to various other nations and resource access points in northwest BC (Johnson 2010; McDonald 2003, 2005). Indian Reserve Commissioner Peter O'Reilly surveyed and sketched Robin Town for the Indian Land Registry in 1892, noting "gardens" on the eastern terrace bank of the village. Oral histories and recent accounts from elders explicitly recall transplanting of northern rice-root to the site for gardening (McDonald 2003). The village area and forest gardens comprise our core sampling area. Outside this core area, the peripheral forest is composed of conifer-dominant trees and low-lying mosses, easily accessed for fuel and other minor food harvests. The peripheral forests are currently encroaching on the villages and forest gardens since human settlement and management practices ceased — a pattern that was also observed at the other three villages.

Gitselasu village of Gitsaex

Gitsaaex is one of five large village complexes (5050 cal BP) located in Kitselas Canyon, a small (2km long) lynchpin canyon on the lower Skeena River in Northwest BC. As the lower-most canyon on the Skeena, permanent occupation by the Gitselasu (Kitselas, “People of the Canyon”) meant they could control important salmon resources (e.g., Coupland 1985). Gitsaex village was inhabited until roughly AD 1880 when people went to the coast to work in the canneries and on fishing boats. The village of Gitsaex includes a complex of fifteen large house depressions, cache pits, and remnant crabapple, hazelnut, and red elderberry (*Sambucus racemosa*) orchards. This is our core sampling area. Outside this area, there is a peripheral closed canopy forest with some recent CMTs. Extensive archaeological surveys were conducted at Gisaaex in the 1970s and 1980s (MacDonald and Inglis 1979, 1981). Today, the canyon is a National Historic Site of Canada and tourist destination for many of the sports fisherman and campers who visit in the summer and fall seasons.

Central Coast Salish Villages

The two study areas in southwestern BC are located in Halkomelem-speaking Coast Salish territory where the Fraser River enters the Gulf of Georgia, roughly 700km south of the Skeena River (Fig. 5). These study areas include the ancestral Tsleil-Waututh village Say-mah-mit in the Port Moody Arm of Burrard Inlet and the ancestral Sts’ailes village of Shxwpópélem on the Harrison River. The Harrison River is a major tributary of the Fraser River roughly 100km inland from the coast and an abundant salmon-spawning river in the Pacific Northwest (Ritchie et al. 2016). Although Port Moody Arm has been affected by intense waterfront development and urbanization, archaeological sites are still intact and pocket parks set up by the city have allowed native vegetation to persist.

Sts’ailes village of Shxwpópélem

Shxwpópélem is one of at least 15 Sts’ailes villages that clustered around the Chehalis River delta and Morris Creek in the heart of the Harrison River Valley. All Sts’ailes villages were situated on both banks of the river and mid-river islands. Archaeological evidence indicates the extent to which people managed and manipulated their immediate ecosystems, especially between ~1600 BP to the early AD 1800s (Ritchie 2010; Ritchie 2016). On a slough adjacent to Shxwpópélem specifically is a processing area where people pit-cooked plants and animals, including the highly valued camas (*Camassia quamash*), hazelnut, multiple berry species (*Vaccinium* spp., *Rubus* spp.), deer, and salmon (Lyons and Ritchie 2017; Ritchie and Ritchie 2016). With the exception of camas, which was likely transported from Vancouver Island, all other plant remains recovered from these pits are native and available locally. Hazelnut, crabapple, Indian plum (*Oemleria cerassiformis*), red elderberry, various currants (*Ribes* spp.) and blueberries (*Vaccinium* spp.) grow adjacent to the archaeological features. Similar to other sites, the villages are surrounded on the peripheries by conifer-dominant forests.

Tsleil-Waututh village of Say-mah-mit

Say-mah-mit is a large Tsleil-Waututh village located on both sides of the lower reaches of the once salmon and oolichan-bearing Noon’s Creek (Pierson 2011) at the eastern extent of Burrard Inlet near Vancouver, BC (Morin 2015; Morin et al. 2016). Say-mah-mit is characterized by stratified shell-midden deposits, hearth features, and occupation surfaces (possibly residential) dating to around 2,200–1,800 years ago (Morin et al. 2016). Some modern development has disturbed the east side of the site, however, hazelnut, crabapple, Indian plum, red elderberry, rice-root, and other important edibles persist adjacent to the archaeological features and were sampled. Peripheral conifer forests are located 300m east of Say-mah-mit village.

4.3.2. Quantitative analysis

Richness analysis and indicator species

To test biodiversity rates between village and peripheral sites, total species richness was calculated as the number of tree, shrub, and herb species that occurred in each 5x5m plot. To account for the non-independence of plots within villages, we used linear-mixed models with history as a fixed predictor effect and village as a random effect. We ran a model for each of our response variables: total species richness, trait community weighted means, and functional diversity metrics.

Trait selection and database assembly

To test how village and peripheral land-use histories affected community-level plant functional traits, we analyzed seed mass, shade tolerance, pollination syndrome, and dispersal syndrome. We predict that species in the village sites will have a larger average seed mass since larger seeds can correlate to larger fruits, the more economically viable part of a plant for humans, and a quality often opportunistically enhanced during selective domestication (Zeder 2015). We predict peripheral forests will be composed of more shade tolerant species. This is because peripheral forests are characterized by canopies that are more closed than those immediately around village sites. The more open nature of villages is due to these areas being cleared of large trees for building, encouraging valued successional berry foods, and for viewscapes. We anticipate a greater proportion of plants in the village sites to be animal-pollinated, specifically by insects, since many of the edible-fruited species for humans tend to be insect pollinated. Finally, we expect a greater proportion of plant species in the village sites to favour dispersal by animal consumption (endozoochory) since the fruits that feed large mammals would also be edible for humans.

All tree, shrub, and herbaceous species from both village and peripheral sites were analyzed and characterized with trait data from the TRY database (Kattge et al., 2011), and were combined with data from previous studies conducted in the Pacific Northwest (Amador et al., 2013; Arista and Talavera; Pojar 1973, 1974; supplementary information). Dry seed mass was standardized to grams per 1000 seeds. For shade tolerance, species were classified as: shade intolerant (1), intermediate (2), or shade tolerant (3). Pollination syndrome was characterized for each species as wind pollinated, insect pollinated or selfing. Dispersal syndromes were classified as endozoochory or non-endozoochory.

Community weighted means

To characterize community-level functional trait patterns, we calculated site-level community-weighted means for each of the four functional traits. Seed mass and shade tolerance were analyzed as continuous variables. Their community-weighted means were calculated by averaging trait values for species at each site, weighted by square-root-transformed species cover values. Pollination and dispersal modes were analyzed as categorical traits, and community-weighted means were calculated as the proportions of species with animal-pollinated and endozoochory dispersal strategies, respectively, weighted by square-root-transformed abundance values. The functional trait analyses used only herb and shrub functional traits since trees were not sufficiently represented at village sites (herbs and shrubs were sufficiently represented at village and peripheral sites).

Functional diversity metrics

Functional diversity can provide information about ecosystem functioning, resilience, productivity (Petchey et al., 2004), and the processes involved in driving community composition (Mouillot et al., 2007). In order to assess functional diversity, we calculated three functional diversity metrics using the R package FD (Laliberté and Shipley 2011). To avoid redundancy given the high rates of correlation between different functional diversity metrics (Díaz and Cabido 2001; Mouchet et al., 2010), we analyzed only three metrics: functional evenness (the evenness of abundance distribution in niche space) (Villéger et al. 2008), functional divergence (the degree of divergence in functional traits within niche space) (Villéger et al. 2008), and functional dispersion (the average distance to the abundance-weighted centroid) (Laliberté and Legendre 2010). We omitted functional richness, a functional diversity metric often analyzed alongside functional divergence and functional evenness, as it does not account for dispersion or relative abundances and is somewhat correlated with functional dispersion (r = 0.425) (Laliberté and Legendre 2010).

Site history and plant community traits

Several tests were performed to assess whether land-use history (village or peripheral sites) affected the seed mass, shade tolerance, animal pollinated, and animal dispersed attributes of each site type. To account for the non-independence of plots within villages, we used linear-mixed models with history as a fixed predictor effect and village as a random effect. We ran the models with several response variables: total species richness, trait CWMs, and FD metrics. We performed all analyses using the lme4 package in R (Bates et al., 2014). Species richness was measured for herbs and shrubs only. To identify species that are characteristic of different land-use histories, we conducted an indicator species analysis using the R package indicspecies (De Caceres and Jansen 2015).

4.4. Results

Overall, 125 taxa were recorded at our four paired village and peripheral sites. Inventories reached sampling redundancy within five plots at village sites and within three or four plots at peripheral sites. Based on our observations, we note that some cultural salient species were not captured in our sampling plots. For instance at Robin Town, wild ginger (*Asarum caudatum*) was previously recorded by one of the authors and at Shxwpópélem, wapato (*Sagittaria latifolia*) was said to be harvested by locals but was not found during our surveys. Despite this, the plots are generally representative of overall richness at each village.

4.4.1. Richness analyses

Our analyses of richness suggest that species composition between village and periphery sites are distinct enough to warrant separate classification of forest type (Table 1). Eleven species are indicators for village sites ($p>0.05$) and are present at all four sites; five species are indicators for periphery sites ($p>0.05$). Across all archaeological sites, the most prominent indicator species for villages were beaked hazelnut, Pacific crabapple, highbush cranberry (*Viburnum edule*), and red elderberry all important stored edible foods for Tsimshian and Salish people. At peripheral sites, the top indicator species are composed of large conifers including Western hemlock (*Tsuga heterophylla*), red alder (*Alnus rubra*), and Western redcedar (*Thuja plicata*).

