4-2017

Understanding Human-Landscape Interaction: Geoarchaeology in the Society Islands, French Polynesia

Katherine M. Peck
College of William and Mary

Follow this and additional works at: https://scholarworks.wm.edu/honorstheses

Part of the Archaeological Anthropology Commons

Recommended Citation
https://scholarworks.wm.edu/honorstheses/1007

This Honors Thesis is brought to you for free and open access by the Theses, Dissertations, & Master Projects at W&M ScholarWorks. It has been accepted for inclusion in Undergraduate Honors Theses by an authorized administrator of W&M ScholarWorks. For more information, please contact scholarworks@wm.edu.
Understanding Human-Landscape Interaction: Geoarchaeology in the Society Islands, French Polynesia

A thesis submitted in partial fulfillment of the requirement for the degree of Bachelor of Arts in Anthropology from The College of William and Mary

by

Katherine Marisa Peck

Accepted for ________________________________
(Honors, High Honors, Highest Honors)

________________________________________
Jennifer Kahn, Director

________________________________________
Martin Gallivan

________________________________________
Gregory Hancock

Williamsburg, VA
April 3, 2017
# Contents

Acknowledgements.................................................................................................................. ii

Introduction........................................................................................................................................ 1

Resilience and Pacific Archaeology ............................................................................................ 5

Geologic and Cultural Context ................................................................................................. 7
  Geology of the Society Islands ................................................................................................. 7
  Culture of the Society Islands .................................................................................................... 11

Methods ......................................................................................................................................... 16

Results.............................................................................................................................................. 24
  Mo‘orea.......................................................................................................................................... 24
  Maupiti........................................................................................................................................... 34

Conclusion ....................................................................................................................................... 45
  Human Modification of Environment......................................................................................... 45
  Management................................................................................................................................. 45
  Comparative Resilience ............................................................................................................... 46
  Reflections on Methods ............................................................................................................. 46
  Future Research .......................................................................................................................... 47

References...................................................................................................................................... 49
Acknowledgements

I would like to thank a number of people who made this project possible. My advisor, Dr. Jennifer Kahn, provided invaluable support and feedback – from when it began as an independent research project my sophomore year, to its end as a senior honors thesis. I would also like to thank my committee members Dr. Martin Gallivan and Dr. Greg Hancock for giving their input and time to this project.

Members of the Coastal Hydrodynamics and Sediment Dynamics lab at the Virginia Institute of Marine Science – Dr. Carl Friedrichs, Dr. Grace Massey, Kelsey Fall, Danielle Tarpley, and Jessica Turner – were incredible resources as I completed grain-size, organic content, and pH analyses. I also want to extend my thanks the Charles Center, who provided funding for this project through a summer research grant which allowed me to perform the bulk of my data collection during the summer of 2015.

I would also like to thank Maya Loehr, Lauren Donahue, and Lydia Brown for listening to me talk about soil for the past two years.

Finally, I would like to thank my family for their love and support and for encouraging me to pursue my passions.
Introduction

The volcanic islands of Maupiti and Mo‘orea are located in the Society Island archipelago of French Polynesia in the South Pacific. The Society Islands are within the ‘Polynesian triangle’ defined with corners at New Zealand, Hawai‘i, and Rapa Nui. The archipelago has a shallow chronology, with first settlement c. 900-1000 AD (Atholl and Sinoto 2002; Lepofsky and Kahn 2011; Wilmshurst et al. 2011). Maupiti is part of the western Leeward group of islands. The island itself is relatively small, and fringed by coral motus (islets). The island’s size is a function of its age. Having emerged around 4 million years ago, Maupiti is the oldest island in the Society Island chain (Guillou et al. 2005). Mo‘orea, one of the younger islands, is part of the eastern Windward group. Mo‘orea emerged much later than Maupiti, around 2 million years ago (Guillou et al. 2005).

Compared to other parts of the world, Maupiti and Mo‘orea have been the source of relatively little archaeological study. Some of the first archaeological surveys in the Society Islands as a whole were conducted by Kenneth Emory in 1933. These excavations focused on monumental architecture, cataloguing marae (temples) and other structures throughout the archipelago (Emory 1933). Emory also laid out a relative chronology for marae construction throughout Polynesia, drawing conclusions about settlement in the Pacific Islands over time. However, Emory failed to provide absolute dates for his sites. Archaeological research in the Society Islands increased after the 1950s, with works such as Emory and Sinoto’s 1964 survey of a set of burials on Maupiti and Green et al’s 1967 excavations in Mo‘orea’s ‘Opunohu Valley. These later studies utilized modern techniques of stratigraphic excavation and radiocarbon dating. The most recent studies on the islands of Maupiti and Mo‘orea have focused less on monumental architecture, and instead have explored themes such as household archaeology,
agriculture, and human-induced environmental change (Kahn et al 2015; Kahn et al 2015b; Kahn et al 2014; Lepofsky and Kahn 2011; Kahn and Coil 2006; Lepofsky et al 1996). A burgeoning subfield of archaeology in the Pacific Islands, as well as in other regions, is geoarchaeology.

Geoarchaeology combines archaeology and the geosciences, and includes the study of topics such as micromorphology, petrology, geomorphology, and sedimentology in an archaeological context. The research produced within this subfield is varied, and ranges from x-ray fluorescence (XRF) analysis of stone tools to determine trade patterns, to micromorphological analysis of soil to look at agricultural features. In addition, geoarchaeological data is one of many proxies that can be used to reconstruct past landscapes in the archaeological record. Looking at changes in sediment composition and deposition patterns over time can provide evidence for human-induced changes in the landscape. By exploring the geoarchaeological record, archaeologists can uncover evidence for activities like forest clearance and agricultural intensification.

In this study, I utilize geoarchaeological methods to analyze 55 soil samples collected from excavations on Maupiti and Mo’orea in 2012 and 2014. Each sample was analyzed for grain size distribution, organic content, pH, and composition. In the following chapters, I explore the impact of human actions on the Society Island environment, and attempt to determine the ecological resilience of these islands over the sequence of human occupation. Using geoarchaeological data as a proxy, I hope to answer the following questions:

1. Have humans (anthropogenic factors) or climate (natural factors) influenced the depositional processes at these sites? If so, through what means?
2. Did the occupants of these sites (Tahitians) alter their behavior to modify their impact on island environments? How does this correlate to modern concepts of resilience?

3. Maupiti and Mo‘orea differ in their ages and in their range of resources. Do the human-induced impacts vary as well? To what social or natural or processes might this variation be connected?

This study is guided by theoretical frameworks provided through modern studies of Polynesian archaeology. Kirch (1997) identifies four major “themes” in the study of Polynesian archaeology as: the anthropogenic impacts on island ecosystems, environmental evidence for human colonization, environmental change and human society, and the relative resilience or fragility of island ecosystems (Kirch 1997). Two themes, anthropogenic impacts on island ecosystems and the resilience of island ecosystems, form key parts of this study.

