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SĀMOAN LANDSCAPES THROUGH TIME: A SPECIAL ISSUE IN HONOUR OF JEFFREY T. CLARK

Guest Editor
SETH QUINTUS

Editor
MELINDA S. ALLEN

Book Review Editor
PHYLLIS HERDA

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DOROTHY BROWN

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Inquiries should be made to:

Hon. Secretary
af-jps@auckland.ac.nz.
The Polynesian Society
c/- Māori Studies
University of Auckland
Private Bag 92019, Auckland

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CONTENTS

It is with a great deal of pleasure that we present this festschrift in honour of Prof. Jeffrey Clark. The long list of contributors that follows is an indication of Jeff's impact not only on Sāmoan archaeological scholars but also those in other allied fields (Social and Biological Anthropology, Geography, Geology and History), as well as the wider Sāmoan community. Moreover, although this issue is devoted to Sāmoan research, as Quintus and Herdrich acknowledge in their Introduction, Jeff's contributions elsewhere in the Pacific, and to the discipline of Archaeology at large, are significant. In the early days of my own career, Jeff invited me to join his inter-disciplinary team in the study of palaeoenvironmental change and human impact along the 32-km Waimea-Kawaihae road corridor (Clark and Kirch 1983), giving wings to my budding interests in human palaeoecology. More recently our paths have intersected through our shared student, and now colleague, Seth Quintus who is also the Guest Editor of this Special Issue. We thank you Jeff, *mahalo nui loa*, for your scholarly insights, your generosity of spirit, and your friendship.

Melinda S. Allen, Editor

Contributors to This Issue

Telei'ai Christian Ausage holds a BEd in Elementary Education (University of Hawai'i, Mānoa, 1991) and a BA and MSS in Sāmoan Studies (National University of Samoa, 2004, 2012). He was Adjunct Professor in Sāmoan culture at the American Samoa Community College (2005–17). His traditional Sāmoan title, Telei'ai, is a Tulāfale from the village of Samatau, Samoa. He is currently the Historian at the American Samoa Historic Preservation Office.

David Baret is an Archaeologist at the Institute of Archaeology of New Caledonia and the Pacific. Over the past 20 years he has participated in field programs in New Caledonia, Fiji and Sāmoa. He has specialised in the study of shell remains. Currently he is in charge of the survey database of New Caledonia's archaeological sites.

Jacques Bolé is an Archaeologist at the Institute of Archaeology of New Caledonia and the Pacific. He has 30 years of experience in Pacific archaeology, in Melanesia and West Polynesia. Amongst his varied areas of expertise, he is the only Melanesian archaeologist to specialise in the field analysis of human remains.

Ethan E. Cochrane completed his PhD in 2004 at the University of Hawai'i at Mānoa and is currently a Senior Lecturer at the University of Auckland. His research examines the evolutionary and ecological processes that shape cultural variation across populations. He has worked in the archipelagos of Hawai'i, Fiji and Sāmoa, along with western Micronesia and Papua New Guinea. His most recent research focuses on early populations in Sāmoa and he has just begun a multi-year project focused on the development of agriculture and changing social complexity on 'Upolu.

Michael D. Coszalter has a BA in Anthropology (University of North Carolina Wilmington). He is currently Executive Assistant at the nonprofit organisation the Full Belly Project in Wilmington, North Carolinaand a University of North Carolina Wilmington Research Affiliate.

Stephanie S. Day is an Assistant Professor at North Dakota State University. She received her PhD in Geology from the University of Minnesota. Her research focuses on understanding how human activity alters landscape evolution processes. She specialises in using GIS and other remote sensing technologies to measure change.

Robert J. DiNapoli is a PhD student and Graduate Teaching Fellow at the University of Oregon. His research focuses on using human behavioural ecology and geospatial modelling to study settlement patterns in Polynesia. His dissertation research on Rapa Nui (Easter Island) seeks to better understand the evolutionary and ecological influences underlying proliferation of the island's famous monuments. He is also currently involved in settlement pattern projects for the archipelagos of Sāmoa, Hawai'i and the Marianas.

Dionne Fonoti is a Lecturer at the National University of Samoa's Centre for Samoan Studies. She is on study leave for the next three years while she undertakes research for her PhD in Cultural Anthropology at Victoria University in Wellington, New Zealand. Her research looks at how cultural heritage management is being negotiated in contemporary Sāmoan society. Fonoti is also a filmmaker and is currently producing a series of public service announcements on heritage for local broadcast.

David J. Herdrich holds a BA and an MA in Anthropology (University of Illinois at Urbana-Champaign 1982, 1985). He served as American Samoa's Territorial Archaeologist from 1995 to 2009. He is currently the Historic Preservation Officer at the American Samoa Historic Preservation Office.

