PACIFIC SCIENCE Early View

A Quarterly Devoted to the
Biological and Physical Sciences of the Pacific Region

I ka wā ma mua: The value of a historical ecology approach to ecological restoration in Hawai‘i

By Natalie Kurashima*, Jason Jeremiah, and Tamara Ticktin

Abstract

Human activity has altered nearly every landscape on earth, and ecological restoration to repair degraded ecosystems has become a conservation necessity. Hawai‘i is a microcosm for intense landscape change, where levels of native biodiversity and threats to it are among the highest in the world, and where Kānaka Maoli (Hawai‘i’s indigenous people) who stewarded these lands for a millennium currently face massive inequalities. Consequently, biocultural restoration has emerged as a method to reciprocally restore ecological and cultural integrity, and is especially applicable in Hawai‘i’s sizeable invasive-dominated areas. Since Kānaka Maoli are an inseparable part of every land and seascape in Hawai‘i, any ecological restoration project has the potential to use a biocultural restoration approach. However, most restoration approaches are purely ecological, and for many conservation practitioners, a socio-cultural understanding of the landscape can seem inaccessible. In this paper, we discuss the value of a historical ecology approach—understanding the interaction between people and landscapes over time—for successful restoration and management of biocultural landscapes in Hawai‘i. We use a case study in Kahalu‘u, Kona to outline historical ecology methods and available resources in Hawai‘i, including written documents, maps, imagery, archaeological studies, and interviews, and discuss applications of this approach on-the-ground. Potential benefits of employing this approach include: expanding knowledge of reference conditions, understanding practices contributing to landscape function over space and time, and building meaningful relationships to engaging community around a site. We argue that a historical ecology approach is readily adoptable into ecological restoration in Hawai‘i, especially in its human-dominated landscapes.

*Corresponding Author E-mail: nataliekurashima@gmail.com

Introduction

Human activity has altered almost every part of the planet through landscape transformation, anthropogenic climate change, altering biogeochemical cycles, and changing biotic compositions through harvesting of species and by facilitating species invasions (Chapin *et al.*, 2000; Vitousek *et al.*, 1997). Globally, this has led to unprecedented natural ecosystem degradation (Steffen *et al.*, 2007). The Hawaiian Islands represents an example of intense landscape change. Hawai‘i has some of the greatest rates of endemism in the world, with about 90% of the native Hawaiian flowering plant species found nowhere else in the world (Eldredge and Evenhuis, 2003). However, it is also deemed the “extinction capital of the world,” with 40% of all native Hawaiian flora currently listed as threatened or endangered (Sakai *et al.*, 2002; U.S. Fish and Wildlife Service, 2010), two-thirds of the native land bird species extinct, and over half of the existing native birds considered threatened or endangered (Banko *et al.*, 2001). Accordingly, ecological restoration projects which seek to repair degraded ecosystems are growing across the archipelago, directed by federal, state, private, and community groups. Since the limited funding available is often channeled towards areas with the highest biodiversity value, most large-scale ecological restoration projects are focused in conservation zones with intact systems, from reef and coastal ecosystems to cloud forests. However, more than half of Hawai‘i’s lands exist outside of formally protected conservation areas (DBEBT, 2015), and are concentrated in lowland areas, which are often human-dominated landscapes, heavily dominated by alien species.

Just as dire as the ecological situation in Hawai‘i, is the related socio-economic conditions of Hawai‘i’s indigenous people who stewarded these lands and seas for almost a millennium (Athens *et al.*, 2014). Similar to other indigenous peoples also under foreign influences and subsequent U.S. colonial occupation, Kānaka Maoli (indigenous Hawaiians and

their descendents) have been systematically dispossessed and separated from their ancestral territories and associated knowledge (Kameʻeleihiwa, 1992; Kelly, 1994), and currently face immense sociopolitical challenges and inequalities, including disproportionately high rates of poverty, homelessness, health problems, abuse, and incarceration (Kamehameha Schools, 2014; Kana'iaupuni *et al.*, 2005; Moy *et al.*, 2010). From an indigenous perspective, the health of a landscape is inherently and reciprocally connected to the health and well-being of its people (Kimmerer, 2011); thus, ecological restoration of ecosystems and cultural restoration require one another. Kimmerer (2011: 259) defines the concept of biocultural restoration as "the mutually reinforcing restoration of land and culture such that repair of ecoystem services contributes to cultural revitalization, and renewal of culture promotes restoration of ecologic integrity." Ecological restoration can restore the cultural and community health of people in a number of ways including: reconnecting people with ancestral practices and traditions, revitalization of traditional ecological knowledge and language, and reconnection with cultural identity and spirituality (Kimmerer, 2011; Pascua *et al.*, 2017). Stemming from this worldview that community health is directly and inherently tied to ecological health, biocultural restoration projects have recently emerged in Hawaiʻi and elsewhere as a method to repair degraded ecosystems and cultural landscapes in concert with healing the relationships and practices of people to those places. In Hawaiʻi, these projects are often initiated by Kānaka Maoli individuals, communities and organzations, and represent an effort to regain of self-determined socio-ecoogical resilience on ʻāina (land and sea) today. The Society of Ecological Restoration (SER) also recognizes this view that some systems require the parallel restoration of the ecosystem with the linked indigenous management regimes, languages, and traditional ecological knowledge (TEK), and where ecological restoration is especially contingent on lasting involvement of local communities (SER, 2002).

In Kānaka Maoli cosmologies, Kānaka come from the same entities that create the earth, the sky, the stars, and all living things in the sea, on land, and in the atmosphere (Beckwith, 1951; Kamakau, 1991; Kameʻeleihiwa, 1992; Malo, 1951; Oliveira, 2014), and are thus kin with all of the elements of their surroundings. From this perspective, Kānaka Maoli and their ancestors are a fundamental and inseparable part of every landscape in the archipelago, and any ecological restoration project within Hawaiʻi from the oceans to the mountain summits, has the potential to be considered biocultural and utilize a biocultural restoration approach.

Despite this, most ecological restoration projects within Hawaiʻi, like many around the world, take a purely ecological approach to restoration, relying solely on biophysical research, targets, monitoring, and success (Wortley *et al.*, 2013). Furthermore, in many areas in Hawaiʻi, communities have not had access to or interaction with some ancestral landscapes for generations, and consequently for land managers and restoration ecologists working to restore those areas, a socio-cultural understanding of the ecosystem can seem inaccessible. However, the relatively new science of historical ecology offers an approach to understanding the interaction between people and landscapes over time, which can be readily utilized in restoration ecology to achieve outcomes of ecological health and community well-being. A purely ecological restoration effort has many benefits, but a historical ecology approach is particularly useful in human-dominated landscapes where intense landscape changes have occurred and/or where a local community is still present but has lost access. The former tend to be last priority for restoration projects, but which cover large areas in Hawaiʻi. In this paper, we explore the advantages and potential outcomes of using a historical ecology approach in ecological restoration in Hawaiʻi. We draw on a case study in Kahaluʻu, Kona to outline historical ecology methods and available resources in Hawaiʻi, and illustrate the potential benefits of integrating into the restoration and management of a biocultural landscape.

Why use a historical ecology approach in ecological restoration?

Historical ecology, a relatively new field, founded from the disciplines of anthropology, geography, ecology, history, sociology, and geography (Balee, 1998), seeks to understand environmental change over time in a socio-ecological landscape in order to inform the future (Crumley, 1994; Egan and Howell, 2001). Historical ecology has a few main tenets including, 1) humans have affected nearly every landscape on earth, which affects present-day landscape spatial distributions, 2) landscapes are the result of dynamic interactions between environment and human culture, and 3) understanding landscape change in the past should be utilized to address current and future concerns (Armstrong and Veteto, 2015; Egan and Howell, 2001). Using a historical ecology approach involves drawing from a variety of documentary and natural historical sources, such as archaeological and ethnohistoric surveys, archaeobiological studies, oral histories, historic maps, written accounts, surveys, and climate records to better understand the past functioning of a system (Egan and Howell, 2001; Swetnam *et al.*, 1999). These sources span a range of spatial and temporal scales, providing a long-term view of a landscape, and the process is especially mindful of the interactions humans have with the system.