When European naturalists first encountered the Pacific Islands, they saw a group of people who, from their perspective, appeared to be in harmony with nature – an existence with little impact on their environment (Lepofsky et al. 1996). For many years the concept of the “dominance of a culture over nature” was thought to be restricted to Western civilizations (Kirch 2005). To European explorers, the Pacific islands seemed like a “Garden of Eden” whose occupants had to do very little work on the land in order to survive (Kirch 1997). This idea of a “noble savage,” a primitive person in harmony with one’s environment, was propagated for decades. However, with the rise of fields like environmental archaeology, the extent to which humans have had an impact on their environment in the past has become apparent (Kirch 2005).

Today, as subfields of archaeology such as geoarchaeology gain in prominence, and techniques of scientific analysis become more advanced, it is easier to observe human impacts in
the archaeological record. One oft-cited example of these impacts in the Pacific Islands are decreases in faunal diversity around the same time as humans formed the first settlement of islands or archipelagoes. These changes have been observed particularly among birds (Anderson 2010, Boyer 2008, Field and Graves 2015, Steadman 1995, Steadman and Kirch 1990). In studying the Pacific Islands, the “noble savage” myth must be considered because of the extent to which it has informed archaeological and anthropological perspectives. Geoarchaeological data allow us to track land management strategies in the Society Islands and how they changed through time, permitting an active or agent-based approach to human-landscape interactions.

Understanding environmental impacts by humans is an important aspect of this study, as is the framework of ecological resilience.

Ecological resilience is a core concept in the natural sciences, particularly in the field of environmental science. Recently, this topic has been applied to archaeology as well (Redman 2005; van der Leeuw and Redman 2002). Resilience theory examines an ecosystem’s ability to recover after environmental impacts. Because this theoretical framework particularly concerns change in “systems that are adaptive” it is especially relevant to small island ecosystems such as Maupiti and Mo’orea (Redman 2005). Ecological resilience as a concept has been utilized in archaeology studies before, such as in Kirch’s 1997 case study of Tikopia and Mangaia. Mangaia, the geologically older island, was unable to recover from human-induced deforestation, because without the forests there was not enough phosphorous cycling through the old, stripped soils. Extrapolating from this study, one might expect that Maupiti, which is twice as old as Mo’orea, is the less resilient of the two. My analyses of the geoarchaeological record will provide information about island resilience over a thousand-year sequence.
In what follows, I first examine the concept of ecological resilience and its applications for archaeology in the Pacific. I also outline the cultural and geologic context in which Maupiti and Mo’orea lie, then describe the methods and sampling procedures utilized in this study. In the main data chapter I describe the sediments and composition across the sites and islands and noticeable trends over time and between layers. Finally, I end with a discussion of site formation processes and how these relate to my larger research questions.

Resilience and Pacific Archaeology

Many fields examine questions surrounding human-environmental interactions, archaeology included. Fisher et al (2009) suggest the importance of using a common framework for examining these interactions: the concept of ecological resilience. Ecological resilience explains the dynamic changes that can occur in “adaptive” systems, like the ecosystems of Maupiti and Mo’orea (Gunderson et al 2010). The concept of ecological resilience allows for ecosystems and human impacts to be studied holistically, by recognizing that the relationship is not linear or purely deterministic. Large “disturbances” can cause an ecosystem to shift, but these shifts are cyclical, modeled by the “adaptive cycle” (Gunderson et al 2010). There are four stages in this adaptive cycle: exploitation, conservation, release, and reorganization (Gunderson et al 2010). Ecosystems move through these stages, but they do not move at a designated pace, nor do they necessarily move through all stages. Some ecosystems experience only a few, while some have multiple cycles of multiple stages occurring on top of one another across time and space (Redman 2005).

Redman (2005) argues that archaeologists can provide substantial contributions to the field of ecological resilience. Social data, such as evidence of material culture or religious activities, is particularly important to understanding ecological resilience, because human
activities can change the resilience of a landscape. In a 2009 study, Redman et al examine the “socioecological landscape” in terms of water management among the Hohokam in the southwestern United States. Examining environmental data and archaeological data, the study shows that a major transition period in Hohokam history (from the “pre-Classic” to the “Classic” periods) coincides with a less resilient landscape. In the Classic period, stream flow was highly variable, and areas were prone to droughts and flash flooding. This variation strained the irrigation systems and decreased available living space, leading to a decreased population in areas that were far from rivers. However, a period of social reorganization during the Classic period allowed the Hohokam to retain sustainable populations despite their changing environment.

Ecological resilience has applications in the Pacific Island region as well. Ecological resilience provides a framework to examine human-environmental interactions holistically, rather than through an environmental determinist lens. Resilience theory recognizes that these interactions are recursive – while the environment can change how a society develops, humans also change their environment to suit their society (Fisher et al 2009). Recognizing the intricate nature of ecosystem change is key to developing an agent-based approach to understanding human-landscape interactions. In particular, the theoretical framework of ecological resilience is key to dismantling the binary conception of early civilizations as either landscape managers or agents of landscape degradation (Lepofsky and Kahn 2011). This framework also allows for a conception of the environment as more than a passive backdrop.

A notable study which incorporated principles of ecological resilience in the Pacific Islands was Kirch’s (1997) publication on the islands of Tikopia and Mangaia. Mangaia is located in the Cook Islands, west of the Society Islands archipelago. Tikopia is a “Polynesian
Peck 7

outlier,” located outside the Polynesian triangle but still culturally Polynesian. Analyzing the sedimentological, palynological, and geochemical record, Kirch made conclusions about the islands’ relative resilience. On Mangaia, Kirch recorded a period of deforestation (confirmed by the pollen record) and a subsequent decrease in soil phosphorous nutrient levels (Kirch 1997). Because of the age of the island, phosphorous was a major limiting factor. Without the forests, phosphorous could not be cycled back into the soil naturally. As a result, cultivation was limited to only a few areas. Kirch links the struggle for resources on Mangaia with periods of warfare (Kirch 1997). Tikopia, on the other hand, is geologically younger than Mangaia, and the island’s ecosystem exhibited resilience to changes brought on by human activity. Tikopia was able to support a large population (for its size) without the period of warfare recorded on Mangaia. Notably, the study does not conclude that the success of Tikopia was entirely determined by the island’s age. Similarly to the Hohokam example, while ecosystem resilience played an important role, changing land management practices by Tikopians allowed for a more sustainable island system.

The concept of ecological resilience is important to consider in this study because of the relative ages and varying resources of the islands of Maupiti and Mo’orea. However, ecological resilience also suggests that, in such studies, it is necessary not only to look at how resource availability shaped social practices, but how social practices shaped resource use.

Geologic and Cultural Context
Geology of the Society Islands
Understanding the geological setting of the archaeological sites from which these samples were collected is vital to making sense of the information the sediments can provide. Several geological studies of the Society Islands have examined the petrology, formation, age,
and the surface sediments of the islands (Blais et al. 2002; Guillou et al. 2005; Rankey et al. 2011).