Species	**Indicators**			**Ethnobotanical Significance**				
	Type of Site Indicator	**Indicator Confidence**	**P. value**	**Edible (Stored)**	**Edible**	**Tech (Fuel)**	**Technology**	**Medicine**
Corylus cornuta (Beaked hazelnut)	Village	0.97954	0.001	X	X	x	X	X
Malus fusca (Pacific crabapple)	Village	0.97693	0.001	X	X		x	
Viburnum edule (Highbush cranberry))	Village	0.91132	0.027	X	X		x	X
Sambucus racemosa (Red elderberry)	Village	1.0000	0.029	X	X		x	x
Maianthemum racemosum (Solomon's plume)	Village	1.0000	0.031		x			x
Rosa nutkana (Nootka rose)	Village	0.71933	0.034	X	X		x	X
Cornus sericea (Red osier dogwood)	Village	1.0000	0.04				X	X
Rubus spectabilis (Salmonberry)	Village	0.7563	0.042	X	X		x	
Crataegus douglasii (Black hawthorn)	Village	1.0000	0.043	x	x		x	X
Lonicera involucrata (Black twinberry)	Village	1.0000	0.05				x	X
Tsuga heterophylla (Western hemlock)	Periphery	0.91442	0.001	X	x	X	x	x
Alnus rubra (Red alder)	Periphery	0.90114	0.004			x	x	x
Thuja plicata (Western redcedar)	Periphery	0.88835	0.008			X	X	
Rubus armeniacus (Himalayan blackberry)*	Periphery	0.93166	0.035		x			
Epilobium angustifolium (Fireweed)	Periphery	0.86155	0.045		x		X	x

*Invasive, non-native
x denotes some use
X denotes extensive use

Table 1. Species indicators (*p* ≤0.05) and their ethnobotanical properties at village and periphery sites.

Consistent with our observations, forests near village sites proved to be overall more species rich that peripheral forest. This result is also consistent with biodiversity studies of archaeological village sites in other parts of the world including the Amazonian neotropical forests (Balée 2013; Heckenberger 2010), the Tehuacán-Cuicatlán Valley (Blancas et al. 2010), northwestern Belize (Ross N.J. 2011) and Papua New Guinea (Lepofsky 1992). Per growth form, villages produced a higher number of both shrubby and herbaceous species, whereas peripheral sites consisted of a higher number of tree species (Fig. 6). Taken together, the edges of these two ecosystems types are especially productive ecotones.

All but two species with significant p-values (p ≤ 0.05) were or are traditionally used by Pacific Northwest Indigenous peoples. Shrubs with edible fruits represented

72.73% of the village site indicator species. In contrast, only one storable edible (Western hemlock, harvested for its cambium) and two edible species (40.0%) the exotic Himalayan blackberry (not present at colonial contact), and fireweed (whose stalk is edible only for a small seasonal window) are indicators a periphery sites. This greater diversity in village sites supports the idea that native ecosystems tended near the home were encouraged for their edible and stored edible properties.

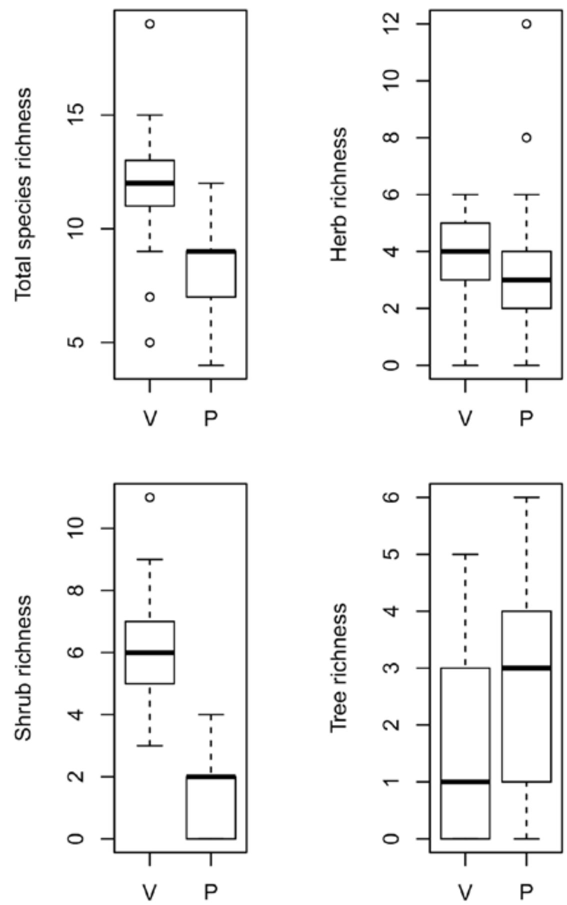

Figure 6. **Total species richness and species richness by life-form type. V refers to village forests and P refers to periphery.**

4.4.2. Community-level functional trait patterns

Our search recovered trait data for species that make up > 80% of plant cover at all plots. Results indicate that there is a difference in the functional traits associated with village versus periphery sites, reflecting the different land-use histories by Indigenous communities who utilized different niche spaces on the landscape. For herbs and shrubs, three of the four functional traits measured varied significantly between the village and periphery sites (Fig. 7). The four traits used to compare community composition and ecosystem functioning indicates that village ecosystems/forests have: 1) an increase in large seedy fruits ($p < 0.001$), 2) more animal pollinated ($p < 0.001$) and animal dispersed plants ($p < 0.001$), and 3) no significant difference in shade tolerance. Overall our results also imply that the selection for certain plant traits may explain cultural preferences, for example, for larger fruits.

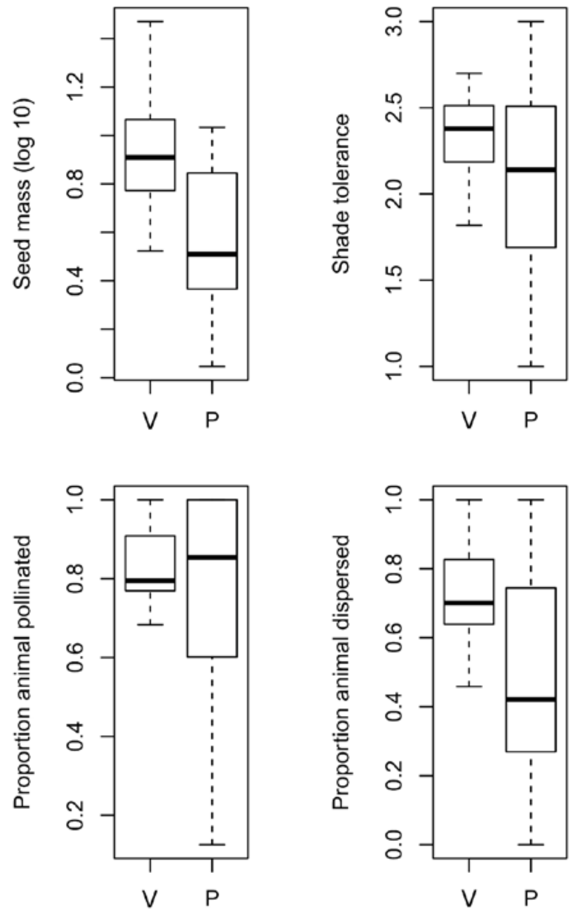

Figure 7. Community-weighted mean of seed mass, shade tolerance, pollination syndrome, and dispersal syndrome traits for herbs and shrubs across village and periphery sites.

The increase in large seedy fruits at villages compared to peripheral forests reflects the ubiquity of perennial food crops in Northwest coast diets. While the Eurasian-model of agriculture (domestication of seedy annuals, see Larson et al. 2014; Zeder 2015) was generally absent at colonial contact in the Pacific Northwest, Indigenous people actively managed and tended perennial species, many of which are represented in contemporary forests (Turner and Peacock 2005). In addition to the economic viability of larger seed mass for humans (larger edible fruits), perennial species profit from a closer relationship with humans because they do not self-pollinate as easily as other plants and therefore may benefit from human propagation and management strategies like coppicing and pruning (Miller and Gross 2011). Pruning can mend damaged shrubs, promote growth and health, increase flowering, and increase yields of fruit trees and berry bushes. Large seeds are also more stress tolerant and adapt more easily to tough conditions like drought and competition, perhaps facilitating transplanting to new geographic or ecological locales (Westoby et al. 2002).

The prevalence of animal dispersed and animal pollinated species at village sites relative to peripheral sites supports the idea that human animals were moving plants into their villages, selecting and tending them over species with other dispersal mechanisms. The increase in animal dispersed/pollinated species at village sites also suggests that, after humans have departed from the villages, forest gardens provided unique ecological roles/functions for pollinators and animals seeking food. While we hypothesized that village sites would host less shade tolerant species in its open canopy, there was no significant difference between sites. We have found that many species with edible fruits in the Pacific Northwest grow in abundance in shaded understories (e.g., *Sambucus*, *Vaccinium*, *Rubus*), but these plants tend not to produce fruit. In more open villages, however, these same species, while equally abundant, tend to fruit more often. This increased fruit production could have led to a larger seed bank of these species in the soil or midden around the village site, and as mentioned above, attracted game for hunting.