Michaela E. Howells received her BA in Anthropology from Central Washington University (2002), her MA in Anthropology from Iowa State University (2006) and her PhD in Anthropology from University of Colorado Boulder (2013). She is currently an Assistant Professor of Biological Anthropology at the University of North Carolina Wilmington and has an active maternal health research programme in American Samoa.

Gregory Jackmond is a Research Archaeologist with the National University of Samoa's Centre for Samoan Studies (CSS). In the 1970s he was a Peace Corps volunteer on Savai'i, where he conducted one of the first archaeological surveys in The Independent State of Samoa in the villages of Sāpapali'i, Fa'aala and Vailoa (Letolo Plantation). He returned to Samoa in late 2016 to assist with CSS archaeological research and is in charge of coordinating the fieldwork and field training of students. He is retired from teaching Computer Science in California and now lives full time in Samoa.

Alex E. Morrison received his PhD from the University of Hawai'i at Mānoa in 2012. His dissertation research, conducted on Rapa Nui, focused on siteless survey methods and settlement-pattern analysis. His primary geographical research areas are Sāmoa, Fiji, the Cook Islands and Hawai'i. His research interests include behavioural ecology, quantitative spatial analysis, agent-based modelling and coastal geomorphology. Alex is currently Senior Archaeologist and Principal Investigator at the International Archaeological Research Institute, Inc. (IARII) in Honolulu, Hawai'i.

André-John Ouetcho is an Archaeologist at the Institute of Archaeology of New Caledonia and the Pacific. He has participated in nearly all the field programmes fulfilled in New Caledonia on archaeological sites over the past 25 years. He specialises in archaeological mapping and ceramic studies, while also participating in programmes in Fiji and the western part of the Sāmoan Archipelago.

Seth Quintus (PhD, University of Auckland, 2015) has been an Assistant Professor of Anthropology at the University of Hawai'i at Mānoa since 2016. Seth was a student of Jeff Clark at North Dakota State University beginning in 2007 and has continued to work closely with Jeff in the Manu'a Islands of American Samoa since graduating. Within a set of broad topics, his research generally concerns the relationship between the environment and political economy in small-scale societies.

Timothy M. Rieth is a Principal Investigator at the International Archaeological Research Institute, Inc. (IARII) in Honolulu. His research focuses on chronology building and faunal studies. Most of his recent work has been in islands of Hawai'i, Sāmoa, Guam and Fiji. He is currently collaborating on an archaeological synthesis for Guam.

Mohammed Sahib is Project Officer at the Centre for Samoan Studies of the National University of Samoa (NUS). As part of his training at NUS he participated in several archaeological field schools, and was responsible for the student participants during the Manono field schools during the period 2013–2015.

Christophe Sand is Director of the Institute of Archaeology of New Caledonia and the Pacific. Over the past 35 years Dr. Sand has worked extensively in the Western Pacific on topics covering the whole spectrum of cultural dynamics, from first Lapita settlement to traditional Oceanic societies and colonial outcomes. He has widely published on these topics while also promoting Pacific heritage as a key element of the region's future.

Va'amua Henry Sesepasara holds a BS in Biology (1970) and a BA in Education (1971), both from Truman State University, Missouri. He also has a BA in Marine Resources Management from Oregon State University, Corvallis (1975) and an MA in Administration/Management from San Diego State University (1988). His traditional Sāmoan title, Va'amua, is a Tulāfale title from the village of Pago Pago. He is currently the Director of the Department of Marine and Wildlife Resources in American Samoa.

Matiu Matavai Tautunu is a Lecturer at the Centre for Samoan Studies, National University of Samoa (Lē Iunivesitē Aoao o Sāmoa). He is completing the second year of his PhD research in Samoan Studies, and his will be the first ever doctoral dissertation written in the Sāmoan language. Matiu is also an accomplished author and poet with three published books, *O le vala'au mai le tu'ugamau* (2007), *O lo'o iai Satani i lou fanua* (2016) and *O le tautua fai matai e fa'amaga ai le ele'ele* (2017). He lives in Apia with his wife and three young daughters and son.

Hans K. Van Tilburg completed his BA in Geography (University of California Berkeley) in 1985, MA in Maritime History and Nautical Archaeology (East Carolina University) in 1995, and PhD in History (University of Hawai'i at Mānoa) in 2002. He is currently the Maritime Heritage Coordinator for NOAA's Office of National Marine Sanctuaries in the Pacific Islands region.