The Society Islands formed as the Pacific Plate moved northwest across a plume of magma (a hot spot) fed by the mantle. In the conventional model of hot spot island development, a lithospheric plate moves at a steady speed across a single, stationary hot spot. The constant volcanic activity generates a chain of islands that are older in the direction of plate movement and younger in the opposite direction. In the case of the Society Island chain, Maupiti, in the far northwest of the chain, is the oldest island, while the islands to the southeast, such as Tahiti and Mo‘orea, are younger (Guillou 2005). A recent K-Ar dating study by Guillou et al. (2005) has proposed that the plate movement producing these islands might be more complex than originally thought, as the north-south age progression is not completely linear. The Society Islands also appear to exhibit a “geochemical asymmetry” that characterizes other Pacific Island chains including the Samoan, Marquesan, and Hawaiian Islands (Payne et al 2012). Payne et al studied this asymmetry by examining the relative enrichment of isotopes in the lavas of the different islands. Both Maupiti and Mo‘orea belong to the southern (Moua) group of islands which are relatively depleted in isotopes compared to the northern (Roca) group (Payne et al 2012). Mo‘orea, however, has some lavas which have been “contaminated” by the northern lavas, meaning that the island has some mineralogical characteristics of a Roca group island, despite belonging largely to the Moua group (Payne et al 2012).

The Society Islands can be broken into Moua and Roca groups, but there is an east/west division as well. Maupiti belongs to the Leeward Island group, while Mo‘orea belongs to the Windward Island group. The Leeward Islands are the group of islands located in the eastern half of the archipelago, while the Windward Islands are the group in the west. The prevailing winds
blow from east to west in the Pacific and hit the islands of the Windward group first. When wet air hits the Windward Islands, it rises, cools, and condenses, creating precipitation. The now dry air continues to the Leeward Islands which are in the “rain shadow” of the Windward group. This process means that Maupiti has much less precipitation than Mo‘orea, which has potential consequences for pre-contact subsistence systems and agricultural intensification.

Like many other Pacific Islands, the Society Islands are composed of mafic igneous rocks. The Society Islands are located on the Pacific side of the andesite line, a roughly circular boundary that can be drawn along the edge of the Pacific Plate. Basalts, and other rocks typical of the oceanic crust, compose the islands found within the Pacific Basin, while “continental” rocks such as the felsic, volcanic rock andesite dominate outside of the line. The andesite line encompasses most of Polynesia, with the exception of New Zealand.

Alkaline flows dominate on both Maupiti and Mo‘orea. Maupiti is primarily composed of basaltic flows, with some hawaiitic flows in the high parts of the island (Blais et al 2002). Several dikes cross the island: mugearitic in the Haranai valley and benmoreitic on the volcano Paharae (Blais et al 2002). A large gabbroic intrusion can be found near the center of the island (Blais et al 2002). In addition to the alkaline basalt and other flows that are found on Maupiti, trachyite and phonolitic trachytes (a feldspathoid-rich variety of trachyite) make up the rocks of Mo‘orea.

The topography of the Society Islands also reflects their differing ages. Hot spot island chains are characterized by certain evolutionary trends. Although the specific timeline of the evolution for each island differs depending on environmental conditions such as the speed of plate movement, in general hot-spot systems follow a set of stages, as described by Ramalho et al (2013). In the first stage a seamount, or a submarine mountain, forms. During the second stage,
the island slowly emerges from the water and eventually becomes subaerial. During the third stage, lavas build laterally atop one another to construct the volcanic shield. Once volcanism stops, the shield is “capped” and the fifth, erosional stage begins. During the erosional stage, geomorphic processes such as erosion and mass wasting, rather than volcanic processes, shape the island. Over time the island’s size decreases substantially while fringing reefs can grow in size. Although the island can continue to emerge as a result of rebound (the uplift of the crust as the load placed by the island is decreased through erosion), eventually the subaerial island will disappear, and an atoll will remain. In the final stage, the atoll sinks entirely, becoming a guyot (drowned island). Mo‘orea, the younger of the two islands, is in its erosional stage. The island is still relatively large, but it is not volcanically active. The island has experienced significant erosion, as evidenced by valleys such as ‘Opunohu and Paopao. Maupiti, on the other hand, is much farther along in its life and can almost be considered an atoll. The island is much smaller, and the surrounding coral motus are part of the large fringing reef.

Understanding the geology of Maupiti and Mo‘orea is important for examining their relative ecological resilience. While both the islands have fundamentally similar geologic histories–hot spot islands of alkaline composition–there are differences in the type and variety of rock found on the islands. While the specific mineralogical compositions of these two islands are different, one of the most important ways in which these two islands vary is in age. As discussed, Maupiti is the oldest of the Society Islands while Mo‘orea is relatively young. Maupiti is therefore smaller, and the island’s size provides a limiting factor for the agricultural productivity of the islands. One of the other important characteristics determined by the islands’ geologic histories is the relative precipitation. As one of the Leeward Islands, Mo‘orea receives more precipitation than Maupiti, providing yet another limiting factor.
Culture of the Society Islands
The Society Islands were first settled c. 900-1000 AD (Atholl and Sinoto 2002; Lepofsky and Kahn 2011; Wilmshurst et al. 2011). The settlement of these islands is part of the larger history of the settlement of Polynesia.

An ancestral people known as the Lapita, named for the type site on New Caledonia, settled the islands of Polynesia (as well as Melanesia and Micronesia) (Kirch 2000). The Lapita people are the descendants of Papuan-speaking people who lived on the ancient continent of Sahul – modern day Australia, New Guinea, and Tasmania – and inter-married with a group of Austronesian people who originated in Southeast Asia (Kirch 2000). Distinctive stamped pottery dates some of the earliest Lapita sites to around 1500-1400 BCE. The earliest evidence of voyaging comes from around 1200 BCE.

Lapita voyaging was purposeful, as evidenced by historical linguistic and archaeological data. Proto-Austronesian language reconstruction reveals that the Lapita had words for complex seafaring terms, including for outrigger canoes and sails (Kirch 2000). Archaeological evidence from Lapita sites shows that there were successive waves of settlers who created permanent settlements on an island and then, after generations, would move onto the next one – rather than using temporary “island-hopping” camps (Allen and White 1989; Kirch 2000). Peter Bellwood (1996) hypothesizes that one of the driving factors of the Polynesian was the culture’s “founder-focused ideology.” Using language reconstruction, Bellwood argues that kin-group founders were important in proto-Austronesian society, and that they and their direct descendants enjoyed special benefits. Settling a remote island offered the opportunity to be a kin-group founder, and the privileges of that rank may have been a significant pull factor for settling the islands of Polynesia.
The settlement of the islands of western Polynesia occurred between 1100 and 800 BCE (Kirch 2000, Wilmshurt et al 2010). A 1,800 year “pause” followed the colonization of western Polynesia, after which the islands of central east Polynesia, including the Society Islands, were settled c. 1000 AD. A subsequent period of “rapid and extensive dispersal” to the more remote islands of eastern Polynesia, including Hawai‘i and Rapa Nui, followed (Wilmshurt et al 2010).