Ecological restoration is "an intentional activity that initiates or accelerates the recovery of an ecosystem with respect to its health, integrity and sustainability" (SER, 2002). This requires an understanding of the composition, function, and structure of an ecosystem over time. However, sometimes restoration ecologists fail to recognize the long-term and cultural functioning of an ecosystem, which can lead to flawed restoration and conservation approaches (Foster and Motzkin, 2003; Walter and Merritts, 2008). A historical ecology approach allows for the understanding of landscape history over space and time through a range of past reference conditions, referred to as the "Historical Range of Variability" (HRV) (Aplet and Keeton, 1999;

Keane *et al.*, 2009). Moreover, it provides insight on the social and ecological functioning of that landscape in the past, offering clues on ways to restore that functioning into the future. The historical ecology approach does not involve selecting one specific reference condition over another within the historic range; these decisions should ultimately be guided by the specific vision of the restoration project.

A recent review of the restoration ecology literature found that most restoration projects do not use reference ecosystem targets, and most of those that did, used a control ecosystem, often the ecosystem before restoration (Wortley *et al.*, 2013). In these cases, restoration ecologists use short-term biological studies to understand the site pre-restoration and to set reference targets. Yet, it has been shown that historical management and disturbances can alter vegetation patterns and ecosystem functioning after hundreds and even sometimes thousands of years (Hermy and Verheyen, 2007; Hightower *et al.*, 2014). Thus, in order to understand the factors that have, are, and will drive ecosystem patterns and processes, a historical ecology approach is necessary. For example, Foster and Motztin (2003) used paleoecological data (pollen/charcoal data), archaeological evidence, ethnographic accounts, plant species distributions, and soil profile data to investigate the conservation and restoration of a unique grassland ecosystem in the American Northeast. They found that the areas thought to be native grasslands were actually derived after European contact. The grasslands were products of clearing and subsequent management by Europeans settlers, who utilized grazing, plowing, as well as fire, and the conservation of these biodiverse areas may depend on the restoration of the cultural practices that once maintained these landscapes (Foster and Motzkin, 2003). This example shows that to understand and manage present-day ecological conditions, it can be necessary to understand the long-term biological and cultural processes within the landscape over time. Often this requires an understanding of the ecosystem prehistorically, or before

indigenous and/or Western management of the landscape, as well as during and after these management regimes, to identify how cultural management has and will influence ecological patterns.

With climate change predicted to alter global and local weather patterns in unprecedented ways and at unpredictable rates this century (IPCC, 2007), some landscapes may shift outside of their historic ranges, signifying that historical sources alone cannot determine restoration targets (Harris *et al.*, 2006). However, an understanding of historic conditions, changes, and ecological responses within the landscape to past climate changes still provides critical information on both past resilience and adaptability of components of the ecosystem, which can be applied to managing for resilience of a system into the future (Millar and Woolfenden, 1999; Hotchkiss *et al.*, 2000). In addition, although there is uncertainty around ecosystem shifts under climate change, there are increasingly more climate envelope models available that predict species shifts under local climate change projections (for Hawai‘i see Fortini *et al.*, 2013, 2015; Kurashima *et al.*, in prep.; Vorsino *et al.*, 2014). These models can be utilized to identify species that are predicted to shift into restoration areas, or to include species that may aid in mitigating shifts (Harris *et al.*, 2006).

A historical ecology approach is especially relevant in Hawai‘i. The expression “I ka wā ma mua, ka wā ma hope,” can mean “through the past is the future.” Here, the past or “ka wā ma mua,” can literally be translated as “the time in front”, while the future, “ka wā ma hope,” can mean “the time behind.” This positional perspective provides insight to the Kānaka Maoli worldview, that one is always looking towards the past, seeking guidance from ancestral knowledge to address the issues of the future (Kame‘eleihiwa 1992: 22). It serves as a constant reminder to first look to the knowledge, values, and approaches of kūpuna (ancestors) when faced with any matter in today’s changing contexts.This perspective still holds true today, with

numerous Kānaka Maoli educational programming and resource management programs emphasizing traditional knowledge applications to current issues like climate change and water scarcity. The principal ideas of the field of historical ecology, namely that a generational, long-range understanding of the past is necessary to address issues today, are already embedded within the Kānaka Maoli worldview.

Second, a plethora of socio-ecological knowledge is currently stored within local Hawaiian communities, as well as in Hawai‘i’s documentary archives, including ‘ōlelo Hawai‘i newspapers, oral histories, and anthropological studies. Knowledge of ecosystems and human interaction with these ecosystems are especially deep in Hawai‘i, where despite widespread colonization, many Kānaka Maoli families have continuously carried out cultural practices such as subsistence fishing, farming, and gathering over numerous generations (McGregor *et al.*, 2003). Additionally, much traditional ecological knowledge is stored within place names, mele (songs and chants), and mo‘olelo (stories), all serving as vehicles for intergenerational transmission of socio-ecological knowledge within communities (Kana‘iaupuni *et al.*, 2005; McMillen *et al.*, 2014; Nāone, 2008). More recently, there has been a renaissance in relearning practices, place names, and associated knowledge systems especially in younger generations (Goodyear-Ka‘ōpua, 2013; Paglinawan and Paglinawan, 2012; Tengan, 2008). Furthermore, many of the aforementioned documentary resources are already utilized and compiled by archaeologists and anthropologists in the form of ethnohistoric or cultural impact studies utilized in cultural resource management in Hawai‘i, although in many cases where the researcher does not have the capacity to read and translate ‘ōlelo Hawai‘i, these documents are often not included. Additionally, many sources have been digitized and are now freely available online (i.e., databases like Pakakilodatabase.com, AVAKonohiki.org, and Ulukau.org), although many more sources wait to be digitized.

Third, while many large landowners and conservation agencies do not use a historical ecology approach in ecological restoration, there are many smaller community and grassroots groups that have interest in and are utilizing traditional and local ecological knowledge in landscape restoration. These small-scale groups are often extremely successful in gathering and organizing people around a site and project. Given that many large conservation areas are on state or private lands and can be remote in nature, these restoration projects may not have a community living in or near it currently. Using a historical ecology approach could provide one method to begin to scale up community engagement around restoration and place. Although the goals of a large-scale restoration project may be very different from that of a community-based project, both can utilize a historical ecology approach based on ancestral knowledge, which can then serve to connect a community or a set of volunteers to a place. Given limited conservation funding, only with the help and commitments of local communities to restoration (Leigh, 2005), will it be possible to extend restoration efforts into large tracts of human-dominated landscapes across Hawai‘i.

How can historical ecology be integrated into restoration initiatives in Hawai‘i?

Case Study: Informing the restoration of Kūāhewa, Kahalu‘u, Hawai‘i Island

We present a case study of a restoration project in Kahalu‘u, Hawai‘i Island to provide an example of historical ecology methods and sources, and how they can be can be applied to restoration. We then discuss some applications and limitations of this approach in Hawai‘i. We provide this case study as a roadmap for those who are unfamiliar with historical resources in Hawai‘i, and as a more complete resource for those who may have already utilized some of these sources in management and restoration.