Sāmoa and Use of the Macron in This Issue

Readers may note variation in the use of the macron in relation to Sāmoa in this issue; this reflects the diversity of usage in the archipelago. Here we follow the use (or non-use) of the macron by the two governments, their agencies and other institutions, as indicated by official web pages. For quotes and references we have followed the use/non-use of macrons as in the original sources. However, in this collection of papers where there is explicit or inferred reference to the archipelago at large, language, culture, practices, etc., we have included the macron in an effort to encourage its wider use and aid non-Sāmoan speakers in proper pronunciation.

Melinda S. Allen, Editor

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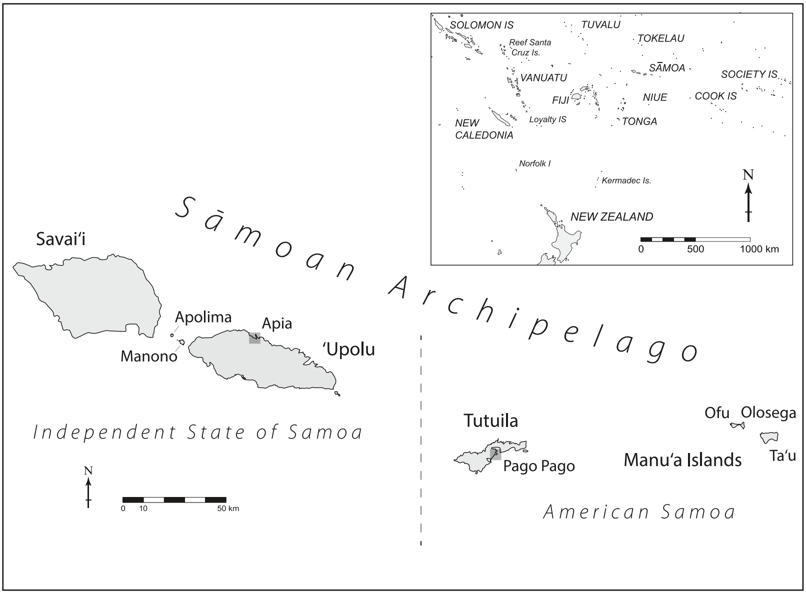
Clark, J.T. and P.V. Kirch (eds), 1983. *Archaeological Investigations of the Mudlane-Waimea-Kawaihae Road Corridor, Island of Hawaii.* Honolulu: Department of Anthropology Report 83-1, Bernice P. Bishop Museum.



Map of the Sāmoan Archipelago and location in the Pacific (inset).

THE CONTRIBUTIONS OF JEFFREY T. CLARK TO SĀMOAN ARCHAEOLOGY

SETH QUINTUS
University of Hawai'i at Mānoa

DAVID J. HERDRICH
American Samoa Historic Preservation Office

The archaeology of Sāmoa, especially American Samoa, has seen significant gains in the past two decades. The foundation for these were laid by a number of individuals, but the contributions of Jeffrey Clark are of particular importance given his long-term focus on the region. He has conducted research on every island of American Samoa, one of few individuals to have done so. He also has been instrumental in maintaining a focus on settlement systems, based on the pioneering work of Roger Green and Janet Davidson on 'Upolu and Savai'i, fundamentally shaping the practice of archaeology in the archipelago. Through this research, he has provided the baseline for the cultural sequence of American Samoa and highlighted the importance of landscape evolution to understanding human settlement patterns.

While perhaps best known for his work in the Sāmoan Archipelago, Jeff has also made contributions beyond the archipelago, conducting field research in Hawaiʿi (Clark 1986) and Fiji (Clark and Cole 1997), while publishing on such topics as digital applications in archaeology, the settlement of Oceania (Clark 1991; Clark and Kelly 1993), and the practice of archaeology in the region (Clark and Terrell 1978). It is through the latter topic that Jeff entered the academic community of Pacific archaeology. The article "Archaeology in Oceania" provided a springboard for much of his later work, though it was initially met with much controversy. In fact, it was through the critique of this article that Jeff met Roger Green and then developed a friendship stemming from shared interests in Sāmoan landscapes.