Extrapolating from more recent population data, anthropologists speculate that the Society Islands were likely densely populated before European contact. Kirch and Yen (1982) calculated that, in 1976, the western Polynesian-outlier island of Tikopia was capable of supporting a population density of 242 people per km². Kirch (2000) defines this as the upper limit of Polynesian island population density, and estimates that Polynesian subsistence agriculture could support between 100 and 242 people per km². Population estimates by voyagers and missionaries at the time of European contact vary in the Society Islands, with estimates of Tahiti’s population ranging from 10,000 to 200,000 (Hamilton and Kahn 2007). Mo‘orea, not as widely visited, was estimated in 1778 by J.R. Forster to have a population of around 20,000 at the time of contact (Hamilton and Kahn 2007). Using a house-counting method in Mo‘orea’s ‘Opunohu Valley, Hamilton and Kahn (2007) estimate a minimum population for the island as 6,190, while an estimate based on the island’s ecological carrying capacity puts the population at 29,218.

The societies of East Polynesia have been used by anthropologists to study the development of social stratification and chiefdoms. Neo-evolutionary thought gained popularity in the anthropology of the 1940s and 50s, and Polynesia was used as a case study for the development of complex societies. Leslie White was one of the early proponents of neo-evolutionism and was influenced by early anthropologists Lewis Henry Morgan and E.B. Tylor.
White argued that culture is result of humans trying to “make a more effective instrument” for “security of life and survival of species” (White 1943). A single human only has a certain amount of energy they can expend, and in order to provide for one’s survival, they must innovate to make that energy expenditure more efficient (White 1943). Cultures advance through stages, from “savagery” to “barbarism” to “civilization,” and cultures at the lowest level (savagery) do not have enough energy to develop the complexity that cultures at later stages exhibit (White 1943). This evolutionary approach is found in the work of Irving Goldman and Marshall Sahlins, who expanded on White’s neo-evolutionary work and applied it to the study of Polynesian culture. Although neo-evolutionary thought does not inform anthropological thought today as it did at the time of Leslie White, work by Sahlins, Goldman, and others provide an important framework through which to view the Society Islands.

Irving Goldman (1958) uses an evolutionary approach in his work in Polynesia, sorting islands into a sequence from traditional, to open, to stratified. “Status rivalry” drives changes in lineage and eventually “evolution” to a more advanced society. In Ancient Polynesian Society (1970) Goldman expands on the evolution of Polynesian societies. He argues that the status system is not the primary cause of evolution within these societies, but rather the status system responds to other changes in the society (such as warfare). As the status system shifts, society as a whole “evolves.” Goldman defines the Society Islands as belonging to a “stratified society,” which he specifies as distinct from the “traditional” societies of Samoa or the “open” societies of Easter Island or the Marquesas (1958).

Like Goldman, Marshall Sahlins (1958) saw stratification as an indication of the “level” of a society. “Primitive” societies, at the “lowest levels” of culture are relatively unstratified, even egalitarian, with rank determined by “universals” such as age or gender. In more advanced
societies, stratification becomes more pronounced, and is determined by other mechanisms. Sahlins distinguishes Polynesian societies depending on the degree to which there is status differentiation in the society (“structural criteria”) and the degree to which rank in a society confers privilege on a high-ranking member (“functional criteria”). In particular, Sahlins gives primacy to the economic privileges of rank – control over production, distribution, and consumption of resources. Because these economic privileges are so important, Sahlins argues that technological innovations and adaptations to the environment by food producers correlate to stratification in these different island societies. While Goldman uses a classification scheme of open, stratified, and complex, Sahlins identifies four major groups of islands which fall on a continuum from most stratified (Group I) to least stratified (Group III). Like Goldman, Sahlins identifies the Society Islands as belonging to the most stratified group, Group I. Using ethnographic evidence and historical accounts, Sahlins lays out the social hierarchy of the Society Islands, defining three major groups – the *ariʻi* (chiefs), the *raʻatira* (subchiefs), and the *manahune* (commoners). The chiefs controlled production, while the subchiefs acted as intermediaries between the chiefs and the source of labor, the manahune.

Many anthropological studies in the Society Islands focus on the archipelago as a whole, or on Tahiti. However, Edward Handy’s *History and Culture in the Society Islands* (1930) describes both Moʻorea and Maupiti and the other islands in the group. At the time of contact both Moʻorea and Maupiti were split up into districts. Moʻorea has eight districts with four “above” (in the north) and four “below” (in the south). This division may have been pre-dated by an organizational system which split the island in half—one northern half and one southern half. Maupiti was similarly divided, but into nine districts. Each district was controlled by a ramage, a unique kinship feature first described by Raymond Firth in *We, the Tikopia* (1936). A ramage,
also called a conical clan, is a descent group that is distinct from a typical clan in several key ways (Sahlins 1958). A ramage is a non-exogamous group of people descending from a common ancestor, but members of the ramage are ranked by how closely they are related to the ramage founder—exemplified as well in the founder-based ideology that Bellwood describes (Bellwood 1996; Sahlins 1958). The districts are arranged radially around the island so that each ramage can draw from both inland and coastal resources (Kirch 1984).

Pre-contact agricultural activity in the Society Islands included cultivation of Polynesian introductions—the species brought to the islands by voyagers, both purposefully and accidentally. Common plant introductions include taro, coconut, banana, and breadfruit. On Mo’orea, analysis of pollen and phytoliths in the ‘Opunohu Valley showed evidence for cultivation of banana, paper mulberry, bottle gourd, sweet potato, breadfruit, and yam (Kahn et al 2014). Lepofsky (1994) identified six different kinds of cultivation in the Society Islands: house gardens, nursery gardens, ornamental gardens, arboriculture plantations, short-fallow swiddens, and wetland agriculture. For this study, the short-fallow swiddens are particularly important because of their effect on the depositional record.

Swidden, also called slash-and-burn, refers to a type of agriculture in which large areas of land are cleared by cutting down trees and burning the remaining stumps/roots. This practice clears land quickly and releases nutrients bound in plants and deposits them into the soil, fertilizing it. Short-fallow, in this case, refers to a system in which the “fallow” periods (where no planting occurs) are relatively short—from a few months to fifteen years (Lepofsky 1994). The shorter the fallow period, the less resilient this practice becomes, because erosion will remove the thin nutrient-rich ash layer. Removal of rooted plants during swidden agriculture decreases
the cohesion of the soil allowing mass wasting to send large quantities of sediment to areas downslope.

Because Maupiti has significantly less rainfall than Mo‘orea, the island cannot support wetland agriculture (Cauchois 2002). Ethnoarchaeological research by Cauchois (2002) has recorded the suite of traditional plants cultivated on the island today, including taro, yam, banana, and sweet potato. The ‘ape is part of this assemblage as well, but is rarely eaten today. Historic introductions include tarua and manioc. Although today slash and burn agriculture is rarely practiced, the archaeological record shows evidence of the practice utilized in the past (Cauchois 2002; Kahn et al 2015). On the other hand, due to its higher rainfall, Mo‘orea can support wetland agriculture. Wetland agriculture practices like irrigation are more resilient than swidden agriculture because the stepped terraces that are utilized prevent the erosion associated with swidden-fallow systems.