Restoration Site

Kūāhewa is a 347-acre parcel located in the district of North Kona in the ahupua‘a (Hawaiian land division) of Kahalu‘u on the leeward side of Hawai‘i Island. Vegetation surveys (Kurashima, 2016) revealed that the site is heavily invaded with alien plant species, with very few native species. However, almost half of the site’s canopy is made up of the native ‘ōhi‘a (*Metrosideros polymorpha*), more concentrated in the mauka (upland) section of the site, which boarders a predominately native forest reserve (Kurashima, 2016; Kurashima and Ticktin, in prep). The site was recently “rediscovered,” when a 2000 survey revealed over 3,500 archaeological features within the project area, which are almost all (98.7%) categorized as traditional Kānaka Maoli agricultural features (Rectman *et al.*, 2003; Monnahan *et al.*, 2015).The Kahalu‘u Field System is arguably the largest intact remnant of the Kona Field System (Rechtman *et al.*, 2003), a culturally important productive complex of rain fed fields that stretched over 140km^2 that traditionally integrated a variety of crops, along with native plant species. The rain fed system in Kahalu‘u was farmed in the time before Western contact (1778) and the decades following by Kānaka Maoli. Since then, the site has not been actively managed, and is seldom accessed, usually by a few for subsistance hunting.

Kūāhewa is similar to other large areas that are either privately or state managed, where the associated community that lived in the area may have been displaced, maybe many generations prior. Consequently, the families that were once apart of Kūāhewa have not been allowed to consistently maintain their practices in this area, and thus have lost the ability to continually develop their relationship with the environment of that place over time as their ancestors once did. This does not mean that this community is totally disconnected, as knowledge of this place endures in many ways, yet it does indicate that the relationship between community and place has been diminished.

Today, the landowner, Kamehameha Schools (KS), the largest private landowner in Hawai‘i with a mission focused on improving the education and well-being of Kānaka Maoli , is seeking to restore the site’s ecological and social function. As a former indigenous agroecosystem, these functions include increasing native conservation value by restoring a diversity of native habitats, as well as enhancing local food production and community resilience through establishing appropriate useful crop and plant species. However, like many systems in Hawai‘i, the site has transitioned from forest to agriculture, then back to forest, but is now alien-dominated. The degraded nature of the vegetation has left almost no living evidence of the species that naturally occurred in the area, nor the species that were cultivated historically alongside these natives. Thus, employing a historical ecology approach was necessary to begin to identify species to utilize in restoration.

Although one focus of the restoration is the reestablishment of traditional crops, there is also a large emphasis on integrating a high diversity native plant species within fields, including threatened and endangered species, as well as restoring large tracts of native forest in the mauka sections of the site. This agroecological approach is representative of Kānaka Maoli management, where native and cultivated systems were somewhat fluid and interdependent, and is also relevant today because many current and former agricultural landscapes in Hawai‘i are dominated by invasive species. KS has been working with collaborator organization, Hō‘ulu‘ulu Kahalu‘u, who recently initiated (January 2016) to host ‘āina-based (or place-based) educational restoration workdays with local educational groups. The voluntary workdays focus on removal of invasive vegetation, establishment of native and culturally important plants, and restoration of cultural sites. The educational experiences range from plant ecology, to the local water cycle, to landscape engineering, and cultivation practices, all from a Kānaka Maoli perspective.

Historical Ecology Methods and Sources for Hawai‘i

In 2012 we undertook a historical ecology approach in order to design biocultural restoration, set goals and metrics of success, and reconnect the surrounding community to Kūāhewa. We reviewed over 20 different types of sources (details in Table 1) in both ‘ōlelo Hawai‘i (The Hawaiian Language) and English spanning from before the initial settlement of Kona by Kānaka Maoli (~mid 1200 AD) (Rieth *et al.*, 2011) to present-day enviromental data and projections of vegetation shifts under future climate change scenarios for Hawai‘i (Figure 1). Recognizing that information about the site is living knowledge, we facilitated a half-day community workshop in Kahalu‘u and conducted subsequent informal interviews with kūpuna and kama‘āina of the area to understand plant species that are valuable to the community. Participant selection for the workshop was purposeful; invitees were those who had an in-depth relationship to Kahalu‘u and/or surrounding region through residence and were also familiar with Kona agriculture through subsistence activities and/or running Hawaiian agricultural programs. During the workshop and interviews, we discussed the study site, its history, any connections and information the participants had to the specific area, as well as recommendations for plant species to be utilized in restoration.

Many sources provided information on the native plants and crops previously planted in the area, information on planting methods and other cultural practices, descriptions of ecological and climatic patterns including weather, place names and locations, and details of the restoration of Kamehameha Pai‘ea’s upland garden in Kona called Kūāhewa. Mainly because of their older publication dates, the vast majority of the sources (n=14) are freely available online (links provided in Table 1), and thus readily accessible for use. Additionally, some sources are free at the Hawai‘i State Archives (e.g., historic photographs), or could be available for certain areas at

the State Historic Preservation Division (SHPD) library (e.g., ethnohistoric and archaeological surveys).

A well-known complication within the field of historical ecology is the issue of varied spatial scale of data. Some of our sources focused at the field or farm level, while others were regional to archipelago wide (Figure 1). Yet, the range of spatial scales is also an advantage for scale-specific information within a Kānaka Maoli worldview. Because our goals were associated with the restoration of a portion of the larger biocultural system of the Kona Field System, we chose to focus on gathering information that was pertinent to the upland Kona region in the ʻāpaʻa or planting zone, which operated in the range of farm to region level.

<<Table 1 near here>>

<<Figure 1 near here>>

Applications and outcomes of Historical Ecology Approach to Restoration

Because access and activities at Kūāhewa had been limited for decades, most people within the surrounding community and at KS had little knowledge of the site beyond the archaeological and ethnohistoric studies, which provided information on the cultural sites and a historical cultural context of the broader area of Kahaluʻu and Keauhou. Therefore, as researchers and land managers tasked with restoring the socio-ecological function of Kūāhewa, the first step was to hoʻokamaʻāina, become familiar with the place. We did this through regular site visits during different times of the year across as many areas of the system that we could access, and through simultaneously gathering and reading any information we could find at multiple spatial scales, including up to the moku, or regional level. The only way to understand if the information from the sources were applicable to Kūāhewa and its restoration was to understand the characteristics and cycles of the site, through being there physically as often as

possible for as many years as possible. It was through this process of building a relationship with Kūāhewa that we were able to make appropriate and sound natural and cultural resource management decisions. For example, through understanding both the historic and observed seasonal rainfall patterns and varied vegetation within microhabitats at the site, we could time the removal of overstory invasive canopy that resulted in minimal understory growth and subsequent outplantings. Simultaneously, we familiarized ourselves with other community organizations and lineal descendants of Kahaluʻu and the surrounding area by attending community-based educational programming and workdays at nearby sites. Through working alongside and consistently showing up to workdays, we were able to establish and grow a relationship with key community members.

Since majority of the site is dominated by invasive species, we needed to understand what plant species were appropriate to restore at Kūāhewa given today's changing environmental and social context. We developed an initial planting list of 70 species, including 37 species that were cited as previously existing in or around the project area in historical documents, a pollen survey, and our interviews. At least 8 of these species were only mentioned by community members as previously existing in the area, highlighting the value of community participation in the historical ecology approach. The list also contained useful native, Polynesian introduced, and non-native but non-invasive species, that are either currently existing on site, present in the adjacent forest reserve, or are ecologically appropriate (see Kurashima, 2016 and Kurashima and Ticktin, in prep. for full planting list). This plant list also includes 8 species that are listed as threatened or endangered, and those whose habitat is expected to be lost in some areas, but maintained within the project area (i.e., kauila [*Colubrina oppositifolia*]) (Fortini *et al.*, 2013). Considering future climate change in this step is ideal as some areas may no longer be appropriate for some species, while other areas may become suitable in the near future and can be considered for current

outplantings. Climate envelope models for every native Hawaiian plant species are available for the archipelago (see Fortini *et al.*, 2013), as well as for Polynesian introduced crop and crop mixes (see Kurashima, 2016).