Shortly after this article's appearance, Jeff's career in Sāmoa began while he was employed at the Bernice Pauahi Bishop Museum. His first project contributed to the development of the American Samoa Preservation Office by recording and providing site inventory numbers for known archaeological sites in the territory (Clark 1980). In fact, among his most notable legacies is the creation of the American Samoa site-numbering system, which is an adaptation of the Smithsonian trinomial. While the number of sites now known for American Samoa has ballooned since the beginning of cultural-resource management in the territory, the initial ones identified by Jeff have certainly structured research, especially in Manu'a. As a side note, during

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his initial survey Jeff did not record the Va‘oto site, inferring that it would be too disturbed to provide reliable information. Subsequently, however, Jeff has gone on to excavate at the site for six field seasons and continues to publish on the material found during these excavations (Clark *et al.* 2016)

In the mid- to late 1980s, three large archaeological projects were undertaken in American Samoa at the behest of the budding Historic Preservation Office. William Ayers was tasked with investigating western Tutuila, Patrick Kirch and Terry Hunt with Manu‘a, and Jeff and David Herdrich with eastern Tutuila. The use of a settlement-system approach during the Eastern Tutuila Project has provided a model for subsequent landscape-based investigations of Sāmoan Islands (Clark and Herdrich 1993). The machete scar that Jeff now proudly displays on his knee, which

Jeff Clark (second from the left, standing), in the early days of his career, with other Bishop Museum Anthropology staff in Konia Hall, 1980. Photo courtesy of Patrick Kirch.

is without fail always blamed on one of the co-authors (DH), speaks to the physicality of those surveys on the ridges of eastern Tutuila, a topic of much amusement.[1] Herdrich's (1991) research on Sāmoan star mounds was a direct result of this project, as were subsequent follow-on studies (Herdrich and Clark 1993). It was also from this project that subsequent research originated in 'Aoa Valley, which has contributed to our understanding of landscape change, sea-level fluctuations and human settlement patterns. Indeed, the coring program initiated at 'Aoa remains one of the best-documented cases of landscape evolution in the region (Clark and Michlovic 1996). This research figured prominently in Jeff's 1996 synthesis of Sāmoan prehistory, which was the first to be completed for the archipelago as a whole (Clark 1996).

After undertaking two field seasons in the Manu'a Group, in 1997 and 1999, and writing a synthetic chapter on the archaeology of Fiji/West Polynesia in 2003 (Burley and Clark 2003), Jeff's interest shifted to digital applications in archaeology and even included co-authoring a paper for *Nature* on Neanderthal dexterity (Niewoehner *et al.* 2003). Much of this research engaged audiences outside of the Pacific, with a regional focus more closely aligned with his academic position at North Dakota State University, a position he held from 1983 to 2017. Highlights include the digital modelling of a Plains Indian village site for the North Dakota State Heritage Center and the development of a video game, *Native Dancer*, which capitalised on the popularity of the video game *Dance Dance Revolution*. This latter effort sought to combat Native American obesity while also promoting Native American cultural practices. However, even while focused on digital archaeology, Jeff maintained an active Oceanic materials laboratory. This allowed students to gain hands-on experience in lab research, which fostered another generation of students interested in Oceania, including one of the co-authors (SQ).

It was not until 2010 that Jeff returned to Polynesian field work, focusing on the islands of Ofu and Olosega. This research is ongoing and has benefitted from several recent technological developments in the discipline that bridge his interests in Oceanic prehistory and digital applications in archaeology. The Manu'a Islands project is among the first to make extensive use of LiDAR imagery for prospection and analysis (Quintus *et al.* 2015), and has also used the dating of branch coral for the construction of high-precision chronologies (Clark *et al.* 2016). While Jeff has now retired from teaching, he continues to be active in publication (Quintus and Clark 2016, forthcoming).

Research Contributions

The articles in this volume are organised around several of Jeff's research foci as well as the major research themes outlined by him for the archipelago (Clark 1996). While these interests were quite diverse, ranging from the semiotic components of monumental architecture to the construction of local Delta R (ΔR) values for the radiocarbon dating of shell, this volume is structured around changes in Sāmoan cultural sea- and landscapes. These include indigenous Sāmoan use of both during pre and post-European times.

Four articles in this volume deal explicitly with settlement patterns and settlement systems. Since Jeff's pioneering work in eastern Tutuila, several substantive, theoretical and methodological developments have modified our understanding of the Sāmoan past. Most notably, knowledge of the extent and chronology of coastal landscape evolution has progressed considerably since Jeff's original work in 'Aoa. This theme, along with many others, is discussed by Morrison and colleagues who have developed an archipelago-wide database to examine changing settlement patterns over time. Likewise, developments in large-scale surveying have led to an increased ability to document expansive human modification to the environment, a key concern of the Eastern Tutuila Project (Clark and Herdrich 1993). Day, Jackmond *et al*., and Quintus all make use of LiDAR datasets to explore the distribution of archaeological remains across large landscapes. In each case, previously unknown archaeological landscapes are documented, the implications of which are both more extensive land-use patterns and higher population sizes in the past. Certainly, the construction of a chronology for the newly uncovered large-scale settlement zones will be an important research step in the coming decade. Within these landscapes star mounds play an important role. As one of the only forms of monumental architecture found in American Samoa, the star mound has been highlighted as a particularly useful part of the archaeological record for understanding political organisation and social inequality (Herdrich and Clark 1993). Since the early work on this feature class, the number of known star mounds has increased considerably, with large numbers in proximity being found on Manono and Olosega. In this issue, Sand and colleagues report in detail on examples from Manono Island and provide additional chronological and morphological data that grows our understanding. As Jackmond *et al.* document, these features are highly visible in imagery derived from LiDAR datasets, and the use of LiDAR will likely provide additional insights into the variation in form and function of these unique features. While these papers are geared toward the pre-European past in the archipelago, the cultural landscape of Sāmoa continues to change. In our final paper, Van Tilburg and colleagues (including Herdrich) describe the development and use of the *fautasi* (traditional Sāmoan longboats), one of the more unique innovations of contemporary Sāmoa.