Methods

55 samples were analyzed from the Society Islands, including samples from two sites (MAU-5 and MAU-11) on Maupiti and one site (SCMO-350) on Mo‘orea. These samples were collected during 2012 and 2014 field excavations by Dr. Jennifer Kahn and her team (Fig. 1).
<table>
<thead>
<tr>
<th>Island</th>
<th>Site</th>
<th>Coast</th>
<th>Site Type</th>
<th>Unit</th>
<th>Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maupiti</td>
<td>MAU-5</td>
<td>South</td>
<td>Residential</td>
<td>TP-1</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>MAU-5</td>
<td>South</td>
<td>Residential</td>
<td>N100 E100</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>MAU-5</td>
<td>South</td>
<td>Residential</td>
<td>N105 E98.5</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>MAU-11</td>
<td>South</td>
<td>Elite Residence/Temple</td>
<td>TP-1</td>
<td>3</td>
</tr>
<tr>
<td>Mo’orea</td>
<td>SCMO-350</td>
<td>East</td>
<td>Residence</td>
<td>TP-1</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>SCMO-350</td>
<td>East</td>
<td>Residence</td>
<td>N95 E113</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>SCMO-350</td>
<td>East</td>
<td>Residence</td>
<td>N95 E112</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>SCMO-350</td>
<td>East</td>
<td>Residence</td>
<td>N99 E112</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>SCMO-350</td>
<td>East</td>
<td>Residence</td>
<td>N99.5 E114</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>SCMO-350</td>
<td>East</td>
<td>Residence</td>
<td>N101 E113</td>
<td>6</td>
</tr>
</tbody>
</table>

Fig. 1 Soil samples analyzed from Maupiti and Mo’orea

<table>
<thead>
<tr>
<th>Island</th>
<th>Site</th>
<th>Beta-#</th>
<th>Material Dated</th>
<th>Provenience</th>
<th>Calibrated Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maupiti</td>
<td>MAU-5</td>
<td>333859</td>
<td><em>Cocos nucifera</em> nutshell</td>
<td>TP1, Layer III Cultural deposit</td>
<td>AD 1470-1640 (95.4%)</td>
</tr>
<tr>
<td></td>
<td>MAU-5</td>
<td>333860</td>
<td><em>Aleurites moluccana</em> nutshell</td>
<td>TP1, Layer III Cultural deposit</td>
<td>AD 1646-1690 (25.5%) AD 1729-1810 (51.6%) AD 1925-1954 (18.2%)</td>
</tr>
<tr>
<td></td>
<td>MAU-5</td>
<td>333861</td>
<td><em>Pandanus</em> key</td>
<td>TP1, Layer IV Pre-Polynesian deposit</td>
<td>49 BC – AD 74 (95.4%)</td>
</tr>
<tr>
<td></td>
<td>MAU-11</td>
<td>391798</td>
<td>Charred <em>Cocos nucifera</em> endocarp</td>
<td>TP1, A6</td>
<td>AD 1500-1595 AD 1610-1655</td>
</tr>
<tr>
<td></td>
<td>MAU-11</td>
<td>395443</td>
<td>Charred <em>Aleurites moluccana</em> endocarp</td>
<td>TP1, A8</td>
<td>AD 1495-1650</td>
</tr>
<tr>
<td></td>
<td>MAU-11</td>
<td>391799</td>
<td><em>Cocos nucifera</em> endocarp</td>
<td>TP1, B3</td>
<td>Modern</td>
</tr>
<tr>
<td></td>
<td>MAU-11</td>
<td>395449</td>
<td>Charred <em>Aleurites moluccana</em> endocarp</td>
<td>TP1, B7</td>
<td>AD 1455-1630</td>
</tr>
<tr>
<td></td>
<td>MAU-11</td>
<td>395450</td>
<td>Charred <em>Cocos nucifera</em> endocarp</td>
<td>TP1, B10</td>
<td>AD 1290-1400</td>
</tr>
</tbody>
</table>

Fig. 2 Radiocarbon dates for MAU-5, MAU-11, and SCMO-350 (Kahn et al 2014; Kahn et al 2015)
Site MAU-11 is located on the south coast of Maupiti (Fig. 3). The site has been interpreted as an elite habitation site that was transformed into a temple site or a site with a ritual function (Kahn et al. 2015). Radiocarbon dates (Fig. 2) show that the site was occupied from the 13th century to the 19th century with three distinct occupation layers (Kahn et al. 2015). The transformation to temple site is likely to have occurred around the 16th century (Kahn 2014). Excavations revealed a high concentration of faunal remains, primarily pig and dog, probably from offerings and feasts at the temple (Kahn et al. 2015). Three samples were recovered from the bottom of TP1 at MAU-11.

MAU-5 is also located on the south side of the island, west of MAU-11 (Fig. 3). Both sites are located in the same catchment area (Fig. 4). The site likely had residential function, perhaps of low to moderate status (Kahn et al. 2014). In contrast to the terrestrial faunal remains found at the elite MAU-11 site, MAU-5 had a high concentration of marine food sources, particularly fish (Kahn 2014). The site dates to the mid 15th – 17th centuries AD (Kahn 2014). The 29 samples from MAU-5 come from three units. The majority (22) of the samples are from the 2012 excavation and come from a TP1 column of sediment, with samples collected every 10 cm. The last samples come from two units excavated in 2014, and represent a short column of samples from unit N105 E98.5 and two samples of distinctive peaty layers from unit N100 E100.
Fig. 3 MAU-5 and MAU-11 (adapted from Fig. 1 Kahn et al 2015)
Fig. 4: MAU-5 and MAU-11 are located on the southeast coast (indicated by the arrow) of Maupiti within the same inland valley system (Image via WelcomeTahiti)

22 samples come from Mo‘orea and were recovered from site SCMO-350. SCMO-350 is located in Haumi Bay on the eastern coast of Mo‘orea (Kahn 2014). Excavations in 2014 revealed that the site has a residential function and has been occupied for 800 years, beginning in the 13th century (Kahn 2014). The samples were taken from five different units. In two cases (units N95 E112 and N99 E112) only one sample was taken. In unit N99.5 E114, eight samples were collected, representing all of the observed archaeological strata. The samples collected from N101 E113 also represent all the observed strata.
The samples were analyzed for grain size distribution, organic content, pH, and composition. Grain size distribution was determined using a wet sieving and pipetting procedure developed by the Coastal Hydrodynamics and Sediment Dynamics (CHSD) lab at the Virginia Institute of Marine Science. Certain aspects of the procedure were modified to fit the samples for this project. The procedure has two parts: determination of grain size, and determination of organic content.