Using a historical ecology approach in the creation of the plant list resulted in recognizing and documenting the historical preferences of the community of Kūāhewa. Historical sources as well as the interviews with the community provided information on crops and plants that have been and are likely to be the most important to the resource stewards of Kahaluʻu over time, helping us to understand the community's vision for specific plant species restoration. With the broad planting list for the study area, we were then able to plan detailed plant mixes for specific sites, and develop resource management goals (i.e., restore one-third of all previously mentioned species (n=12) by the third year of restoration).

Another step in the revitalization of Kūāhewa was to restore the identity of the place. One example is the name of the system itself, which previously termed at KS, "Kahaluʻu Field System." Yet, after gathering the moʻolelo of Kamehameha Paiʻea's restoration of a vast upland farm his people called, Kūāhewa, in historic Hawaiian language newspapers and other sources, we reestablished the name of Kūāhewa and its associated history and mana (power; energy) at the site. The historical ecology approach also yielded many names of places, land divisions, cultural sites, planting methods, winds, and rains which are used during any management or education concerning the site. Restoring these names also in turn restores the function to these places and phenomena in the way that the kūpuna of Kūāhewa once knew them. For example, we developed an ʻoli kāhea (chant asking for permission) specific to the site, first honoring the area through calling out the names for the water cycle and land boundaries, then recognizing Kamehameha's historical restoration of the area with his people. Finally, the ʻoli acknowledges the current generation of stewards of Kūāhewa and their purpose to replant and restore for

Kūāhewa's sustainability into the future. In many places, it may be more appropriate to continue process of haku mele (composition) about an area or process to reflect and honor the place and its function in today's context. By speaking these traditional names again and echoing them throughout Kūāhewa; by creating an ʻoli to honor Kūāhewa, this generation of resource stewards affirms themselves to the place in a way that the kūpuna who cared for this place generations ago once did. The value does not lie only in the specific content of names or information uncovered, but in the process of using that knowledge again, which then returns the purpose and function to that knowledge.

Due to the dense vegetation in some areas, it was difficult for anyone, both managers and visitors, to access many of the cultural sites and restoration areas. We established interpretive trails of sites using the archaeological studies and the help of an archaeologist familiar with the restoration area. Using the historical resources, we selected characteristically common Kona Field System sites, along with sites unique to Kahaluʻu, then designed an easily accessible trail to these sites. We also developed a narrative for each location, highlighting information from the historical record, such as specific planting methods and types of crops planted at the site. The development of the interpretive trail has allowed for better access for targeted resource management (native plant, crop, and cultural site restoration). Starting with a relatively small number of sites (around 15) and connecting trails helped us to set achievable goal for initial invasive species removal, cultural site restoration, and native replanting. Furthermore, we used the interpretive trail each time a visiting group visits as a way to introduce volunteers to a wide variety of restoration areas quickly and easily, serving as a way for people to build pilina (connection, relationship) with Kūāhewa.

Due to limited access to Kūāhewa for generations, we needed to reopen and reestablish relationships between the surrounding community and Kūāhewa as well between us as resource

managers and the community. With a specific outplanting plan, established interpretive trails and narrative, we were able to host visitors, which included community members, students, contracted crews, researchers from local universities, other natural resource managing organizations, and groups from within KS, in a much more meaningful way. The historical ecology approach provided us with a trove of information, which we shared with all visitors either in conversation, or through visuals such as large durable historic maps. The maps operate at different scales to explain both the specific adaptations of Kānaka Maoli practices to a sites as well as broader landscape patterns across the island. The maps help individuals place themselves within the landscape over space and time, and also serve to establish pride and a connection to the ingenuity of the kūpuna who once managed Kūāhewa. Sharing the information from the historical ecology approach and resulting narrative is also a way to show the community our respect for the site and for them –i.e., a form of reciprocity. Learning as much as possible through the historical ecology approach and physical presence served as an indicator to some of the kūpuna, who have knowledge of the area, that we had "done our homework." It was a way to demonstrate how much we valued Kūāhewa and valued the time we had with the kūpuna of the place, because it was only after years of the research process and subsequent increased understanding of the place over time that we were able to ask them meaningful questions that could then in turn help to drive restoration.

With the numerous hands on site, we were then able to work towards the restoration of many of the Kānaka Maoli practices associated with Kūāhewa. One example was our efforts to revitalize various planting methods and techniques discussed in historical documents. One site we cleared on the trail consists of built-up planting rings in an area that is intermittently filled with standing water. This site was considered unique, and is not known by the archaeologist to exist in other parts of the Kona Field System. We reestablished the name of mākālua, which

refers to planting in mulched holes, pits (Handy *et al.*, 1972) to this site. A group of local and Kānaka Maoli students from the surrounding area filled these mākālua with soil and mulch derived from the surrounding invasive species and planted huli (cuttings) of kalo (*Colocasia esculenta;* taro) that they brought from their garden, while we all chanted an ʻoli associated with planting. The act of bringing kalo huli and putting their hands into the soil is also a form of reciprocity between those Kānaka and Kūāhewa. Though the varieties of kalo, the type of mulch, and the chant may or may not be exactly what was used traditionally, the value lies in the process of returning the function to the mākālua and the function to the collective community as the stewards of this place. The tradition also continues in the monitoring and continued relationship of these students to with these outplantings over the year and experimenting with better ways to ensure the continued growth of these crops, just as the kūpuna of Kūāhewa once did. By reestablishing the succession of planting, the succession of stewardship of Kūāhewa, this generation of stewards becomes part of the moʻokūʻauhau, the genealogy of the place. In this way, we as the collective stewards (resource managers, researchers, students, community members) will always be tied to and will always have a kuleana (responsibility) to this place.

More information and visuals on our process is available at: http://www.huihouluulu.org/.

Discussion

Our case study focused on restoration of an agroecological site, including both forest and agriculture systems, but our approach is applicable to restoration of forests or other natural ecosystems in Hawaiʻi. Our site has not been occupied for generations and did not have a specific community tied to it through practice. In this way, it is comparable to some of the more remote areas of Hawaiʻi, where Kānaka once had a more constant relationship with, but have since been displaced. In these areas, a historical ecology approach can serve as the first step in a

biocultural restoration process to ultimately can aid in reestablishing relationship between resource stewards, including the community, and the place.

As we showed, there is a wide variety of freely available resources that can be a critical part of restoration. One of the most important applications of historical resources is in helping to determine reference conditions in landscape restoration, which can often help to then generate species lists for outplanting. Because restoration goals were biocultural –to restore the ecological and the Kānaka Maoli cultural system and their interconnections, the decision was to restore to a context that emphasized both. Therefore, many of the reference conditions chosen were during the time of the cultivation of the Kona Field System (~1300-1900) (Allen, 1991). Yet, we did include reference conditions from pre-contact and information about future climate change into our resulting plant list. Even if the reference conditions for restoration are pre-Polynesian management, a historical ecology approach can still be used to both determine this earlier range of historical variability, and to provide information on landscape change over time. For example, the archeobotanical study indicated the previous presence of native species not found in the surrounding forest nor mentioned by the community. Their current absence from the greater area and absence in the mind of some of the people of the place could indicate long-standing changes to their recruitment.

In addition, plans for the reference condition can shift over time. For example, in our case defining the reference condition has been, and will continue to be, a collective and iterative process. For example, though we have a planting list of ecologically and culturally appropriate species that guides outplantings, groups continually bring seedlings as makana (gifts) to the site. Often, they will ask what is appropriate and we provide the list, but other times they will bring what they feel is appropriate. Although a historical ecology approach can provide a guide,

ultimately, it is the decision of the (collective) stewards of a place to decide on the most appropriate reference condition(s).