This special issue recognises and builds on Jeff's many contributions to Sāmoan archaeology and Pacific studies at large. We are all appreciative of Jeff's enthusiasm for Sāmoan archaeology as well as his collegial nature, great sense of humour, exceptional mentorship and long-lasting friendship. From his attempts to blindly identify multiple single-malt scotches during field work, one of his most stinging failures, to his thought-provoking discussions during conference dinners, we have all enjoyed and benefited professionally and personally from Jeff's joyful personality and good company.

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NOTE

1. Jeff: Hey, Siapai, what are we going to do to that ridge? Siapai: We are going to *kill* it, Jeff! Jeff: That’s right, Siapai, we are going to *kiiilll* it!!

CITATION DETAILS

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THE SĀMOA ARCHAEOLOGICAL GEOSPATIAL DATABASE: INITIAL DESCRIPTION AND APPLICATION TO SETTLEMENT PATTERN STUDIES IN THE SĀMOAN ISLANDS

ALEX E. MORRISON
International Archaeological Research Institute, Inc.

TIMOTHY M. RIETH
International Archaeological Research Institute, Inc.

ROBERT J. DiNAPOLI
University of Oregon

ETHAN E. COCHRANE
University of Auckland

Jeff Clark's contributions to the archaeology of Sāmoa and Hawai'i are numerous and variously highlighted throughout this Special Issue. In this paper we describe our efforts to assemble an archaeological geospatial database incorporating the locations of more than 900 archaeological sites and features distributed across the archipelago with an associated suite of 420 radiocarbon and 10 thorium-series dates. The Sāmoa Archaeological Geospatial Database builds on the pioneering settlement pattern research by Jeff Clark and Roger Green and the current corpus of radiometric dates from the archipelago. While the database offers an important first step for examining regional patterns in demography and land use, much additional work is required to convert previously recorded "site"-based data into meaningful comparable analytical units for settlement pattern studies (see Morrison 2012; Morrison and O'Connor 2015). We highlight this process with an example drawn from Clark's archaeological surveys in 'Aoa Valley on Tutuila Island.

SĀMOAN SETTLEMENT PATTERN STUDIES

For archaeologists interested in settlement pattern research in Polynesia (see Morrison and O'Connor 2015 for a recent review), the Sāmoan Archipelago is significant largely as a result of Roger Green, Janet Davidson and colleagues' initial research during the 1960s in the western part of the archipelago (formerly Western Samoa) (Green and Davidson 1969, 1974). The resulting two volumes of *Archaeology in Western Samoa* were the first to describe the spatial and temporal distribution of Sāmoan site types and archaeological deposits on the islands of 'Upolu and Savai'i and set the agenda for later archaeological research conducted within the remaining Sāmoan Islands. Although by the

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close of the 1970s only limited archaeological research had been conducted on the eastern islands of Tutuila, Ofu, Olosega and Ta‘ū (see Frost 1978; Kikuchi 1963), the mid-1980s witnessed the growth of more intensive research projects covering large landscapes. Explicitly noting the lack of research similar to Green and Davidson's in the eastern islands, Jeff Clark and colleagues (e.g., Clark 1993; Clark and Herdrich 1988, 1993; Clark and Michlovic 1996; Clark *et al*. 1997) conducted settlement pattern research in the eastern district of Tutuila Island, which they termed the Eastern Tutuila Archaeological Project. They sought to improve "our understanding of how prehistoric populations were distributed over the landscape, how that pattern of distribution changed over time, and the systemic relationships between … those populations and their environmental surroundings" (Clark and Herdrich 1993: 147).