4.4.3. Functional diversity

Village sites had higher functional evenness ($p = 0.028$), and functional dispersion ($p = 0.0023$) but similar functional divergence ($p = 0.298$) (Fig. 8). The greater functional evenness observed at village sites may indicate a greater likelihood of resilience in the face of encroachment, partially explaining the long-term persistence of these anthropogenic garden ecosystems (even after 100 years of neglect). Functional evenness reflects the distribution of species abundance in niche space, with higher values (as seen in villages) showing more effective use of the range of locally available resources (Mason et al., 2005). Lower values (as seen in peripheral areas) indicate that some parts of niche space are underutilized. This may potentially lead to lower productivity and susceptibility to invasion (Mason et al., 2005), for example by Himalayan blackberry (*Rubus armeniacus*), an invasive plant, and species indicator of peripheral sites. Higher functional dispersion may account for species abundances, largely independent of species richness or number (e.g., Laliberté, and Legendre 2010).

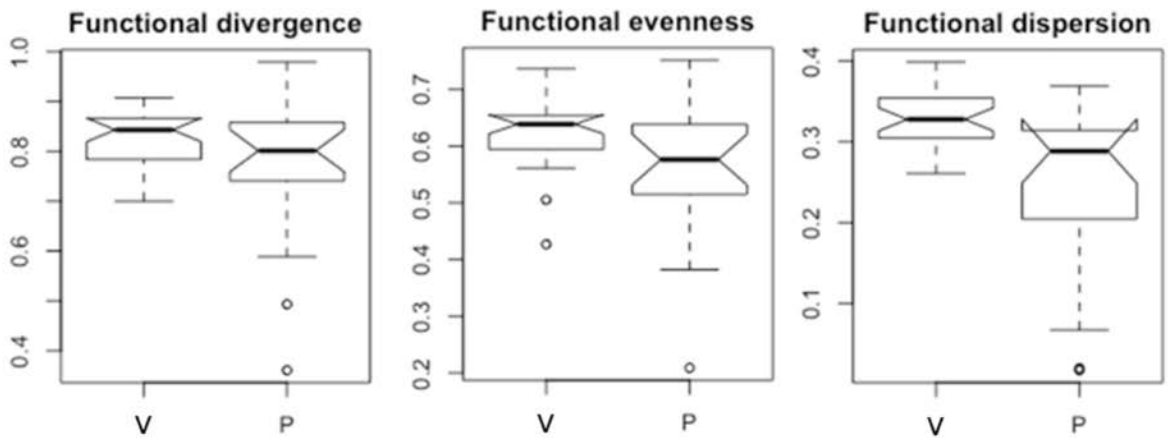

Figure 8. Functional diversity metrics represented between village and peripheral sites.

4.5. Discussion

Plant communities in village sites differed substantially from peripheral forest sites, not only in taxonomic identity but also in functional traits and functional diversity. Using a functional-ecological approach to study anthropogenic ecosystems allow us to link different human land-use practices with long-term ecological patterns. For example, the greater abundance of large-seeded fruits at villages compared to peripheral forests reflects the importance of perennial food crops in Northwest coast diets (e.g., Turner and Peacock 2005). The Eurasian-model of agriculture (domestication of seedy annuals, see Larson et al. 2014; Zeder 2015) was absent at colonial contact in the Pacific Northwest, yet Indigenous people actively managed and tended perennial species, many of which are represented in contemporary forest gardens. In addition to the economic viability of larger seed mass for humans (larger edible fruits), large seeds tend to be more tolerant of stressful conditions like drought and competition (Westoby et al. 2002). In habitats with periodic disturbances, large-seeded plants are expected to have more consistent reproductive success (Venable and Brown 1988), perhaps making them an especially reliable food source. While we hypothesized that village sites would host less shade tolerant species in its open canopy, there was no significant difference between sites. We have found that many species with edible fruits in the Pacific Northwest grow in abundance in shaded understories (e.g., *Sambucus*, *Vaccinium*, *Rubus*), but these plants tend produce smaller fruits and less consistently (personal observation). In more open villages, however, these same species tend to fruit more often (personal observation). This increased fruit production could have had a cumulative effect on abundance, leading to a larger seed bank of these species in the soil or middens around the village site.

The prevalence of animal dispersed and animal pollinated species at village sites relative to peripheral sites supports the idea that humans (recognized as one of the many animals in this niche) were moving plants into their villages, selecting and tending them over species with other dispersal mechanisms. Humans have extended the range of important perennial plant foods throughout the Pacific Northwest and have long tended these plants near their homes (Turner and Loewen 1998; Anderson 2005; Deur 2002; Lepofsky and Lertzman 2008; Reedy-Maschner and Maschner 2012). For example, a Kwakwaka'wakw elder recounted transplanting highbush cranberry, Heiltsuk people were known to move various berry bushes to their lands, and a Gitga'at woman suggested, "borrowing a root" (of a special yellow-fruited *Sambucus racemosa*) from one territory to her own (Turner and Peacock 2005:125). Linguistic evidence suggests that hazelnut may have been transplanted from southern BC to the northwest well before settler-colonialism (Turner 2014; Armstrong chapter 5, this dissertation). Plant seeds and propagules could have moved through the hands of various communities by gifting, trading, reciprocity, encroachment, or amalgamation (Anderson 2005; Turner and Loewen 1998; Turner 2014).

The increase in animal dispersed/pollinated species at village sites also suggests that after humans departed from the village, forest gardens began to provide unique ecological roles and functions for pollinators and animals seeking food. Currently, forest gardens at all four of the village sites might be considered "remnant" as they are now largely out of use and human harvest or management is rare. However, these gardens still provide unique habitat and resources for pollinators and other animals. At the village of Dałk Gyilakyaw evidence of moose, bear, and deer is especially common. Gitsm'geelm people used to return to their abandoned village in the 1950s and 60s, for hunting trips because it was especially good for large-game hunting. Gitsm'geelm Elders still remark that old village sites are the best place to hunt. Today, young hazelnut shoots and huckleberry bushes are heavily browsed, indicating that game still frequent the site. The higher density of animal pollinated and dispersed species in forest gardens compared to peripheral forests was not likely an intended consequence on the part of the original managers, but the legacy of their actions lead to higher a diversity of animals and pollinators in these forests a century after humans left them.

Our results suggest that biodiversity and functional-ecological measures can be used to understand how Indigenous management practices relate to plant diversity and biological conservation (see Halpern and Spies 1995; Nabhan 2014). Since village forests had greater functional diversity, they likely provide a suite of ecosystem functions that peripheral conifer forests do not (Whittaker and Heegaard 2003). Functional evenness reflects the evenness of abundance and distribution of plant traits, with higher values (as seen in villages) showing more effective use of the range of locally available resources (Mason et al., 2005). Lower values (as seen in peripheral areas) indicate that some parts of niche space are underutilized. This may potentially lead to lower productivity and susceptibility to invasion (Mason et al., 2005), for example by Himalayan blackberry (*Rubus armeniacus*), an invasive plant, and species indicator of peripheral sites. The greater functional evenness observed at village sites indicates a greater likelihood of resilience in the face of a disturbance or encroachment which is important for regional biodiversity and forest management in BC, and may explain why forest gardens persist even after a century since inhabitants left their settlements. Higher functional dispersion indicates how well multiple species co-occupy a single niche space. Therefore higher functional dispersion in forest gardens may account for species abundances, largely independent of species richness or number (e.g., Laliberté and Legendre 2010).

Plant communities in forest gardens and in other highly anthropogenic ecosystems have not been well studied from a functional-ecological perspective. This reflects the fact that there is little awareness that there are long-term Indigenous effects in the region and that these effects have distinct ecological legacies (e.g., Hoffman et al. 2016). Forest gardens give pause for reflection on how we value different ecosystems, niche spaces, and cultural landscapes. This especially true in an age of accelerated climate change and as we try navigate or mitigate adverse ecological effects from industry, government and on-going settler-colonialism. We are only beginning to understand the complex social-ecological systems in the Pacific Northwest (Lepofsky et al. 2017). This research shows how Indigenous landscape management increased local biodiversity and ecosystem functioning but this also raises more questions: How old are these management practices? How pervasive are these types of anthropogenic ecosystems? How can the past critically inform localized conservation? How should our increased recognition of past management and engagement with ecosystems influence discussions of Indigenous rights and title to manage and occupy their traditional lands (Augustine and Dearden 2014; Howden 2001)?