In order to determine grain size, 10 g of sample were weighed out. A 10% Calgon (sodium metaphosphate and sodium bicarbonate) solution was added to the samples, in addition to deionized water. Before placing the beakers in a sonicator bath for an hour, the samples were left to soak in this solution overnight. The Calgon, soaking, and time in the bath breaks down aggregated clumps of sediment, creating a homogenized sample that can be more easily sieved.
Because many of the Society Island samples were high in clay and silt, they required this extra treatment.

After preparation, the samples were sieved through two screens: a 1mm (0 φ) screen and a 63μm screen. The CHSD procedure uses an 850μm and 63μm screen. However, in order to isolate a portion of very coarse sand for preparing point counting slides, the 850μm screen was replaced with a 1mm screen. Grains caught on these screens were placed into pre-weighed glass beakers and left in an oven to dry overnight. The grains smaller than 63μm moved through the screens and then into a porcelain bowl, and were then poured off into a 1000 mL beaker. This process separated the sand (∋ 63μm on the Wentworth scale) from the silt (4-8φ) and clay (smaller than 8φ).

In order to calculate the percentages of silt and clay, the 1000 mL beaker containing the mud from the sieving was stirred vigorously for 20 seconds to suspend the particles. A 20 mL sample of the solution was taken at a depth of 20 cm and placed in a pre-weighed aluminum tray. Based on the temperature and a settling time equation developed at VIMS, the solution was left to settle for a length of time (around two hours) and a second sample was taken at 10 cm. All samples were dried overnight.

Once dry, the samples were left to cool in a desiccator and were then weighed. The samples were then placed back in the oven for an hour and weighed again. This process was repeated until the weights were within 0.0005 g of each other. With the average of the two weights, the total dry solids (TDS) for each sample was calculated. This value is the total number of inorganic and organic material in the sample. Additionally, using the settling time equation, the amount of silt and clay was calculated by subtracting the weight of the 20 mL pipette sample
taken from a depth of 10 cm after settling (8φ) from the weight of the 20 mL pipette sample taken at 20 cm before settling (total 4 φ + 8 φ).

A loss on ignition test was used to determine organic content. In order to perform this test, the samples were placed in a 550°C muffle furnace for 15 minutes. Before the test was performed, an aluminum tray containing a test sample of excess >1mm material was burned in the muffler to ensure that material such as shell was not altered during the test (because this would affect the point counting results). Once cooled, these samples were weighed using the same procedure described above. These results are the total fixed dry solids (TFDS), the amount of inorganic material in the sample. Dividing the weight of each portion by the total weight of the sample gives the percentage of each size category. Subtracting the TFDS from the TDS resulted in the total volatile dry solids, (TVDS) or the portion of the sample which was organic material.

In addition to grain size and organic material, pH and composition were determined. pH was calculated using a Beckmann φ200 series pH meter with a Futura gel-filled 3 in 1 electrode. As the pH testing occurred over several days, the meter was first calibrated using 4.0, 7.0, and 10.0 buffer solutions (commercially available solutions manufactured to be precisely a given pH). The electrode was then cleaned with a potassium chloride solution and rinsed in deionized water. In order to test the pH of the dry samples, 20g of sediment was mixed with deionized water and the probe was inserted into this solution. Because deionized water has no pH, the probe read the pH of the sample itself. Due to the amount of sediment needed to perform the pH test, some samples were not tested due to inadequate sample size.

Point counting was the last test performed. The >1mm portion of the sample was affixed to a regular microscope slide and the slides were examined under an overhead-lit binocular
microscope. The goal was to count 100 grains for each slide, however some samples with a smaller coarse sand portion had slides with too few grains for this number to be reached. In these cases, all the grains were counted and the total number of points was noted as well.

Based on Kirch and Hunt’s 1993 study, volcanic lithics, calcareous sediment (shells with rounded edges that are part of the deposited sediment), and micro-artifactual/faunal materials were counted. Micro-artifactual/faunal materials include charcoal, marine shell, bone, sea urchin, small flakes, and terrestrial gastropod.

Results
The results of the grain-size, organic content, pH, and point counting analysis are summarized below for each unit at each site. I then offer up a synthesis for each site.

Mo’orea

SCMO-350

Samples were analyzed from six units at SCMO-350. Three units, TP-1, N99.5 E114, and N101 E113 had samples taken at regular intervals, producing “columns” of sediment. Three units, N95 E112, N95 E113, and N99 E112 did not have samples collected in columns. Instead, only some of the major stratigraphic units identified during excavation were sampled. The results of these latter tests are included here for purposes of comparison.

TP-1 (Fig. 6)

TP-1 is a comparatively shallow test unit, excavated to a depth of 60 cm below the surface. Samples were taken from the upper and lower sections of A and B. Grain-size analysis showed that proportions of medium to coarse sand, silt, and clay did not change significantly over the course of the layers, but the proportion of very coarse sand decreased as depth increased. pH tests were only conducted on the sample from lower A; the test revealed that the
soil is basic. Organic content varied only by 1% with depth. The lithology of the samples was largely calcareous, and the proportion of volcanic lithics increased as depth increased.

Figure 6: TP-1 Grain Size Distribution and Lithology with depth
This unit was excavated to sterile soil at 90 cm below the surface. The B layer of this unit includes a “storm surge” with mixed cultural deposits identified during excavation. Samples were taken from the upper and lower parts of A, the upper and lower parts of B, and C (sterile). Deposits from the storm surge were not tested. The deposits from this unit are completely calcareous. The pH is basic with almost no variation throughout the column. The organic content varies more between layers here than in the other units, from 7-16%, however the content does not change regularly over depth. The grain size remains even throughout, with lower A and lower B showing a spike in the smaller size classes (clay and silt).
Figure 7: N99.5 E114
This unit was excavated to 90 cm below the surface. Samples were taken from each archaeological layer. The base of A2 was identified during excavation as a potential prepared floor. The storm surge observed in the previous unit was also found in the B layers of this unit. The lithology of this unit's layers is primarily calcareous and the grain size distribution remains even throughout. The prepared floor layer shows an increase in clay. The sterile subsoil (layer C)
Peck 29

has very little silt and clay compared to the cultural layers. pH remained basic with little variation throughout the profile. The organic content varied between layers by an average of 4%.

Figure 8: N101 E113 Grain size distribution and lithology
These units had between one and three samples each taken and tested. The organic content, pH, and lithology data is presented in tables rather than graphically. All have a calcareous lithology. The pH is basic for all, although the sample from a peaty B layer in N99 E112 is closer to neutral. The grain size data is presented graphically, and shows a similar distribution of sediments between the units.