The results of the Eastern Tutuila Archaeological Project, along with contemporaneous investigations conducted in the Manu‘a group (Hunt and Kirch 1988; Kirch 1993), produced new information about the prehistory of the archipelago's eastern islands that could be compared with the earlier projects on ‘Upolu and Savai‘i. Consequently, by the early 1990s it was possible to summarise broad archipelago-scale patterns in Sāmoan settlement and chronology and begin to discuss research problems for the island group as a whole. This task was taken up in synthetic publications by Clark (1996) and later Green (2002). The foundational work by Green and Davidson, Clark (see above), and Kirch and Hunt (Hunt and Kirch 1988; Kirch 1993) outlined the major themes in Sāmoan archaeology and set the stage for academic and cultural resource management (CRM) projects that would be carried out in subsequent decades (e.g., Addison *et al*. 2008; Burley and Addison 2014; Carson 2006; Cochrane *et al*. 2004; Cochrane *et al*. 2013; Cochrane *et al*. 2016; Martinsson-Wallin 2016; Pearl 2004; Quintus 2012; Quintus *et al*. 2015, 2016; Rieth and Cochrane 2012; Rieth *et al*. 2008; Wallin *et al*. 2007).

Major research themes outlined by Clark (1996) and later Green (2002) include the relationship between landscape evolution and settlement pattern, the chronology of inland and upland expansion, the development of the Sāmoan village layout, and the development of monumental architecture. All of these research themes have been variously taken up by archaeologists working in the archipelago over the last several decades, attesting to the influence of Clark and Green on Sāmoan archaeology and regional settlement pattern studies more generally. The following section describes our efforts to compile settlement pattern and chronological information generated over nearly 60 years into a comprehensive spatial and temporal database. After describing the database development and preliminary analytical results, we discuss the remaining steps necessary to conduct analyses with this database in the context of "siteless" survey techniques (e.g., Dunnell 1992; Dunnell and Dancey 1983) and settlement pattern studies.

THE SĀMOA ARCHAEOLOGICAL GEOSPATIAL DATABASE DEVELOPMENT METHODS

The Sāmoa Archaeological Geospatial Database combines spatial and temporal data into a single searchable database format. Available publications and CRM documents were reviewed to compile the following: i) a database of radiocarbon and thorium-series dates and ii) a geographic information systems (GIS) database representing the spatial locations of known archaeological sites. Data were compiled in a single relational database in ArcGIS v10.5 (ESRI 2017). The methods for developing the final database are described in greater detail below.

Radiometric Dating Database Development

The last 30 years have seen a substantial increase in archaeological research in the Sāmoan Archipelago, particularly in American Samoa. Academic research programmes and, importantly, CRM projects have resulted in an assemblage of over 400 radiocarbon determinations. The majority of this corpus has been generated by CRM projects and remains in little-known and poorly circulated "grey literature". Rieth and Hunt (2008; see also Rieth 2007; Wallin *et al*. 2007) initially compiled data, tabulating 236 radiocarbon ages as of 2007. An additional 194 radiocarbon dates and 10 thorium-series dates were added to the database between 2007 and 2018, making the current total 420 radiocarbon dates and 10 thorium-series dates. Each age determination entry in the database includes fields corresponding to laboratory number, island, site number, provenience information, GIS number, sample material type, isotopic fractionation ratios, conventional radiocarbon age, calibrated age ranges at 1 and 2 standard deviations and bibliographic reference.

GIS Database Development

The locations of the majority of the known sites across the archipelago with published spatial information were compiled in the geodatabase and included brief text descriptions and contextual information provided in the original publications. Additional fields incorporated in the database include site number, feature type, artefacts found in association, site function (if known) and bibliographic reference.

To incorporate site spatial data from older research and hard-copy publications into the geodatabase, paper maps were georeferenced to orthorectified IKONOS base satellite imagery (in WGS 1984, UTM Zone 2S) by scanning the maps and manually rotating and scaling the images in ArcGIS v10.5 until the coastlines on the maps matched the location of the shoreline on the IKONOS imagery. The estimated accuracy of the georeferenced maps is approximately 10 metres or less. In addition to the georeferencing error, there is likely some additional unknown error as a result of the geopositioning techniques used during the original field projects. Nevertheless, our spatial estimates still provide useful information about the general locations of the sites and in some cases associated features and areas within sites. Upon completion of the georeferencing procedures, the site locations indicated on the maps were digitised as a set of point geometries. Identical methods were used to plot site locations generated by more recent archaeological research (e.g., Cochrane *et al*. 2016; Ishimura and Inoue 2006; Martinsson-Wallin *et al*. 2003, 2005; Petchey 2001; Sand *et al*. 2016); however, in the majority of these cases the locations of archaeological sites are more accurate as a result of modern field methods for geopositioning. In some cases, the locations of sites were not clearly depicted, but the corresponding villages were noted, which were used for coarse locational information.