The persistence of forest gardens and the high functional diversity observed (compared to peripheral forests), despite over 100 years since the cessation of management, is indicative of the resilience and robustness some human land-uses strategies can have on an ecosystem. This kind of "positive" effect did not occur across all Indigenous territories, as evidenced by the lower functional diversity of peripheral forests. Resource exhaustion and depletion likely occurred in some areas before colonial contact — but this does not negate the complex role that culture (coded laws, religion, social status) played in stewarding the land in positive ways (e.g., Anderson 2014; Campbell and Butler 2008). While we focus on ecosystem services and functions, it is equally important to consider the role of cultural practices and communal management strategies vis-à-vis forest gardens (Berkes 2012; Campbell and Butler 2008; Turner 2005). Furthermore, for many contemporary Indigenous communities, forest gardens are vestiges of their ancestors. Forest gardens tie people intimately to place and allow communities to reimagine and reinvigorate their cultural landscapes. Such actions are nation building-exercises and can help with language-revival, food sovereignty initiatives, strength in land claims, and movements towards restorative justice. However, if the threats of climate change and on-going expansion of settler-colonial agendas are any indication of how eco-cultural resources are perceived and treated (e.g., Hornborg and Martinez-Alier 2016; White 2016), the advocacy, protection and adaptive management of these places are crucial (Lepofksy et al. 2017; Rosa and Dietz 2012). Biodiversity and functional diversity loss affects a wide-ranging group of human beings, but especially those who depend more directly on the land for a living (Savo et al. 2016). In Northwest BC, many Ts'msyen and Gitxsan people rely on wild game and wild plant harvests for their subsistence and local economies (Daly 2005; Gottesfeld and Anderson 1988). The destruction of functionally diverse, and culturally important places like forest gardens is especially risky in remote communities (or "frontiers", see Tsing 2005) like Northwest BC, where the proponents of extractive industry tend to "ramp up" their developments that negatively affect the watersheds they occupy. This highlights the politics of biodiversity and functional ecology, which plummet into the complex depths of interspecies interactions and ontologies, food sovereignty and security, and the linkage of ecological resilience, governance and security (Youatt 2015).

4.6. Conclusion

Our long-term perspective of human land-use legacies in the Pacific Northwest uses functional ecology to consider a new level of landscape analysis. This analysis reveals how various types of social-ecological relationships result in patchworks of different vegetation cover and therefore distinctive ecosystem functions across the larger landscape. Forest gardens provided a suite of ecological services in the past, but continue to provide ecosystem functions and services in the present. We were able to demonstrate that First Nation village indirectly encouraged plant species with characteristics associated with attracting animals, such as tendencies toward animal pollinated and dispersed fruits. For the time being, and until we can accurately answer questions about forest garden conservation, heritage, and governance, it is critical that we aim to document and protect these unique anthropogenic ecosystems.

Persistent changes mean that the past cannot be a blueprint for the future, but understanding the history and functional diversity of anthropogenic ecosystems like forest gardens will inform how present ecosystem conditions came about, how these ecosystems function, and will contribute to best practice management decisions. This research expands on previous work suggesting Indigenous land-use practices can offer management alternatives to Western-based land practices which can lead to increased habitat loss and resource depletion (Brody 1981; Butler and Menzies 2007; Corsiglia 2006; Nadasdy 2003; Simpson 2001). The contribution of traditional land-use practices to localized conservation will be important in cases where Western conservation initiatives are confronted the absence of baseline data for forested ecosystems, and other difficulties of examining forest use and conservation in remote regions over time (Bush 1996; Cunningham 2001; Hastrup 2013; Orlove and Bush 1996; Silvano et al. 2008; Posey 1990). Our “functional-ethnoecological” approach to understanding forest gardens and the wider cultural landscape is meant to demonstrate the ecological complexity of cultural landscapes. This builds on the knowledge and work of communities who continuously fight for rights and title to their land where there is heightened vulnerability to resource depletion and accelerated climate change.

Chapter 5. Management and traditional production of beaked hazelnut (k'áp'xw-az', *Corylus cornuta*; Betulaceae) in British Columbia

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5.1. Abstract

Hazelnuts (*Corylus* spp.; Betulaceae) constitute an important food, technology, textile, and medicine resource for Indigenous peoples across Canada. As with other types of traditional ecological knowledge and wisdom, the legacy of residential schools, on-going colonialism, loss of access, and development have affected how people remember this vital plant. This chapter focuses on the memories and stories of elder Wal'ceckʷu (Marion Dixon) from the Nlaka'pamux Nation of the southern interior of BC to help foster the re-emergence of hazelnut management in BC and beyond. Using archaeological and ethnohistoric data, as well as drawing on the memories of other elders throughout BC, we hope, with this cultural keystone species, to draw connections between people and place — and to emphasize how such connections can preserve traditional homelands in a socially informed and just way.

5.2. Introduction and methods

This chapter focuses on the ethnoecology and archaeology of one of the many important plants for Indigenous people in British Columbia, Canada: beaked hazelnut. At the core of this chapter are the memories and stories of Marion Dixon Wal'ceckʷu (née Charlie), a member of the Nlaka'pamux Nation (Interior Salish) in south-central BC[1].

[1] Marion has lived many lives, travelled widely, is mother of four, grandmother of four and today she teaches traditional cedar root and cherry bark weaving in the Fraser Valley. In 1944, just before she was two years old, Marion's father passed away. Her mother was forced into the wage-labour system to provide for her five children so Marion, the youngest, was sent with her brothers to the 'bush' to be looked after by their grandparents, Annie and Patrick Charlie and great uncle Art Charlie. Residential school agents were sent to take the children away but Marion was fortuitously

Since she was two years old, Marion lived with her grandparents on the land and somewhat in isolation from expanding settler-colonialism for over twelve years. She fished, hunted deer and bear, trained alone for power in isolated places, tended gardens, and picked berries and hazelnuts (Fig. 9). Prior to Chelsey and Marion's collaborative work, hazelnut seemed like a somewhat forgotten and obscure plant, like a number of other formerly important traditional food plants (Turner and Turner 2008). According to Marion, who has been interviewed by anthropologists over decades, "no one ever asked me about the hazelnut". Although Nancy's collaborative work with Annie York recorded important practices and ethnobotanical properties (Turner 2014; Turner et al. 1990), few in BC are aware that a native hazelnut even grows here, let alone that it was, as Marion puts it "one of my grandmother's most important plants."

too young and able to dodge their attempts. Later, her grandmother would hide Marion in the forest or under floorboards to escape the relentless efforts of state abduction. Eventually, when she was 14, Marion was taken from her grandparents and forcefully enrolled at the St. George's Lytton residential school. She does not recall her own, nor her family's experiences of residential school with any fondness.

Figure 9. **Clockwise from left, Marion's grandmother and great uncle with Marion (perhaps 2 years old) bundled on the packhorse above Spuzzum and Anderson Creek. Marion pictured along CN rail track at the age of 4 or 5. Marion, her mother Lena Johnnie (née Charlie) and grandmother Annie Charlie picking berries with tumpline baskets up the Coquihalla. Marion's Grandfather Patrick Charlie, grandmother Annie and uncle Art Charlie in front of their log cabin in 1937.**

Worldwide over 25 species have been described in the genus *Corylus*, commonly called hazelnut, cobnut or filbert (Bassil et al. 2005). In BC, two varieties of *Corylus cornuta* (var. *cornuta* and var. *californica*) grow in low to mid elevations, in moist soil or rocky outcrops (Fig. 10). Tolerant of both shade and open sun, they are most productive in open woods and moist thickets. Hazelnuts purchased from the grocery store and global food markets are mostly genotypes of the cultivar *Corylus avellana* L., (*C. maxima* L.) is more often considered a polymorphic form of *C. avellana*), the world's fourth economically important nut crop, domesticated in Turkey and/or the Caucasus almost 5,000 years ago (Bassil et al. 2005; Martins et al. 2015). *Corylus avellana* grows from a large central trunk and produces a dozen or so nuts per cluster. The native beaked hazelnut in BC is more shrub-like, with usually multiple stems per bush, but growing up to 10 metres tall. It produces only 2-5 nuts per cluster and the nuts are slightly smaller than the commercial forms. As members of the birch family (Betulaceae), hazelnuts are related to birches and alders, and similarly are monoecious (producing separate male pollen catkins and female flowers on the same bush). The plants are wind-pollinated, with pollination occurring early in the spring, before the leaves have expanded.

Figure 10. Shrubby native hazelnut (*Corylus cornuta*) in the Suskwa, near Hazelton, British Columbia in July 2014.

Beaked hazelnut and the closely related American hazelnut (*C. americana* Walt.) were valued food and medicine plants across Turtle Island and were used by Algonquin, Cree, Mi'kmaq, and Maliceet peoples, and by many groups of BC, including Straits Salish, Halq'eméylem, Squamish, and Nuu-chah-nulth on the Coast, and Nlaka'pamux, Stl'atl'imx (Lillooet), Syilx (Okanagan-Colville), Secwepemc (Shuswap), Ktunaxa (Kootenay), Nisg̲a'a and Gitxsan in the Interior, as well as by virtually all First Peoples of Western Washington (Kuhnlein & Turner 1991). This chapter, while focusing on Marion's (Nlaka'pamux) experiences, also draws on the relationships of a number of BC communities to this special plant.

Both formal and informal interviews with farmers, hikers, those generally interested in wild foods, and First Nations community members were undertaken over the last two years to better understand the ethnoecology of beaked hazelnut in BC. Interviews were conducted with Indigenous community members from around the Skeena River (Gitsm'geelm and Gitxsan territories) in Northwest BC. The content of these interviews focused on ethnobotanical properties of hazelnut such as their uses for food, fuel, medicine and building materials. We also asked about management history and specific harvesting techniques that increase the productivity and proclivity of hazelnut. In addition, we consulted literature surveys of hazelnut use by Indigenous peoples of BC as well as botanical floras of the area to better determine its taxonomic and phytogeographical status.