Figure 8.1: N101 E113 organic content and pH

_N95 E112, N95 E113, N99 E112_ (Fig. 9, 10, 11, 12)
### Figure 9: N95 E112, N95 E113, and N99 E112 Lithology

<table>
<thead>
<tr>
<th>Unit</th>
<th>Depth</th>
<th>% Calcareous</th>
<th>% Volcanic</th>
</tr>
</thead>
<tbody>
<tr>
<td>N95 E112</td>
<td>B7</td>
<td>96.875</td>
<td>3.125</td>
</tr>
<tr>
<td>N95 E113</td>
<td></td>
<td>98.93617021</td>
<td>1.063829787</td>
</tr>
<tr>
<td>N95 E113</td>
<td>B Intrusion</td>
<td>91.39784946</td>
<td>8.602150538</td>
</tr>
<tr>
<td>N99 E112</td>
<td>Peaty B</td>
<td>92.85714286</td>
<td>7.142857143</td>
</tr>
</tbody>
</table>

### Figure 10: N95 E112, N95 E113, and N99 E112 organic content

<table>
<thead>
<tr>
<th>Unit</th>
<th>Depth</th>
<th>Organic Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>N95 E112</td>
<td>B1</td>
<td>7.8543</td>
</tr>
<tr>
<td>N95 E113</td>
<td></td>
<td>6.2135</td>
</tr>
<tr>
<td>N95 E113</td>
<td></td>
<td>6.7513</td>
</tr>
<tr>
<td>N95 E113</td>
<td>B Intrusion</td>
<td>6.5884</td>
</tr>
<tr>
<td>N99 E112</td>
<td>Peaty B</td>
<td>7.3548</td>
</tr>
</tbody>
</table>

### Figure 11: N95 E112, N95 E113, and N99 E112 pH

<table>
<thead>
<tr>
<th>Unit</th>
<th>Depth</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>N95 E112</td>
<td>B7</td>
<td>8.09</td>
</tr>
<tr>
<td>N95 E113</td>
<td></td>
<td>8.51</td>
</tr>
<tr>
<td>N95 E113</td>
<td></td>
<td>8.29</td>
</tr>
<tr>
<td>N95 E113</td>
<td>B Intrusion</td>
<td>-</td>
</tr>
<tr>
<td>N99 E112</td>
<td>Peaty B</td>
<td>7.71</td>
</tr>
</tbody>
</table>
Fig 12.1: N95 E112 grain size distribution

Fig 12.2: N95 E113 grain size distribution
Fig 12.3: N99 E112 grain size distribution

Synthesis

Averaging the values from each layer across SCMO-350 generated a set of site-wide averages, allowing a larger scale of analysis than looking at individual units. On average, pH stayed basic and varied only slightly stratigraphically, staying between 8 and 8.5. Organic content is low in layer C but increases in layer B and remains constant within the subsequent layers. The overall lithology is calcareous, although some volcanic lithics are found throughout. Lower A, with 13% volcanic lithics, is the layer with the highest proportion site wide. In terms of grain size, the lowest layers has the highest proportion of sand. In the occupied layers there is an increase in clay and silt, and while the silt remains constant from B upwards, clay decreases. The Mo‘orea samples show evidence of human alteration to the soil, specifically by the introduction of organic matter. Human activity such as food preparation can introduce organic content to soil, and the increasing organic content in the upper layers supports the field interpretation of the lower layers (including layer C) as part of a sterile, pre-occupation layer. These results also support the
interpretation of the bottom of layer A as an artificial “prepared floor,” created by bringing in clay-rich material from elsewhere.

Maupiti
MAU-5

Two units at MAU-5 were sampled in a column: TP-1 and N105 E98.5. Two samples were taken from the unit N100 E100 which were not in a stratigraphic column. Instead, certain deposits were targeted because of unusual characteristics observed during excavation.

TP-1 (Fig 13)

TP-1 was sampled every 10 cm (below the surface), with the exception of the intervals 20-30 cm, 80-90 cm, and 150-160 cm. Unlike the Mo‘orea units, point counting revealed that the lithology of these samples, in particularly the upper layers, is primarily volcanic lithics. Notably, at a depth of 70 cm, 100 cm, and 190 cm the samples shifted to a calcareous lithology. The size of the grains tends to increase towards the bottom of the unit, particularly after 180 cm. Organic content varied gradually down the column, although remained between 5 and 11% organic composition. pH showed a gradual increase down the column from slightly acidic to basic.
Fig 13: MAU-5 TP-1 Grain size distribution and lithology
Fig 13.1: MAU-5 TP-1 organic content and pH
Four unique samples were taken from this unit, in 20 cm intervals beginning at 100 cm below datum. Like TP-1, the lithology of this unit is primarily volcanic lithics with little variation as depth increases. The bottom-most layer has more calcareous sediment than any of the others (10%, compared to <5%), meaning this layer is likely the remnants of the natural, pre-occupation beach. The organic content also remains very similar over the course of the 60 cm, varying only by 2%. pH was near neutral or slightly basic. The grain size distribution was very similar throughout. Notably, this unit contained larger proportions of silt and clay in the distribution than the other units. The only layer that varies is the bottom layer, which has a higher proportion of sand-sized sediment. These results provide further support for the hypothesis that this layer represents the pre-occupation beach.
Fig 14. MAU-5 N105E98.5 Lithology and Grain size distribution
This unit was excavated to 100 cm below the surface. The lower part of the B layer showed evidence of a high-energy storm deposit during excavation. The lowest layers – C and a “peaty” C were sampled for analysis. Grain size analysis revealed that the peaty layer has a higher proportion of small grains (silt and clay). The peaty layer also had a higher organic content and a lower pH. These layers were primarily composed of volcanic lithics, with some calcareous sediment. The peaty layer had a much lower proportion of calcareous sediment.
Fig 15: MAU-5 N100 E100 Grain Size Distribution and Lithology

Fig 15.1: MAU-5 N100 E100 5 Organic Content and pH
Synthesis

A comparison of site wide averages by archaeological layer is not useful for this site because several averages would only include one data point. Instead they will be qualitatively compared. In all three sites, the grain size distribution is even. Unlike in SCMO-350, where sand-sized grains dominate, at MAU-5 sand, silt, and clay are represented in very close proportions. The overall grain size increases with depth, the proportions of sand to silt and clay increasing towards the bottom of the units. Volcanic lithics dominate the lithology at this site, particularly in the layers above 160 cm. The column of sediment from TP-1 shows that towards the surface, the volcanic lithics gradually decrease and are replaced by calcareous sediment. This column also shows that at two points – at 70 and 100 cm below the surface – calcareous sediment dominates. Site wide pH was basic, and while the smaller units do not show a clear pattern as to how the pH changes with depth, the longer column of sediment shows that the pH increases up the column, and then begins to decrease around 100 cm below the surface. Organic content does not vary widely with depth, although appears to increase from the sterile soil to the occupied layers.

The high proportion of volcanic lithics at this site closer to the surface is evidence of human landscape modification, in particular deposits of alluvium released by agricultural activities on the slopes of the island. The lowest, calcareous layers represent the sterile, pre-Polynesian beach, with sediment deposited by natural processes. The switch to a volcanic lithology in the layers in which humans are present is a result of human activities, namely the intensification of agricultural over time. The layers which show an influx of calcareous sediment (at 70 and 100 cm below the surface) could represent storm surges, in which marine sediment was carried onto to the shore by a tsunami or higher than average surf. This marine sediment
would then have buried the alluvial deposits. Alternatively, these periods of marine sediment could be times when the agricultural sites above the MAU-5 site were abandoned.