The final step in the development of the database was to integrate the radiometric and spatial databases into a single relational database platform using ArcGIS v10.5, to allow queries based on the characteristics of any data entered in the age estimate or the GIS table, and display GIS point geometries based on spatial attributes or chronometric qualities. The following section briefly describes the data in the Sāmoa Archaeological Geospatial Database.

General Patterns in the Spatial and Chronological Data

Table 1 shows the number of archaeological point geometries in the geodatabase distributed by island. Variation in the distribution of points is largely related to the geographic focus of research programmes and cultural resource management projects (e.g., Clark and Herdrich 1993; Cochrane *et al*. 2004; Green and Davidson 1969, 1974; Jennings and Holmer 1980; Jennings *et al*. 1976; Rieth and Cochrane 2012). A cursory investigation of the GIS points (Figs 1–3) reveals a number of important patterns. For example, the majority of the western portion of Tutuila has seen limited archaeological work, with almost no large-scale surface surveys conducted. Consequently, our understanding of Tutuila's prehistory may only correspond to the eastern and central parts of the island. A similar situation exists on Ta‘ū, where fairly limited fieldwork has been completed in upland and interior locales. Comparatively speaking, the large island of Savai‘i has seen minor amounts of archaeological work since Green and Davidson's research and Jackmond and Holmer's (1980) reconnaissance survey of Sāpapali‘i, the exceptions being projects conducted at Pulemelei Mound and the surrounding area (e.g., Martinsson-Wallin *et al*. 2003, 2007), and limited work conducted by Ishimura and Inoue (2006). Undoubtedly, the island contains an abundance of archaeological remains with important ramifications for our understanding of Sāmoan prehistory. An additional relevant factor leading to island-scale discrepancies in site distributions is variation in the way that archaeological spatial units (that is, "sites") are defined. Problems related to the site concept are discussed further below.

Table 1. GIS and radiocarbon entries in the geodatabase by island.

Island	Sites	Radiocarbon Dates
‘Upolu	378	70
Apolima	1	0
Tutuila	269	248
Savai‘i	113	20
Ofu and Olosega	72	45[a]
Ta‘ū	66	20
Manono	3	17
Total	902	420

[a] Ten thorium dates also are available for Ofu Island (see Clark *et al*. 2016).

Table 1 also shows the number of radiocarbon dates for each island. As is the case with the distribution of spatial entries, Tutuila and ‘Upolu have the largest number of age determinations. Again, this reflects the early history of projects conducted on ‘Upolu and the growth of CRM archaeology as it relates to development projects on Tutuila. Fifty-five age determinations have been acquired for the small islands of Ofu and Olosega, a result of several substantial research projects (e.g., Clark *et al*. 2016; Kirch 1993; Quintus *et al*. 2015). Savai‘i has provided a limited number of radiocarbon determinations, with those present primarily related to archaeological investigations within the Pulemelei area (Martinsson-Wallin *et al*. 2003, 2007) and limited earlier archaeological projects during the 1960s (Green and Davidson 1969).

The geodatabase provides the current best compilation of settlement pattern and chronological data for the Sāmoan Archipelago. Although these datasets offer important information regarding land use, demography and spatial organisation across the islands, it must be noted that the distribution of entries for age estimates and archaeological sites is strongly influenced by contemporary factors, such as the history of infrastructural development, the rise of CRM archaeology in American Samoa, and methodological issues related to how we define archaeological units for the purposes of management and analysis.

While the Sāmoa Archaeological Geospatial Database is useful for quickly assessing the spatial and temporal distribution of archaeological site data across the archipelago, as well as generating new theoretical models and hypotheses regarding land use and spatial organisation (e.g., Morrison and