5.3. Results and discussion

During the interviews, an overwhelming majority of the participants mention the "pesky squirrels" that seem to beat them to the nuts every summer. The native red squirrel (*Tamiasciurus hudsonicus),* whose range overlaps with hazelnut, seems to cause the most strife for hungry pickers and farmers. Marion recalls one method of outsmarting the little rodents:

> "…to get them away you pick a whole bunch, the leftovers from last year that are on, not in the wrappers anymore. We take them and we, we a dig a little trench far away from the trees where we had our bushes and then, we put them over there so the squirrels are all busy over there while we're [picking]…"

Hazelnut ripens sporadically by plant, but predictably in its timing. Depending on the latitude, for 3-4 weeks in the late summer the nuts are ready for picking. The green husks (involucres) soften and begin to open, exposing the nut. Some have taken to picking the nuts early to beat the squirrels and, like a green tomato, allow them to dry and ripen indoors. In northern BC, some Gitxsan elders had their own clever means for dealing with squirrels. Sim'oogit (Chief) T'enim Gyet remembers:

> *"…the squirrels help us…we don't pick [the hazelnut], we cheat. We wait for the squirrels to catch them and clean them so we don't have to."*

Sim’oogit (Chief) T’enim Gyet refers here to taking nuts from squirrel caches. Squirrel caches can be found around hazelnut groves by using sticks to poke around for loose soil or by observing leaf formation patterns for anomalies, as T’enim Gyet did when he was young. *Stl¹atl¹imx (Lillooet) harvesters noted that* squirrel caches (***spúl'pel')*** were viable hazelnut stores for both humans and bears (Turner et al. 1987). Gathering food resources from rodent or “raiding caches” was also common practice in Europe and relatively common across North America; in Siberia, it was common to leave some of the cache left or provide other offerings so that the rodents would survive and provide more food in the following years (see Ståhlberg and Svanberg 2010). Annie York recorded stories of winter dances and potlatches in Spuzzum during the early twentieth century and recalled:

> “I seen an old lady there once — she wasn’t no bigger than this (four feet approx.). Her power was a chipmunk and a squirrel. She’d never dance unless you brought her a basket of hazelnuts. She was a beautiful dancer. Not the scary kind. She has a robe made out of squirrel. I cried when I saw the squirrel’ tails. ‘Gee’, I thought, ‘they must have killed a lot of squirrels.’…She was from [the village of] Skeluleʔeɬx.” (Laforet & York 1998:151).

In almost any hazelnut grove throughout BC, at the right time of year, one can find piles of hazelnut husks and shells conspicuously displayed on logs or rocks where squirrels would have rushed to clean the nuts before storing them. In Sm’algya̱x, the Ts’msyen (Tsimshian) language, the term for hazelnut, winneeym desx, literally means “food of the squirrel” (Turner 2014). Squirrels feature prominently in narratives about hazelnut and are to some degree companion species. As such, they play an important role in our research on tracking the ancient and ongoing management of this native plant species.

There is a disjunct population of hazelnut in northwestern BC that may be the result of human introduction (Turner 2014; Klinkenberg 2015). A small but vigorous population of hazelnut grows along the Skeena and in the Nass Valley, and in some areas, such as the town of Hazelton (named after its hazelnuts) it is the dominant understory (Johnson 2010). This population, however, is isolated from the main range of the species in BC. Its occurrence in northwestern BC could be: (1) a remnant population from a previously larger range that was disrupted by geological events such as receding glaciers, (2) a result of dispersal by animals, such as squirrels, expanding its range or, (3) a result of anthropogenic activity, where Indigenous people long ago transplanted nuts, roots or cuttings from somewhere in the species' original range to a site or sites along the Skeena.

Widespread trade networks and evidence of transplanting have been extensively documented among Indigenous people in BC (Turner & Loewen 1998; Turner et al. 2013). Additionally, recent linguistic evidence supports the transplanting hypothesis for hazelnuts. Names, referents, and translations of hazelnut have been compiled for over 25 languages and dialects in BC (Kuipers 2002; Turner 2014). The Gitxsan words: ***sg̲an-ts'ak*** (upriver dialect) and ***sg̲an-ts'ek'*** (downriver dialect) are of particular interest. The morpheme ***sg̲an*** refers to any bushy plant while the root morpheme ***ts'ak'*** or ***ts'ek'*** refers explicitly to hazelnut. The Nisg̲a'a name for hazelnut is also related: ***ts'ak'a tyaý̓tkw*** or ***ts'ak'a ts'inhlik*** (translated as "dish of thunder" or "dish of squirrel", but with an obvious correspondence between the first part of the name and the Gitxsan). The root morpheme in both cases is similar to the Proto-Salish word for hazelnut: ***s-ts'ik'***, or ***sts'ik*** (Kuipers 2002). The impossibility of ***ts'ak'/ts'ek'*** and ***s-ts'ik'*** and ***s-ts'ik*** to be cognates with this term (because they are in entirely separate language families) suggests the Gitxsan and Nisg̲a'a terms are likely loan words from a Salishan language or possibly even from Proto-Salish, the ancestral Salish language. That is, the word was probably borrowed and, evidently, so was the nut itself. The actual origin is complicated by the fact that in various other Salishan languages, variants of this term are applied to whitebark pine (*Pinus albicaulis* Engelm.), a tree also with edible "nuts" or seeds, and is also sometimes cross-referenced to "squirrel" (e.g. Stl'atl'imx (Fraser River): ***s-ts'ə́k'*** (seeds) (general for any conifer seed, but specific to this species); Nlaka'pamux: ***sts'ə́k'*** (seeds; also pine seeds, sunflower seeds, beans in gen.; see Proto-Salish, above); and Secwepemc: ***stsek'*** (seeds); ***stsek'éɬp*** (tree) (cf. ***estsek'*** 'squirrel' **+ *-eɬp*** 'plant') (Turner 2014).

Although there are possible geological and zoological explanations for the existence of the hazelnut population in northwestern BC, our on-going research, including a study of hazelnut population genetics using microsatellite markers, archaeological surveys and paleoecological methods, will help us better understand the historical ecology of this important plant. Increasingly, scientists are realizing that few, if any ecosystems on earth have been left untouched by humans. The "pristine myth" (Denevan 1994) that has governed Western notions of “wild” and “empty” spaces in BC and elsewhere is starting to fade from the discourse. As we discuss below, the importance of hazelnut among Indigenous peoples in BC, its presence in and around archaeological sites and the growing evidence supporting anthropogenic origins or influences on some ecosystems in BC suggest that hazelnut was likely cultivated in at least some areas before European settler-colonizers arrived.

5.3.1. Paleoethnobotany

Archaeological data highlight temporal dimensions to ethnobotanical research and help inform our narratives of past and on-going plant use. While ethnohistoric and ethnographic information (below) provide specific and synchronic records, paleoethnobotanical evidence can complement the stories of ancestors and situate our narratives throughout time. Investigations of ancient plant remains in northwestern North America reveal long-term and extensive relationships between people and their inhabited landscapes (Lepofsky 2004). The occurrence of hazelnut at various archaeological sites in BC conjures up an image of ancient harvests and feasts, from which shells were deposited in ancestral homes then unearthed in contemporary times to remind us of longstanding Indigenous connections to land.

Combined with linguistic and ethnographic evidence and traditional knowledge, paleoethnobotanical analyses tell us about ancient plant uses for food, technology, medicine, and how people interacted with these resources in ancient times. Unfortunately, while the field of paleoethnobotany is growing, plant analyses are still an overlooked area of inquiry in most archaeological investigations (Lepofsky and Lyons 2003; Turner et al. 2013). This is especially true in BC where the majority of seeds and other small plant remains are not systematically collected from excavations or reported on in any meaningful capacity (Lepofsky and Lyons 2013).

Despite this, hazelnut has been recovered from at least five sites in BC where intentional and carefully planned paleoethnobotanical excavations were undertaken. The excavation of DhRp-52, roughly 40km east of Vancouver, is considered one of the in most successful paleoethnobotanical projects in BC; it included early stage planning and consultation with paleoethnobotanical specialists to determine research questions, rigorous sampling strategies, and thorough analyses. This excavation unearthed over 36 plant taxa represented by seeds, nuts, and needles, etc. Most famously, an extensive wapato (*Sagittaria latifolia* Willd.; Indian potato) patch was discovered, along with 3,213 waterlogged hazelnut shell and nut fragments (cal 4100-3200 BP) (KDC Archaeology 2010). Because plants can be deposited by both natural and cultural processes, and because hazelnuts are eaten and dispersed by squirrels, deer, Steller's Jays, and grouse, archaeologists developed experimental strategies to test whether the hazelnuts from DhRp-52 were of ancient origin or whether they had been deposited later by animals. Determining the source of plant remains is a fundamental part of understanding archaeobotanical assemblages (Pearsall 2015). (Chelsey has spoken with professional archaeologists in BC who have not collected hazelnut shells from their excavation units because they assumed the shells were from nearby modern hazelnut stands and had been buried by squirrels.) Archaeologists working at DhRp-52 collected contemporary farmed hazelnuts from Holmquist Orchards in Lynden, in Washington State and compared shells cracked open by squirrels and by the Holmquist family dog with those from the archaeological site. They concluded that the clean and straight cut marks on the archaeological specimens did not resemble the fracture patterns from the animals (teeth or gnaw marks) or natural decay. The thousand-year-old excavation of mass hazelnut remains just under 100 kilometers from Marion's home today confirms a strong and enduring interaction between humans and culturally important plants like hazelnut.