**MAU-11**

One unit was sampled from MAU-11.

**TP-1 (Fig 11)**

Unlike the units at MAU-5, the lithology of this unit was primarily calcareous. The organic content remained very similar as depth increased. pH was not performed on these samples because there was limited material. The proportion of clay in the unit generally increased with depth, while the proportion of silt decreased with depth. The overall proportion of sand remained constant, although layer B had a higher proportion of up to 63μm sand.

![Fig 17: MAU-11 TP-1 Grain Size Distribution and Lithology](image-url)
Because only one unit was sampled, the description above represents the most general site-wide sediment description. However, it is interesting to note the differences in sediment composition between MAU-11 and MAU-5. While MAU-5 had a lithology that was primarily volcanic lithics, MAU-11 had a primarily calcareous lithology, despite the fact that the sites are located in the same catchment and would likely be influenced by the same geomorphic processes. Additionally, at MAU-5, the proportion of >1mm sand increases after site occupation, but MAU-11 does not show the same increase. As discussed previously, this lithic-dominated coarser sand that is prevalent at MAU-5 is likely alluvium deposited over the site as a result of
agricultural activities occurring on the upper sloped of the island. The dominant calcareous lithology at MAU-11 suggests that the occupants of this site managed their agricultural activities to protect MAU-11 from being buried by alluvium, possibly because of its elite status.

Garnets

In addition to the results discussed above, point-counting of sediments during this investigation revealed rare, small garnets (fig. 12). The presence of garnets in this sediment is unusual, and could be the result of garnet-bearing mantle xenoliths brought to the surface during a post-erosional rejuvenation eruption on the island (Keshav et al 2007). While not recorded in geologic literature on the Society Islands, garnet-bearing xenoliths have been observed on O‘ahu in the Hawaiian Islands (Keshav and Sen 2001). These garnets are a variety called majorite and were transformed from pyroxene in the deep upper mantle (Keshav and Sen 2001).

Fig. 18 Garnet (indicted by arrow) in point counting sample from Maupiti (TP-1)
Conclusion
The results of my geoarchaeological research relate directly back to the research questions I considered at the beginning of this study. These data suggest evidence for human modification of sites and depositional processes, as well as landscape management.

Human Modification of Environment
Agricultural activities practiced by these sites’ occupants modified depositional processes. This modification is particularly apparent at MAU-5. Geoarchaeological analysis showed that the layers occupied by humans were different than the natural, pre-occupation beach. These modifications come in the form of increased organic content and grain size and changing lithology over time. The increased grain size and changing lithology can be connected to swidden agriculture, occurring in the interior of the island during the period of occupation. As discussed previously, swidden agriculture decreases soil cohesion and makes small landslides more likely. Intensification of swidden agriculture over time created the alluvial deposits which cover MAU-5.

Management
In addition to modifying their landscape, the occupants of these sites managed their interactions with their environment. Once again, this management is particularly apparent on Maupiti. MAU-5, a residential site, is impacted by alluvial deposits from the slopes of the island. MAU-11, an elite residence/temple site in the same catchment does not exhibit the same terrestrial deposits. Instead, the deposits at MAU-11 are calcareous, indicating that it was not impacted by the influx of sediment that occurred in its catchment. The residents of Maupiti were aware of the negative effects of swidden agriculture on sites located below agricultural fields, and modified their activities in order to preserve the important site of MAU-11 – Vaiahu Marae, the largest pre-contact temple complex on the island.
Comparative Resilience

I set out not only to examine human-environmental interactions within but across these islands. Mo’orea and Maupiti have different environmental settings, and it stands to reason that the human-induced impacts would vary as well. However, the geoarchaeological data I collected in this study is insufficient to provide a clear answer to this question. The geoarchaeological evidence suggests that impacts on the island of Maupiti were greater than on the island of Mo’orea, because one of the sites on Maupiti was heavily impacted by deforestation-driven sediment deposition. However, the largely calcareous sediment at the sites on Mo’orea is probably due to the placement of the site SCMO-350 relative to the ocean. Mo’orea has a larger beach flat than Maupiti, and so SCMO-350 was placed further from the center of the island (compared to MAU-11 and MAU-5 on Maupiti). There is evidence that swidden agriculture was heavily practiced on parts of Mo’orea, particularly its north shore (Kahn et al 2015). Due to site placement of samples in my study I cannot conclusively say that these agricultural practices had more impacts on the smaller island of Maupiti than on Mo’orea.

What this work does show, as in the case of the relative resilience of Tikopia and Mangaia (Kirch 1997), is that land management strategies on small islands such as Maupiti have an important role in their ecological history. It would be easy to say that, because Maupiti has a smaller beach flat than Mo’orea, sites had to be placed close to the cliffs, leaving them vulnerable to burial – meaning that Maupiti is less resilient. However, the occupants of Maupiti developed resilient practices in order to prevent agriculture from detrimentally impacting one of their most important sites.

Reflections on Methods

In answering the questions of landscape modification, lithology, determined through point counting was most useful for this study. Volcanic vs. calcareous lithology was the clearest
indicator that sediment came from the interior of the island rather than a marine setting. In general, in environmental settings where changes in distribution over time are less subtle, changes in grain size distribution may be easier to relate to cultural processes. Because the other material classes counted (such as micro-artifactual remains) were so small, they did not prove as useful for analysis. Organic content was also an important indicator, providing a proxy for human occupation of the site.

Of all the tests performed, pH analysis provided the least useful information for making interpretations. For all sites on all islands the pH was basic and varied little between layers. Calcareous sediment and faunal remains can raise the pH of soil, and so this measure can provide information about the presence of these materials (Kirch 1989). However, this information can also be revealed through point counting. pH can also be a measure of how well the soil will preserve artifacts – acidic soils degrade artifacts, while alkaline conditions are more favorable to preservation (Kirch 1989). This study shows that the conditions on Maupiti and Mo‘orea are more favorable for artifact preservation. While pH may be a useful measure for some studies, it should be employed strategically and, when sample is limited, may not be necessary.

Future Research

This study revealed potential for future geoarchaeological work in the Society Islands. Future research could include collecting multiple sediment cores across different sites. Analysis of cores like these would provide a more complete geomorphological history of the islands, especially if the depth of the core spanned before human occupation. The results of my grain-size analysis clearly show an increase in alluvial deposition which correlates with the arrival of humans. Having a depositional record from substantially before occupation would provide another line of evidence showing that the alluvial deposition is human induced and not naturally occurring events. Additionally, further sediment coring could be useful in identifying other areas
of landscape management, where negative impacts to the environment were managed to protect culturally important sites.
References


Firth, Raymond. 2013. We the Tikopia: A Sociological Study of Kinship in Primitive Polynesia. Routledge.