Our case-study illustrates that this approach can be used to provide guiding principles for appropriate restoration, both ecologically and culturally, and aid in setting social and cultural goals of restoration alongside biological ones. It also demonstrates how much of the information gathered in a historical ecology approach can be shared with restoration participants as a way to further engage them in the biocultural history of the site. These applications not only provide valuable insights about restoration to the land owner, ecologist or manager, but can serve to build relationships between community and place as well as manager to community. Kānaka Maoli scholar C. Kanoelani Nāone writes, "We sustain and grow our connection to the land by sharing stories of place. By learning the names of places we claim and opening a dialogue with ʻāina, we come to understand the deeper meaning of place" (Nāone 2008: 333). Restoration and management can facilitate these connections of communities to ʻāina by enabling both physical access to lands and just as importantly through sharing and restoring the stories, names, and history of a place. It is important to note however, a historical ecology approach does always necessitate a community-based effort, and can be utilized in restoration not driven by community.

There are limitations in both the access and utilization of some of the historic sources. First, those not freely available online have a cost, which are usually minimal, but ethnohistoric and archaeological studies can be very costly to the landowner, organization, or individual, usually costing upwards of $15,000. However, these types of studies have been executed in many areas and are publically available at the State Historic Preservation Division (SHPD) library. Archaeobotany studies, which are especially helpful in determining plant species composition over long time scales, are much less common, but have been executed in some

areas. Managers and ecologists can look for published studies done in similar ecological zones or biocultural landscapes (i.e., within a lowland mesic forest on the same island) for pertinent information. There are also a number of historic sources at the Bishop Museum, but access is limited by appointment as well as designated time restrictions for research. Another limitation is language. Many sources are solely in ʻōlelo Hawaiʻi and older documents are written in colloquial ʻōlelo Hawaiʻi, which requires a more advanced understanding of the language. However, with the growth of ʻōlelo Hawaiʻi programs throughout the archipelago, there are many students of the language that one could employ for the task of reading, summarizing, and/or translating. Finally, some areas within Hawaiʻi may have less available data than others, depending on the specific history of people on those landscapes over time. In these cases, it is important to remember that there are people who are still connected to that place and have valuable knowledge of the history of the area, who can be contacted. Although an all-inclusive picture of the history of a landscape is unachievable, failing to ignore the history of a place altogether could be perilous to the socio-ecological success of a restoration project.

With worldwide environmental degradation, ecological restoration is increasingly becoming a requirement within the field of conservation (Hobbs and Harris, 2001). There is limited programmatic funding at the government, non-profit, and community levels, especially for projects outside of formal conservation areas, and more and more projects are turning to volunteers for labor assistance to leverage costs and reach management goals. The success of restoration and conservation projects is dependent on public support and community involvement (Higgs, 2003; Leigh, 2005; Ryan *et al.*, 2001) and this is especially true if restoration efforts are to be scaled up to the vast areas of human-dominated landscapes that lie outside of protected areas. Studies on the U.S. continent, have found that "helping the environment," and "learning" are the most important motivations for conservation volunteers

(Bruyere and Rappe, 2007; Guiney and Oberhauser, 2009; Ryan *et al.*, 2001). But, in places like Hawai‘i, where the land and seascapes are an essential part of the genealogy, identity, and well-being of its indigenous people for generations upon generations (Kana‘iaupuni *et al.*, 2005; Nāone, 2008), motivations to volunteer are more akin to responsibilities to take care of a family member. This drive is powerful, and desires to return to ancestral lands and learn the history of place is on the rise in Hawai‘i. Biocultural restoration projects that utilize a historical ecology approach are a powerful tool to foster existing connections or in other cases, help to reestablish relationships of individuals and communities to ‘āina, potentially enabling long-term restoration success. The following quote from a community volunteer at Kūāhewa exemplifies this:

> “*Our people have been threatened by abuse—physical, mental, social, for generations. Our land has been abused—development, large-scale agriculture, pasture, invasive species, fire, for generations. And we continue the cycle of abuse both on the land and to ourselves as people. We have a kuleana* [responsibility] *to restore these Hawaiian landscapes to not only heal the land, but to heal ourselves, families, and ultimately our communities for future generations.”* –Kamuela Meheula of Holualoa, Kona

In an era where most of Hawai‘i’s human-dominated lowland areas are characterized by non-native vegetation (Hawaii Gap Analysis Program, 2006), and the indigenous people of Hawai‘i face health and well-being challenges, it is now not enough to mitigate ecological threats or restore ecosystems alone. In Hawai‘i, management strategies that restore people to lands through access, cultural practices, and knowledge, is the only way to truly restore these human-dominated landscapes, and ensure the sustainability of restoration into the future. The consequences of biocultural restoration programming with an approach that truly integrates local and Kānaka Maoli communities goes far beyond achievements of biodiversity, but works towards the renewal and strengthening of people to place, their culture, and each other.

Acknowledgements

This research was supported by the Ford Foundation, the Andrew W. Mellon Foundation, the Kohala Center, and the Kamehameha Schools. We would like to thank the Keauhou-Kahaluʻu community, Kara Ueki, and Billy Lee for their help in this research.

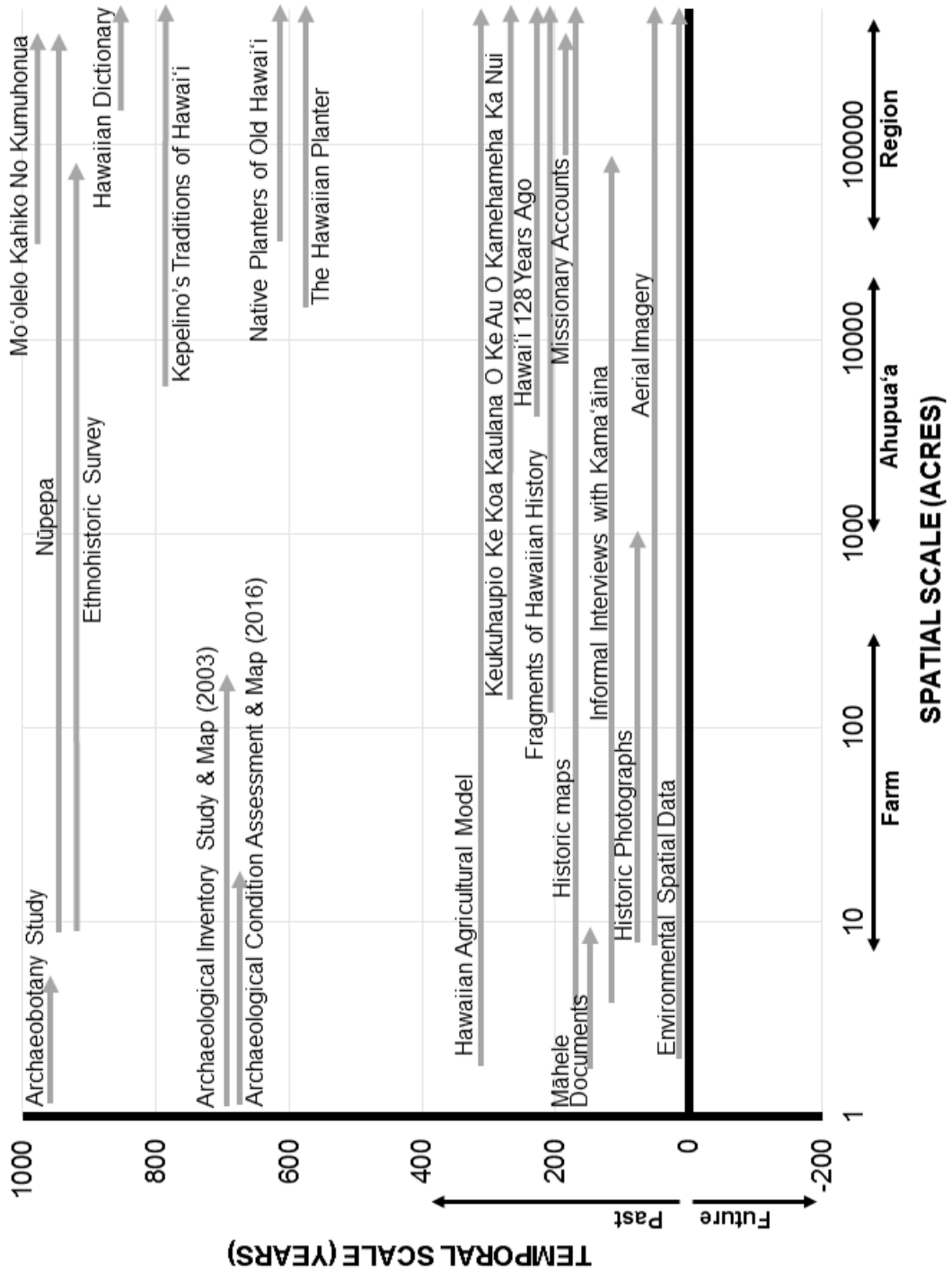

Figure 1: Spatial and temporal scale of the sources used in the restoration of Kūāhewa

Literature Cited

Allen, M.S. (Ed), 1991. Gardens of Lono: Archaeological Investigations at the Amy B.H. Greenwell Ethnobotanical Garden, Kealakekua, Hawai‘i. Bishop Museum Press, Honolulu.