Closer to Marion's ancestral territory, four archaeological sites along Kwoiek Creek, an intensively occupied valley in Nlaka'pamux (Kanaka Bar First Nations) territory, illuminate the ancient and enduring relationship between Nlaka'pamux people and hazelnut (Lyons 2013). Most of the Kwoiek Creek excavations date back to between 1400–200 BP. The sites include small camps, roasting pits, mat lodges, pithouses, cache pits, a rock shelter, pictographs, and well-established networks of trails and bridges. Charred hazelnut remains were recovered from both the pithouse (n=22; EaRj-65) and rockshelter (n=2.5; Earj-81), both sourced from hearth features (Lyons 2013). In this context it is likely that shells were incidentally burned while roasting or intentionally burned for fuel. Recently a few small hazelnut fragments were recovered from a newly excavated archaeological site at Arrow Lakes towards the Rockies however they have yet to be associated with any dates and no report has been written yet (Natasha Lyons personal communication). Hazelnut shells have also been excavated from an archaeological site near Kamloops (Ignace et al. 2017)

The final archaeological excavation to report hazelnut remains is 1400km northwest of Marion's home, in the Prince Rupert Harbour, south of the Alaska panhandle. Hazelnut shells were excavated from late layers (1920-1952 AD) in a continuously occupied Northern Ts'msyen (Tsimshian) habitation site (Martindale & Jurakic 2004). The occurrence of hazelnut in this context is peculiar for two reasons. First, the archaeological site is well outside the contemporary distribution of hazelnut, and second, the closest hazelnut stands are part of the northern disjunct population along the Skeena, hypothesized to have resulted from ancient translocation. Archaeobotanical remains excavated beyond the range of their distribution are often flagged as anthropogenic in origin, and to some extent managed (Fritz 2000; Lepofsky and Lertzman 2008; Minnis 2004).

Lastly, the paleoecological records can also telling. At Cranberry Lake in southwestern Washington, hazelnut pollen appears in the pollen record in abundance in the earlyHolocene before the Mazama Ash (6800 BP), indicating the potential for human interaction for at least 7000 years (Leopold & Boyd 1999).

5.3.2. Tending hazelnuts

The Nlaka'pamux homeland is an ecological mosaic; steep mountain slopes rise from the south Fraser River Valley covered in rich forests of aspen, birch, Douglas-fir, lodgepole pine, western red-cedar, Engelmann spruce and subalpine fir (Turner et al. 1990). Upriver, around Spence's Bridge, the forests are replaced by a vast grassland steppe of wispy mixed sagebrush and bunchgrasses. To the east, the Thompson River harbours woodlands of ponderosa pine (*Pinus ponderosa*), black cottonwood (*Populus trichocarpa*) and Rocky Mountain juniper (*Juniperus scopulorum*). The Nlaka'pamux (literally "people passing through a narrow place, a canyon") harvested over 120 species of plants for food, medicines, tonics, rituals and building technologies (Turner et al. 1990), and they cared for and managed their diverse homelands in a variety of ways.

Iterations of the term “caring for” such as stewardship, tending, management, co-management and even co-evolution have been used to highlight any practices that are legitimized by social norms to guide a system towards achieving desired goals and objectives (Anderson K. 2005; Anderson E. 2014; Lertzman 2009; Natcher 2005). Whichever iteration is preferred, Nlaka’pamux people actively engaged in maintaining and increasing valued plant resources in their territories. Marion’s name, Wal’ceck^{w}u, literally means “to look after things and to harvest things to save others”.

By now, many anthropologists are aware that, while Indigenous peoples of northwestern North America did not practice a traditional Eurasian style of agriculture (planting large plots of annual vegetables and grains), they were in fact tending or cultivating large food production areas (Deur 2002; Deur and Turner 2005), orcharding fruit trees like Pacific crabapple (*Malus fusca*), berry bushes and nuts (McDonald 2006), burning landscapes to create multiple successional habitats (Johnson 2010; Turner 1999) and managing plants in a multitude of ways to increase access and the production of economically important parts (Turner 2014; Turner et al. 2013).

Bitteroot (*Lewisia rediviva*, ***spítl’m*** or ***łk^{w}’ə́pn***) for example, was a staple root crop for many nations in the Interior plateau area and was selectively harvested and transplanted to extend its range and access (Bandringa 1999; Turner 2005). Vegetable crops are famously treasured by Indigenous nations in the Pacific Northwest and include of a host of locally managed species favoured for their rhizomes, tubers, corms, bulbs and roots. The Nlaka’pamux managed vegetable crops of desert lily (*Calochortus macrocarpus*; ***məqʔ-úʔseʔ***), desert parsley (*Lomatium macrocarpum*, ***q^{w}’əq^{w}’íle***), balsamroot (*Balsamorizha sagittata*, ***sníłqn***), glacier lily (*Erythronium grandiflorum*, ***sk’ém’ets***), spring beauty (*Claytonia lanceolata*, ***tətúwn’***) and bracken fern (*Pteridium aquilinum*, ***séʔaq***). Although these plants did not undergo full-blown domestication with associated genetic alterations, their populations are presumably not entirely wild either, having had their natural reproductive strategies and life histories interrupted by intentional human activity. Worldwide, there are a variety of such plants, used for food, textiles, building materials, and medicine that were tended or cultivated without undergoing full domestication. These plants are used, and typically managed, but for one reason or another, are not classified as domesticates — likely because they have not sufficiently evolved from their wild forbears. Although there are different cultivars of *C. avellana*, many nut-bearing trees and shrubs are classic examples of this "not wild" yet "not domesticated" grey area.

Nuts have been widely procured by so-called hunter-gatherers around the world for millennia. Many nuts tend to be emphasised as a staple food because of their predictable yield with high caloric value (Harris 1977). In California and Oregon, acorns (*Quercus* spp. and related species) were harvested and processed in massive quantities; thousands have been excavated from archaeological leeching pits along the Columbia River (Croes et al. 2009). In the eastern woodlands, hickory, pecan, butternut (*Carya* spp.), walnut (*Juglans nigra*), chestnut (*Castanea dentata*) and beechnut (*Fagus grandifolia*) were dominant tree species and in many cases the nuts were dietary staples (Yarnell & Black 1985), but their heavy exploitation did not lead to domestication. Harris (1977) argues that the physiological characteristics of nut taxa preclude them from the typical pathways toward domestication. For one thing, nut-bearing trees take long to mature to the point of production, and secondly, they have fewer reproductive barriers and can cross-pollinate, often eliminating isolation, a key factor in plant domestication which ensures selected traits are not dulled by introgression (hybridizing with parent species) (Larson et al. 2014; Zeder 2015).

While the native BC hazelnut may not have undergone domestication in the classic sense, it was actively transplanted and managed. Marion notes:

> "Around [Spuzzum, in the Fraser Canyon, above Yale], yeah, you take them and you plant them in a different spot. You don't have to plant them in rows or anything, just plant them so that they're all together, so when you go out to harvest them, they're all in one spot… Oh yeah in the fall-time that was my job with my uncle. He dug the holes and I'd pull the little plants and we put them in there and buried them and in the fall time, cause it gets a lot of rain, so they would relax and grow. And it takes maybe 2-3 years to where there's lots of nuts on them but, I mean they do… my uncle used to dig the roots and cut…there's a red piece in there about this big [~10 cm] and he would cut them off and that was the…stop producing? When that thing gets too long it stops producing? But he used to do it every two years. He would dig them up and chop that little, I don't know, the tree keeps growing but it stops producing the nuts so we used to chop them off. When we dig them up when they're small, you see that little white thing there, you have to pull them off."

Marion’s experiences transplanting and coppicing hazelnut are echoed by the memories of her cousin, Annie York, who recounted the importance of burning to increase nut production. Referring to selective burning decades ago, Annie noted:

> “They come down here for it. And then they [were] always burning them. . . those bushes, here and there, but not all of them, and that's what makes them grow and makes them plentiful." (Turner et al. 1990:190-191)

Hazelnut productivity increases in the presence of fire (Pojar & Mackinnon 2004). Even in places where it has not been intentionally burned or transplanted, hazelnut occurs successively after fires and is an indicator species of fire according to forest ecologists in BC and Washington State (Boyd 1999). Various Indigenous people in California cared for hazelnut shrubs or “flats” by using fire to encourage the growth of young shoots. Fire induced the sprouting of straight young shoots preferred in weaving and other building implements (Anderson 2005). Broadcast burning was undertaken in the late summer or early fall among the Yurok, and while point burning at low elevations seems to have been common in Nlaka’pamux territory (Boyd 1999; Turner et al. 1991), Karuk people would burn “entire hillsides” (Anderson 2005:172). Boyd (1999) notes hazelnut burning in the Willamette Valley in associated Garry oak ecosystems by the Kalapuya, and Johnson (1999) speculates hazelnut burning in Gitxsan territory. Since burning has ceased in many regions (often forcefully by law), many elders notice that hazelnut has stopped producing and “nothing is any good anymore” (Schenck & Gifford 1952:382 in Anderson 2005:172).

In BC, hazelnut is known to associate with Pacific crabapple, Ts’msyen community members often say that wherever there are crabapple trees or hazelnut trees, there is a village. This is a very good site indicator that has been noted elsewhere on the coast (McDonald 2005). At archaeological sites in the Lower Mainland of Vancouver, as well as in the Lower Skeena in Canyon Ts’msyen territory, hazelnut and crabapple grow side-by-side, along with many other important food, material and medicinal species (Armstrong 2016; Turner et al. 2013). Marion remembers transplanting and harvesting crabapple with hazelnut as companion plants in orchard-like settings near their home:

> "We just cut the hazelnut, we take the little ones and we pick all the little bushes of trees…more like we do with apples and everything else. You know, you transplant them. That's what we did with them. We had our own little nut farm."

Around the world hazelnut has been harvested and managed in similar ways. Old Irish folktales recall the deiri dun or "dark oak woods" where people lived on acorns and hazelnuts. Anderson (2014) notes that harvesting of wild hazelnuts in early Gaelic Ireland graded into management through practices like coppicing. Hazelnut was an especially prominent plant in old Celtic poems, revered as a "model of loveliness", as an important food and even worshipped in religious contexts (Anderson 2014:142). At the archaeological site of Staosnaig on the Isle of Colonsay in Western Scotland (cal 9000 BP), thousands of hazelnuts were excavated and interpreted as a mass hazelnut-processing site and not simply as the remains of an opportunistic picking event (Mithen et al. 2001). Evidently there are a number of reasons for managing hazelnut; it is one of the few nut species in BC, it is easily stored and was used not only for food, but also for medicine, fuel, building implements, weaving materials, and much more.

5.3.3. Hazelnuts as food

Hazelnuts are a high source of protein and are rich in unsaturated fats. They are a significant source of thiamine and vitamin B6 and other B vitamins (Kuhnlein & Turner 1991). They can be eaten raw and store for years without deteriorating. Like Marion, Gitx̲san elders in Northern BC remember hazelnut as a Christmas food, no doubt because nuts would keep for months when fresh food was scarce. Nuts were collected *en masse* and either left to dry as is (involucres can rot off the shells without turning the nut) or de-husked and processed all at once. The Wintu in California used willow switches to beat the involucres off the kernel (Anderson 2005). Marion recalls the hard work involved in collecting and processing nuts:

> "When they're ready, we pick a whole bunch of them and we'd put them in a basket or a box or whatever we had. And we get them dry. And we would sit there for days, and days, and days, cause we used to have bags and boxes and baskets of them, and then one day when its raining or snowing outside, I had my own little hammer and I'd sit there and break them, pick shells off them and put them in the thing and then my grandmother would prepare them but it took days and days and days to pick them, never mind opening them and days, and days to preserve them [in oil], then use them as we want to use them for."

Like many nut species, hazelnuts are an important source of oil. (Hazelnut oil is sold today for culinary and medicinal purposes.) Hazelnut oil is high in oleic acid, a mono-unsaturated fat thought to help lower cholesterol and reduce blood pressure. It was used for cooking and was mixed with bear grease for storing dried berries and other plant foods. Rendering the nuts down to oil was another effective means of preserving and storing.

> "My grandmother, she'd take them, she'd put them in the pan again, she'd put them on the stove again, so they were dry… then the next morning she got a cotton cloth and she had ah, plastic was a hard thing to find in those days. But there was that saran wrap that something came in that saran wrap and she always saved that saran wrap. I wondered why she saved it. She put the nuts in there, put the cotton cloth over it, got my little hammer little mallet, and then I had to sit there and smash these….smash these things in a pan making sure that none of the oil is going to disappear. And then she'd take that oil and she would grab that, put it into that cotton cloth, she'd gather it up and then she'd hang it up and then she'd squeeze it. And all the oil would drip into this little container. Well, you don't get very much oil out of all the nuts, but we got a lot out of it…and then she'd take that oil and she would take a teaspoon and put it in this little spot and put another one in this and another one here…she had 5 different things she used as medicine [and food]."

Hazelnuts were valued for their versatile nature, they could be eaten raw, stored or cooked (Turner et al. 1990). Nlaka'pamux ethnographer and student of Franz Boas, James Teit (1900:233) recorded instances of hazelnut trade among the Nlaka'pamux; nuts were exchanged between the Upper and Lower Nlaka'pamux [Thompson] for dried roots and other plant foods. Hazelnuts were also extensively traded along the Klikitat trail in south-central Washington, a widespread trail network that connected people from multiple bioregions to trade from diverse resource bases (Norton et al. 1999). The nuts were also a quick-fix healthy snack. If one was out hunting for long stretches, a few hazelnuts could easily restore energy:

> "My grandmother, she made me a necklace out of hazelnuts on a thread, she'd get them in halves, you know how they go into halves? And she would put them right around my neck. And you know, if I wanted to eat it like you do those candy [necklaces], I would. She would do that so I would have a snack anytime. I used to snack on hazelnuts…so I grew up on hazelnuts."

Marion's memories of hazelnuts as a snack, a food store, and a source of oil are testament to the versatility of this important plant (Fig. 11). One could easily imagine how such a nurturing and tasty food could re-emerge in communities today.

Figure 11. Marion peeling the dried involucres (green husk-like coats) off of hazelnuts picked near her home in Hope, BC. The involucres are modified leaves that protect the nut with their abrasive hairs that can cause a mild irritation. Marion demonstrates how to pick the fringed edges to expose the nut without damaging the hands.

5.3.4. Hazelnut as medicine

When we think about nut-bearing plants we tend to think about them predominately as a food source. However, the arrangements of natural fats and vitamins offered by nutting plants have many medicinal benefits. Marion remembers hazelnut first and foremost as a medicine:

> "We used it for colds, ear infections, open cuts, diaper rash, and when you have brown spots on your face, like some people get from sun, use hazelnut oil on it and it takes it off, and if your hair drops out too…"

The medicinal oil is rendered much like it is for food. When it was processed, half would be stored for food and the other half for medicine. Marion recalls her grandmother mixing the hazelnut oil with bear grease for hair and skin treatments. Because of the high vitamin E content, hazelnut oil is slow to go rancid and was used to protect hair and reduce sunspots. According to Marion, her great uncle maintained his jet-black hair well into his senior years by applying a healthy coat of hazelnut oil every once in a while. The oil also has astringent actions to reduce face blemishes and over-active oil glands, and antibacterial components can fight skin bacteria. At farmers' markets in BC, vendors sell hazelnut oil and claim it is the best topical treatment of eczema. Newsom (2006) reports that the milk from the nuts had medicinal properties and was used as an astringent for cuts as well as curing colds and coughs. The Yurok in California pounded hazelnut kernels into a flour and added warm water to feed to persons with sick or weak stomachs (Anderson 2005). Marion remembers,

> "When my auntie was sick [with pneumonia] my grandmother always got the hazelnut oil and squeeze it into a spoon and would give her a bit of it. It would stop her cough a bit."

There are also health benefits from direct nut consumption. The total antioxidant capacities (TAC) of European hazelnut are a rich form of natural antioxidant supplementation (Atlun et al. 2011). The nuts provide dietary fiber, are low in saturated fat and cholesterol, and according to the United States FDA, eating 1.5 ounces of hazelnuts per day *may* reduce the risk of heart disease and blood clotting (Hazelnut Marketing Board 2016).

5.3.5. Hazelnut in technology

Hazelnut is a fine grain hardwood with young pliable shoots whose elasticity increases after soaking; it can be stiff and difficult to bend at maturity. At both stages the wood is very light, suitable for various weaving and other sculpting endeavours or larger building implements. Today, the wood is commonly used for woven wattle fencing, basket-making and personal artisan projects like boat-building, walking sticks, or wicker chair crafting and used commercially as a colourful highly-figured wood species. Wood analysis from Viking settlements on the Faroe Islands (AD 770–1015) report hazelnut wood as an important building material for houses and utensils (Malmros 1994).

In the Pacific Northwest, hazel wood was an important material as well. Pomo and Ohlone people in California, and Gitxsan Sim'oogit T'enim Gyet in northern BC preferred young hazelnut shoots for arrows because of its "bendy strength". Marion recalls her uncle fashioning his "light" snowshoes from hazelnut wood, a use also noted in Anderson's (2005) observations among the Karuk who used three-year-old hazelnut wood (one-half inch diameter) to make the circular frame for their snowshoes.

In California and Oregon hazelnut was preferred primarily as basketry material (Anderson 2005; Boyd 1999). The young straight shoots that sprout after fire are used for weaving various baskets, such as cradle boards and carrying baskets, they were twisted into rope for fish traps and surf fish baskets (Anderson 2005). Hazelnut shoots were also used by Indigenous people in Canada for matting, for edging birch bark baskets (Nesom 2006), seat cushions, sleeping bed mats, and as mats for cleaning salmon on (Turner 1998:157-186).

Other technologies included the use of hazelnut shells for fuel; the oily pericarps were thrown into fires to keep them burning (perhaps this is why we find them in hearths archaeologically). The roots were used by the Nlaka'pamux to produce a blue dye (Turner et al. 1990). The shells and involucres were also used as a kind of insecticide. Marion notes:

> "Yeah you just take them, and wait till you get a bunch done, until you get a box full of them done then you got a whole bunch. Then you just crack them and open them up and take the shells out and keep them separate. Then the shells — my grandmother used them for snails…she'd put the shells under the plants so the snails don't go on them."

On a sojourn through the Mount Revelstoke National Park, a German hiker called hazelnut "the Swiss Army knife of the plant world". Her observation was astute; there are dozens of uses and cultural associations for hazelnut. As a food, medicine, cosmetic, or building technology this unsuspecting plant grows throughout many areas of BC and has contributed to the sustenance and resilience of Indigenous people for millennia.