Aplet, G., Keeton, W.S., 1999. Application of historical range of variability concepts to biodiversity conservation, *In:* Baydack, R.K., Campa, H.I., Haufler, J.B. (Eds.), Practical Approaches to the Conservation of Biological Diversity. Island Press, Washington, D.C., pp. 71–86.

Armstrong, C.G., Veteto, J.R., 2015. Historical Ecology and Ethnobiology: Applied Research for Environmental Conservation on and Social Justice. Ethnobiol. Lett. 6: 5–7.

Athens, J.S., Reith, T.M., Dye, T.S., 2014. A Paleoenvironmental and Archaeological Model-based Age Estimate for the Colonization of Hawai’i. Am. Antiq. 79: 144–155.

Balee, W., 1998. Advances in Historical Ecology. Columbia University Press, New York.

Banko, P.C., David, R.E., Jacobi, J.D., Banko, W.E., 2001. Conservation Status and Recovery Strategies for Endemic Hawaiian Birds. Stud. Avian Biol. 22: 359–376.

Beckwith, M.W., 1951. The Kumulipo. University of Hawaii Press, Honolulu.

Bruyere, B., Rappe, S., 2007. Identifying the motivations of environmental volunteers. J. Environ. Plan. Manag. 50: 503–516.

Chapin, F.S., Zavaleta, E.S., Eviner, V.T., Naylor, R.L., Vitousek, P.M., Reynolds, H.L., Hooper, D.U., Lavorel, S., Sala, O.E., Hobbie, S.E., Mack, M.C., Díaz, S., 2000. Consequences of changing biodiversity. Nature 405: 234–42.

Crumley, C.L., 1994. Historical Ecology: Cultural Knowledge and Changing Landscapes. School for Advanced Research Press, Santa Fe.

DBEBT, 2015. The State of Hawai‘i Data Book: A Statistical Abstract. State of Hawai‘i, Department of Business, Economic Development and Tourism, Statistics and Data Support Branch. Honolulu.

Desha, S.L., 2000. Kamehameha and His Warrior Kekūhaupi‘o. Kamehameha Publishing, Honolulu.

Egan, D., Howell, E.A., 2001. The Historical Ecology Handbook: A Restorationist‘s Guide to Reference Ecosystems.

Eldredge, L.G., Evenhuis, N.., 2003. Hawai‘i’s biodiversity: a detailed assessment of the numbers of species in the Hawaiian Islands. Rec. Hawai’i Biol. Surv. 2001-2002. Bishop Museum Occasional Pap. 76: 1–30.

Fortini, L., Price, J., Jacobi, J., Vorsino, A., Burgett, J., Brinck, K., Amidon, F., Miller, S., Gon III, S. “Ohukani”ohi’a, Koob, G., Eben, P., 2013. A Landscape-based assessment of climate change vulnerability for all native Hawaiian plants. Tech. Rep. HCSU-044, Univ. Hawaii Hilo 96720: 1–134.

Fortini, L.B., Vorsino, A.E., Amidon, F.A., Paxton, E.H., Jacobi, J.D., 2015. Large-scale range collapse of Hawaiian forest birds under climate change and the need 21st century conservation options. PLoS One 10: 1–22.

Foster, D.R., Motzkin, G., 2003. Interpreting and conserving the openland habitats of coastal New England: Insights from landscape history. For. Ecol. Manage. 185: 127–150.

Goodyear-Ka‘ōpua, N., 2013. The Seeds We Planted: Portaits of a Native Hawaiian Charter School. University of Minnesota Press, Minneapolis.

Guiney, M.S., Oberhauser, K.S., 2009. Conservation Volunteers’ Connection to Nature. Ecopsychology 1: 187–197.

Handy, E.S.C., 1940. The Hawaiian Planter: His Plants, Methods and Areas of Cultivation. Bishop Museum Bull. 161: 227.

Handy, E.S.C., Handy, E.G., Pukui, M.K., 1972. Native Planters in Old Hawai‘i: Their Life, Lore, and Environment. Bishop Museum Bull. 233: 383-385.

Harris, J.A., Hobbs, R.J., Higgs, E.S., Aronson, J., 2006. Ecological restoration and global climate change. Restor. Ecol. 14: 170–176.

Hawaii Gap Analysis Program, 2006. A gap analysis of Hawaii February 2006 final report [WWW Document]. URL http://gapanalysis.usgs.gov/

Hermy, M., Verheyen, K., 2007. Legacies of the past in the present-day forest biodiversity: A review of past land-use effects on forest plant species composition and diversity. Ecolog. Res. 22: 361–371.

Higgs, E., 2003. Nature by Design: People, Natural Process, and Ecological Restoration - Eric Higgs - Google Books. The MIT Press, Cambridge.

Hightower, J.N., Butterfield, A.C., Weishampel, J.F., 2014. Quantifying ancient maya land use legacy effects on contemporary rainforest canopy structure. Remote Sens. 6: 10716–10732.

Hobbs, R.J., Harris, J.A., 2001. Restoration Ecology : Repairing the Earth ’ s Ecosystems in the New Millennium 9: 239–246.

Hotchkiss, S., Vitousek, P.M., Chadwick, O.A., Price, J. 2000. Climate Cycles, Geomorphological Change, and the Interpretation of Soil and Ecosystem Development. Ecosystems 3: 522-533.

‘Ī‘ī, J.P., 1959. Fragments of Hawaiian History. Bishop Museum Press, Honolulu.

IPCC, 2007. Climate Change 2007: Synthesis Report, Assessment, Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (Core Writing Team). Cambridge University Press.

Kamakau, S.M., 1991. Tales and Traditions of the People of Old: Nā Moʻoleo a ka Poʻe Kahiko. Translated from the newspaper Ke Au ʻOko ʻa by Mary Kawena Pukui, arranged and edited by Dorothy B. Barrère. Bernice P. Bishop Museum Special Publication 51.

Kameʻeleihiwa, L., 1992. Native Lands and Foreign Desires: Pehea Lā E Pono Ai? Bishop Museum, Honolulu.

Kamehameha Schools, 2014. Ka Huakaʻi: 2014 Native Hawaiian Educational Assessment. Kamehameha Publishing, Honolulu.

Kamehameha Schools, 2013. Kahaluʻu Field System Plan. Kamehameha Schools Internal Document, Honolulu.

Kana'iaupuni, S.M., Malone, N.J., Ishibashi, K., 2005. Income and poverty among Native Hawaiians: Summary of Ka Huakaʻi findings 10.

Keane, R.E., Hessburg, P.F., Landres, P.B., Swanson, F.J., 2009. The use of historical range and variability (HRV) in landscape management. For. Ecol. Manage. 258: 1025–1037.

Kelly, M., 1994. The Impacts of Missionaries and Other Foreigners on Hawaiians and Their Culture, in: Hasager, U., Friedman, J. (Eds.), Hawaiʻi Return to Nationhood. International Working Group for Indigenous Affairs, Copenhagen, pp. 91–105.