5.4. An alternative pathway

The BC gold rush in the 1850s and 60s breached and penetrated the Nlaka'pamux heartland. The colonial state and its agents subsequently settled the Fraser Valley and laws were enacted to disenfranchise and eliminate the Nlaka'pamux from their traditional land tenure systems and the accompanying management practices that maintained the cultural landscape. In order for the newly formed government of BC to establish a land cadastre to control and sell land, Indigenous people had to be removed. For example, in order to increase colonial settlement in the Fraser Valley and to control the "impenetrable jungle" of inland forests, in 1823 pre-emption was instituted. Pre-emption was a type of government grant that required settlers to work and maintain land by clearing, gardening, and constructing fenced enclosures — "the visible trappings of civilization" (Oliver 2013). In exchange for title, those that could not afford to buy land outright, transformed the ecology of the Fraser Valley and simultaneously contributed to the erasure of Indigenous people on the land. While the colonial superstructure and its propaganda of "progress and settlement" may not have filtered down to the every day life and experiences of the lower class settler on the "frontier" (e.g., Oliver 2013), it still had remarkable and lasting impacts on Nlaka'pamux people and their territories.

The goal of this study is not to espouse an idea that Nlaka'pamux people lived in perfect harmony with their homeland; we accept that different human activities have varying degrees of ecological impacts. However, hazelnut management, either transplanting or planned burning, had low ecological impact and high cultural value. The combination of these two realities supports the reinstitution of traditional orcharding in Indigenous BC. The gathering of traditional plants is a foundation of identity, contributes to healthier diets, economic sovereignty, and has positive ecological impacts (Anderson 2005). Cultural revitalization camps ("culture camps") in Gitxsan territory like Madii-Lii and Ts'eliksit Immersion camps are aimed at teaching children the traditional, respectful ways of harvesting and processing plant foods and medicines (including hazelnut) for their families. Resistance camps and check points like Unist'ot'en in Wetsuwet'en territory are growing their own food and building large permaculture systems that encourage native plant species.

Hazelnut is but one plant in the composite of traditional Nlaka'pamux and other Indigenous peoples' landscapes. But Marion's memories, the archaeology, the ethnohistory and the shared stories of this important species bear special attention. Nlaka'pamux territory, once a peppered cultural landscape that sustained its inhabitants, is in some areas, due to overgrazing, soil compaction and other processes, leading to desertification. On top of the meshwork of its cultural worth, native hazelnut could help manage some areas of the Fraser Canyon dealing with complex ecologies. Hazelnut has been used in ecological restoration (O'Dell and Argen 2013) as it can provide ecological services like slope stabilization and in some areas is well-adapted to dry, water-poor environments.

Globally, the USA is the third biggest producer of *Corylus avellana*, whose commercial production is concentrated in the Willamette Valley (Hazelnut Marketing Board 2004). The Eastern Filbert Blight (EFB) devastated the hazelnut industry there and entered BC sometime around 2003.The disease is caused by the fungus *Anisogramma anomala* (Peck) and often leads to hazelnut death within 5-12 years (Sathuvalli et al. 2011). Although the fungus attacks the *Corylus* genus broadly, in Mother Nature's infinite wisdom it is perhaps unsurprising that the native *Corylus* in the Pacific Northwest carries blight-resistant genes. Plans to breed in this gene in laboratory settings are on-going at the University of Minnesota and University of Oregon, Corvallis. However, in true permaculture spirit, growing native hazelnut (if not growing it for commercial production) is preferred as it has lower ecological impacts and in many areas is already locally adapted to soil and climate. Grown responsibly, hazelnuts are a high-value, low input crop ideal for BC (O'Dell and Argen 2013). The pathways to food sovereignty and eco-cultural health are many. Like the title of this volume, the stories that remerge from the ashes — from Marion's memories, from archaeology and from the many other shared stories — will help inform and restore a future for our children, a future that is culturally informed and socially just.

Chapter 6. Conclusion: Diversity

"*The 'blessed unrest' embedded in diversity is far more than just the spice of life that keeps our sense alert and delighted; it is literally the stuff of life that makes our world work (and play) in myriad ways*". (Nabhan 2016:4)

The future of our planet hinges on the compassion, solidarity, and work of communities defending their land and seascapes and the diversity within them. This dissertation attempts to embody diversity: the diversity of methods and of worldviews, the study of biodiversity and trait diversity, and an appreciation for language diversity and multidisciplinarity. In this contribution I attempt a kind of synthesis of diversity — a pidgin language for bridging the biological and cultural, and Western and Indigenous worldviews. This is not a new or novel attempt (e.g., Atalay et al. 2014; Berkes and Davidson-Hunt 2006; Gorenflo et al. 2012; Sutherland 2003), but a necessary one if we hope to actualize the struggles amidst a changing world.

In his book *Ethnobiology for the Future*, Gary Nabhan (2016) suggests seven broad hypotheses in need of exploration in the next generation of ethnobiology. One of these states that, "the cessation or erosion of various culturally elaborated management practices for soil, water, food, fuel, medicines, and fiber may tangibly diminish heterogeneity and species diversity in a locale or a region" (Nabhan 2016:7). The forest gardens of the Pacific Northwest reviewed in Chapter 4 exemplify the outcomes of localized and Indigenous-based management practices, which not only increase the proclivity, productivity, quality, and predictability of valued plants, but also contribute to local biological diversity along the Fraser and Skeena Rivers. While some Indigenous peoples are still aware of these forest gardens, those in academia and industry are only beginning to understand how plant diversity in the Pacific Northwest is inextricably linked to Indigenous management systems (e.g., Anderson 2005; Turner 2014).

The bold print in Nabhan's hypothesis is **cessation**. While scientists will undoubtedly attempt to record and study forest gardens objectively, it is important to remember these ephemeral sites are the result of Indigenous knowledge and work, and their descendants and caretakers are caught up in the oppressive struggle of so-called modernization and assimilation. This struggle, one shared among Indigenous communities worldwide, is the struggle "…to survive in the margins, to seek freedom and better conditions, [and] to seek social justice." (Smith 2012:199). As archaeologists working in settler-nations, what Bruce Trigger (1984:360) called colonialist archaeology, it is imperative that we acknowledge how archaeological interpretations have long diminished and disenfranchised Indigenous peoples from their lands and histories (e.g., for the sake of nationalist, colonialist, and imperialist interests; Trigger 1984). A community-oriented archaeology that advocates a plurality of views (as similarly advocated in feminist critiques of archaeology — see Wylie 1995), should reject the ethnocentrisms embedded in research findings and interpretations. Such interpretations fortify privileges while simultaneously reinforcing structural oppression. Decolonizing and community-oriented, collaborative work will halt or at least slow the cessation and erosion of bicultural diversity around the world.

In order to conceive of historical ecology in more community-oriented ways, and without (mis)appropriating Indigenous worldviews and ontologies, we can think of Indigenous social-ecological systems as both ancient assemblages and living ancestors. Witmore (2014) argues that old and out-dated archaeologies see the past as a separate realm where lives were distantly lived and the only way to access them is through the material record. However, a New Materialist archaeology — growing out of the ontological turn, species turn, and so forth (e.g., Escobar 2007; Preda 1999) — challenges archaeologists "not to look beyond the pot, the awl, [the forest garden], …not to probe the allegedly transcendent realm of culture…for answers to why things are" (Witmore 2014). Rather, archaeologists must constitute all entities as part of their own emergence. That is, the archaeology of things must be replaced by what Witmore (2014:204) calls an "ecology of practices", which contemplates the world with care and wonder. In current cultural resource management and academic contexts, this type of practice would be thought provoking yet challenging.

As it currently stands, heritage legislation in BC offers no pathway toward protection for ecologically significant and culturally distinct spaces like forest gardens, medicinal plant gathering areas, or living cultural resource plants. Although it might be tempting to push for a State-sanctioned safeguarding of forest gardens, it would likely only harden the hierarchy of power-relations that currently constrain local decision-making. Legislating the protection of forest gardens could also result in their commodification, potential over-consumption (e.g., rote inventories — see Ferris 2007; Welch and Ferris 2014), and their meaning stripped from the land as they are transformed from living forests to an assemblage of polygons. Furthermore, forest gardens and other traditionally managed habitats are not static entities to be prodded, barricaded, and defined by legal teams and policy-makers. The past cannot be a blueprint for the future (e.g., Rhemtulla and Mladenoff 2007), but by reconstructing historical patterns we can understand how contemporary landscapes came about, how they function (ecologically and socially), and we can contribute to *localized* management and restoration decisions — decisions made by the descendants of the creators and users of those places.

Historical-ecological research is one path towards a more community-oriented archaeology and ecology of practice. By fusing natural and social sciences towards applied research goals, we begin to speak the language of people who, on the ground, experience the landscape in social and ecological meshworks and with wonder and feeling. By speaking this language, it gives researchers and communities, as Welch (2014:93) notes “a common vocabulary, common ground, and then common cause”. A community-oriented approach in historical ecology and archaeology is therefore emerging and iterative. This approach allows us to critically map the orthodoxy of archaeology, history, ecology, and anthropology, and proceed with a research program readily equipped to deal with the complex social-ecological issues of an uncertain future. I hope, that with this research, I have started on this path to a better, more just future for people and their shared landscapes.

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