Kepelino, Z., 2007. Kepelino's Traditions of Hawaii. Bishop Museum Press.

Kepelino, Z., 1932. Kepelino's Traditions of Hawaii. Bernice P. Bishop Museum, Honolulu.

Kimmerer, R., 2011. Restoration and reciprocity: The Contributions of Traditional Ecological Knowledge, *In:* Egan, D., Hjerpe, E.E., Abrams, J. (Eds.), Human Dimensions of Ecological Restoration: Integrating Science, Nature, and Culture. Island Press, Washington, D.C., pp. 257–276.

Kurashima, N., 2016. Hōʻuluʻulu: The Biocultural Restoration of Indigenous Agroecosystems in Hawaiʻi. Unpublished PhD Dissertation. University of Hawaiʻi at Mānoa, Honolulu.

Kurashima, N., Fortini, L., Ticktin, T., 2016. The potential of indigenous agricultural lands for food production, security, and resilience to climate change. Manuscript in preparation.

Kurashima, N., Ticktin, T., 2016. Indigenous Agriculture as a Restoration Strategy: Assessing the Ecological, Social, and Cultural Outcomes. Manuscript in preparation.

Leigh, P., 2005. The ecological crisis, the human condition, and community-based restoration as an instrument for its cure. Ethics Sci. Environ. Polit. 5: 3–15.

Malo, D., 1951. Hawaiian Antiquities (Moʻolelo Hawaii), Bernice Pa. ed. Bishop Museum Press, Honolulu, HI.

Maly, K., 2012. He Moʻolelo ʻĀina: Kahaluʻu- Kaulana i ka Wai Puka iki o Helani a me Keauhou- I ka ʻIliʻili Nehe: A History of Kahaluʻu and Keauhou Ahupuaʻa District of Kona, Island of Hawaiʻi. Kumu Pono Associates LLC, ʻEwa Beach.

McMillen, H.L., Ticktin, T., Friedlander, A., Jupiter, S.D., Thaman, R., Campbell, J., Veitayaki, J., Giambelluca, T., Nihmei, S., Rupeni, E., Apis-Overhoff, L., Aalbersberg, W., Orcherton, D.F., 2014. Small islands, valuable insights: Systems of customary resource use and resilience to climate change in the Pacific. Ecol. Soc. 19: 44.

Menzies, A., Wilson, W.F., 1920. Hawaiʻi Nei 128 years ago. Publisher not identified, Honolulu.

Millar, C.I., Woolfenden, W.B., 1999. The role of climate change in interpreting historical variability. Ecol. Appl. 9: 1207–1216.

Monahan, C.M., Thurman, D.W., Thurman, R.R., 2015. Intensive Mapping & Archaeological Condition Assessment 24-acre Portion of Kahaluʻu Field System Kahaluʻu Ahupuaʻa, North Kona District Hawaiʻi Island, TMK (3) 7-8-002:010 (por.) & 7-8-008:078. Prepared for Kamehameha Schools, Honolulu.

Moy, K.L., Sallis, J.F., David, K.J., 2010. Health indicators of Native Hawaiian and Pacific Islanders in the United States. J. Community Health 35: 81–92.

Nāone, C.K., 2008. ‘O Ka ‘Āina, Ka ‘Ōlelo, a me ke Kaiāulu. Hūlili Multidiscip. Res. Hawaiian Well-Being 5, 315–339.

Oliveira, K.-A.R.K., 2014. Ancestral Places: Understanding Kanaka Geographies. Oregon State University Press, Corvallis.

Paglinawan, R.K., Paglinawan, L.K., 2012. Living Hawaiian Rituals: Lua, Hoʻoponopono, and Social Work. Hūlili Multidiscip. Res. Hawaiian Well-Being 8: 11–28.

Pascua, P., McMillen, H., Ticktin, T., Vaughan, M., Winter, K.B. 2017. Beyond services: A process and framework to incorporate cultural, genealogical, place-based, and indigenous relationships in ecosystem service assessments. Ecosyst. Serv. *In Press*. DOI: 10.1016/j.ecoser.2017.03.012

Phillips, B., 2016. Pollen Analysis of the Kahaluʻu Field System, Kahaluʻu Ahupuaʻa, Hawaiʻi Island. EcoPlan Associates, Inc. Prepared for Kamehameha Schools.

Pukui, M.K., n.d. “Moʻolelo Kahiko no Kumuhonua,” in Hawaiian Ethnographical Notes vol. 2. Bishop Museum, Honolulu.

Pukui, M.K., Elbert, S.H., 1986. Hawaiian Dictionary. University of Hawaii Press, Honolulu.

Rechtman, R., Clark, M.R., A., D.S., 2003. Archaeological Inventory Survey of a Portion of the Kona Gold Coffee Plantation (TMK:3-7-8-02:06,10): Volume 1. Prepared for Mr. John Parry, Kona Gold Coffee Plantation Inc., Rechtman Consulting, LLC, Keaʻau.

Rieth, T.M., Hunt, T.L., Lipo, C., Wilmshurst, J.M., 2011. The 13th century Polynesian colonization of Hawai’i Island. J. Archaeol. Sci. 38: 2740–2749.

Ryan, R.L., Kaplan, R., Grese, R.E., 2001. Predicting Volunteer Commitment in Environmental Stewardship Programmes J. Env. Plan. Manage. 44: 629–648.

Sakai, A.K., Wagner, W.L., Mehrhoff, L. a, 2002. Patterns of endangerment in the Hawaiian flora. Syst. Biol. 51: 276–302.

Society for Ecological restoration Science & Policy Working Group, 2002. The SER Primer on Ecological Restoration.

Steffen, W., Crutzen, J., McNeill, J.R., 2007. The Anthropocene: are humans now overwhelming the great forces of Nature? Ambio 36: 614–621.

Swetnam, T.W., Allen, C.D., Betancourt, J.L., 1999. Applied historical ecology: Using the past to manage for the future. Ecol. Appl. 9: 1189–1206.

Tengan, T.P.K., 2008. Native Men Remade: Gender and Nation in Contemporary Hawai‘i. Duke University Press, Durham.

U.S. Fish and Wildlife Service, 2010. Hawaiian Islands Plants: Listed Species, as Designated Under the U.S. Endangered Species Act [WWW Document]. URL http://www.fws.gov/pacificislands/ publications.html (accessed 1.20.16).

Vitousek, P.M., Mooney, H. a, Lubchenco, J., Melillo, J.M., 1997. Human Domination of Earth’s Ecosystems. Science 277: 494–499.

Vorsino, A.E., Fortini, L.B., Amidon, F.A., Miller, S.E., Jacobi, J.D., Price, J.P., Gon, S., Koob, G.A., 2014. Modeling Hawaiian ecosystem degradation due to invasive plants under current and future climates. PLoS One 9: e95427.

Walter, R.C., Merritts, D.J., 2008. Natural streams and the legacy of water-powered mills. Science 319: 299–304.

Wortley, L., Hero, J.M., Howes, M., 2013. Evaluating ecological restoration success: A review of the literature. Restor. Ecol. 21: 537–543.

Table 1: Sources and the data gathered in historical ecology approach, including information about their accessibility and scope

Source and Author	Access	Language	Example Information Provided	Spatial scope	Temporal Scope	Financial Cost
Hisotrical Written Documents						
Nūpepa – Hawaiian language newspapers (Various, 1838-1927) Used search word "Kuahewa" to find: 10 Newspapers: 31 articles, 15 moʻolelo (stories), 1 mele (song), 1 nane (riddle)	Online at papakilodatabase.com or nupepa.org	ʻŌlelo Hawaiʻi	• Stories of Kamehameha Paiʻea's restoration of Kūāhewa • Details of agricultural practices (sharing of cutlivars by aliʻi, community work) • Information about the name Kūāhewa • Traditional sustainable agricultural practices	Farm to Region	Long	Free – Low (if translator needed)
Ethnohistoric Survey of Keauhou and Kahaluʻu (Maly, 2012) A combintation of sources including surveys, stories, mele, nūpepa, māhele documents (see below)	Prepared for Kamehameha Schools (most information originally found in the Hawaiʻi State Archives), exisiting studies are available at ulukau.org, or at the State Historic Preservation Division (SHPD)	English & translated ʻŌlelo Hawaiʻi	• Place names, water locations, habitats for certain species • Traditional practices (water gathering/storage, crops used, planting methods and names, planting ceremonies, sharing customs)	Farm to Region	Long	Free –High
Māhele documents (Land Commission Awards- LCAs, Native and Foreign	Hawaiʻi State Archives and Online at papakilodatabase	ʻŌlelo Hawaiʻi	• Names of ʻili (land division within an ahupuaʻa) • Crops planted in each areas, number of fields	Farm	Short	Free– Low (if translator needed)

Testimony)	.com and avakonohiki.org		• Plants gathered and locations • Locations of house sites			
Moʻolelo Kahiko No Kumuhonua (Pukui, n.d.)	Bishop Museum Archives	ʻŌlelo Hawaiʻi	• Kaʻao (origin story) of Hawaiian crops in Kona	Region	Med	Free - Low
Fragments of Hawaiian History (ʻĪʻī, 1959)	Book	English & ʻŌlelo Hawaiʻi	• Descriptions of Kūāhewa • Crops planted • Winds of Kona	Ahupuaʻa to Region	Med	Low
Kekuhaupio Ke Koa Kaulana O Ke Au O Kamehameha Ka Nui (Samuel Manaikalani Kamakau, 920-1924) **Kekuhaupio and His Warrior Kamehameha (Desha, 2000)**	Orignial article in Ka Hoku O Hawaiʻi accessible through papakilodatabase.com Translated and published as a book, also available on uukau.org	ʻŌlelo Hawaiʻi Translated to English	• Description of the development of Kūāhwa including the work, rules/laws, its name, proclimations, and crops planted	Farm to Region	Short	Free – Low
Kepelino's Traditions of Hawaiʻi (Kepelino, 2007, 1932)	Book and available online at catalog.hathitrust.org/Record/001635258	English (Older edition has ʻŌlelo Hawaiʻi & English)	• Kona specific plants, traditional planting terms, planting methods • Kona seasons, including weather, phenology, animal activity, stars • Explination of food preferences of dryland kalo in Kona	Region	Med	Free – Low
The Hawaiian Planter: His Plants, Methods and Areas	Out of print book and available online at	English	• Tradtiional planting terms • Kona planting areas, crops, methods	Can be region specific	Med	Free

of Cultivation (Handy, 1940)	https://www.scribd.com/					
Native Planters of Old Hawai‘i (Handy *et al.*, 1972)	Book	English	• Traditional planting terms • Traditional planting customs/ceremony • Kona planting areas, crops, methods	Region to archipelago	Med	Low
Hawaiian Dictionary (Pukui and Elbert, 1986)	Book and available online at ulukau.org	‘Ōlelo Hawai‘i to English and English to ‘Ōlelo Hawai‘i	• Traditional plnating terms	Region to archipelago	Med	Free – Low
Hawai‘i Nei 128 years ago (Menzies and Wilson, 1920)	Out of print book, available onine at play.google.com	English	• Forest descriptions • Native plants- names and locations • Various agroecosystem descriptions • Crops used in upland Kona systems • Kona weather pattern • Forest and agriculture interactions • Names and locations of chiefly agricultural areas	Region to archipelago	Short	Free

Missionary accounts Reminiscences of Old Hawai‘i (Sereno, 1916) Journal of William Ellis: A Narrative Tour Through Hawai‘i in 1823 (Ellis, 2004) The Life and Times of Mrs Lucy G. Thurston, Wife of Rev. Asa Thurston, Pioneer Missionary to the Sandwich Islands (Thurston, 2007)	Book and available online at books.google.com Book Book	English	• Crops, planting methods, uses of plants, water gathering, planting locations	Region	Short	Free – Low
Maps and Aerial Imagery						
Historic Maps (Various, 1875-1954)	Some managed by Kamehameha Schools and some publically available online at the Department of Accounting and General Services site: ags.hawaii.gov/survey/map-search/	English	• Place names • Ecolgoical boundaries (i.e., trees, gulch, hills) • Locations and sizes of LCAs and Royal Patent Grants • Locations of crops, forest types, cultural sites, trails, water holes • Land tenure over time	Farm to Region	Short – Med	Free

Aerial Imagery (USGS, 1954; USDA, 1964; NOAA, 2000)	Available online at the UH Mānoa MAGIS site: guides.library.manoa.hawaii.edu/magis/home	English	• Change in forest cover over time • Locations of agricultural fields, roads, trails, houses, pasture	Ahupua‘a to Region	Short	Free
Hawaiian Agricultural Model – Traditional and under Climatic Changes (Kurashima *et al.*, in prep)	Will be available at kipukadatabase.com in 2017	English	• Locations of pre-colonial (prior to 1777) lo‘i, dryland, and agroforestry systems • Locations of areas resilient to three climate change scenarios (A1B, RCP 4.5, RCP 8.5)	Farm to Archipelago	Med	Free
Current Environmental Spatial Data	**Elevation & Topography** (http://viewer.nationalmap.gov/basic) **Soils** (http://soildatamart.nrcs.usda.gov/) **Rainfall** (http://rainfall.geography.hawaii.edu/) **Climate** (http://climate.geography.hawaii.edu/) **Geology** (http://pubs.usgs.	English	• Environmental and Climate Characteristics of spatially explicit areas	Farm to Archipelago	Short	Free

	gov/of/2007/1089/) **Various layers** (http://planning.hawaii.gov/gis/)					
Native Hawaiian Plant Species Climate Envelope Models (Fortini *et al.*, 2013)	Report available at: http://hilo.hawaii.edu/hcsu/documents/TR44_Fortini_plant_vulnerability_assessment.pdf	English	• Locations and spatial shifts of all Native Hawaiian plant species under downscaled precipitation and temperature projections for Hawai‘i (A1B scenario)	Farm to Archipelago	Med	Free
Photographs						
Historic Photographs (Kamehameha Schools, 1950’s)	Managed by Kamehameha Schools, some available in Hawai‘i State Archives	captions in English	• Landscape conditions • Plants present historically	Farm to Region	Short	Free at the archives
Archaeological Studies						
Archaeological Inventory Survey of a Portion of the Kona Gold Coffee Plantation (Rechtman *et al.*, 2003), includes map	Prepared for Kamehameha Schools (many archaeological surveys are available at SHPD)	English	• Locations, types, conditions, photographs, maps of cultural sites • Historical and cultural context	Farm to Region	Med	Free – High
Intensive Mapping & Archaeological Condition Assessment 24-acre Portion of Kahalu‘u	Prepared for Kamehameha Schools (many archaeological surveys are	English	• Extremely detailed map of cultural sites, vegetation, topography • Evidence of different traditional planting methods	Farm	Med	Free – High

Field System (Monahan *et al.*, 2015), includes map	available at SHPD)					
Archaeobotany study (Pollen and Phytolith Testing) (Phillips, 2016)	Prepared for Kamehameha Schools	English	• Identification and age of short lived plant species in charcoal samples at specific locations • Identification of phytoliths of plant and crop remains at specific sites • Evidence of native plants and crops being grown at specific times and sites	Farm	Long	High
Interviews						
Informal interviews with kūpuna and kamaʻāina of the area	Find and approach some key people within the community	English	• Place names, weather patterns, locations of fields and crops, crops planted in area over time, planting methods • Ecosystem health over time • Values within a community overtime	Farm to Region	Med	Free – Low