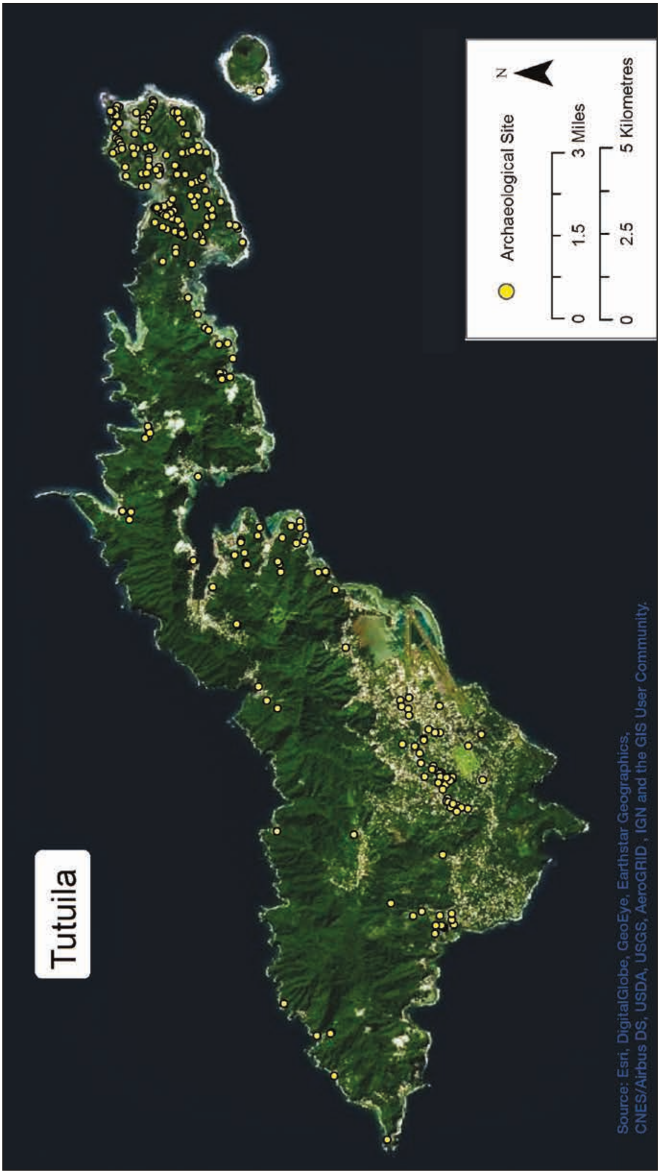

Figure 1. Distribution of archaeological sites on Tutuila in the Sāmoa Archaeological Geospatial Database.

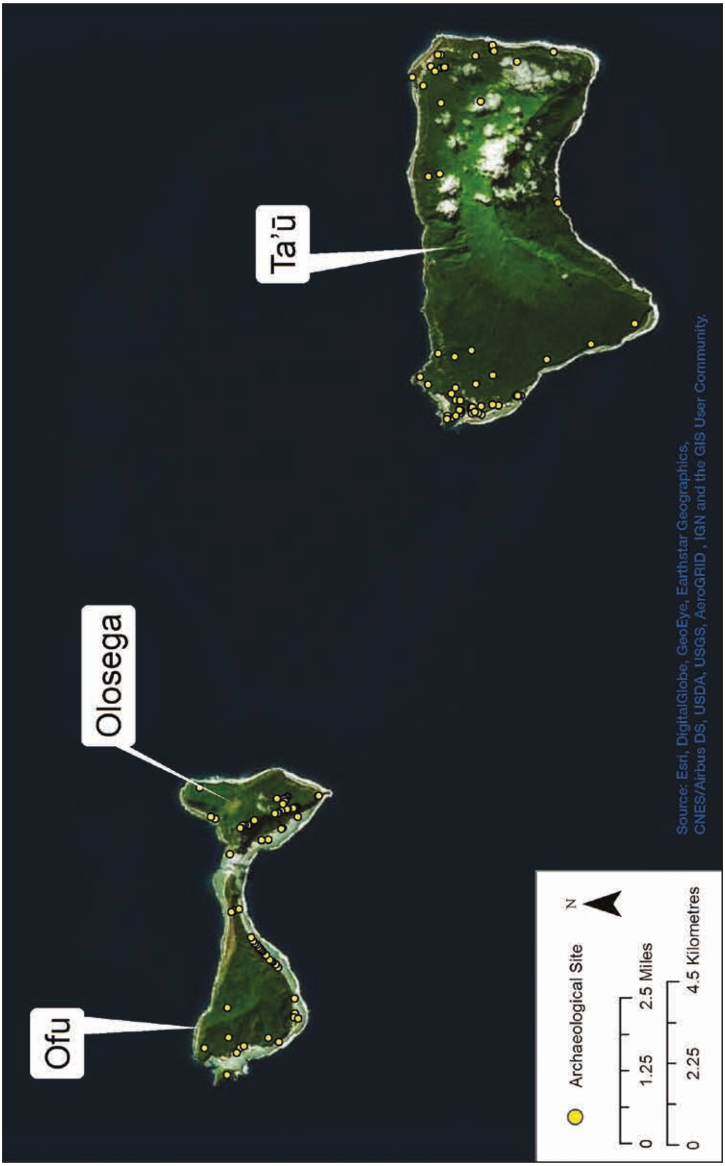

Figure 2. Distribution of archaeological sites in the Manu'a Islands in the Sāmoa Archaeological Geospatial Database.

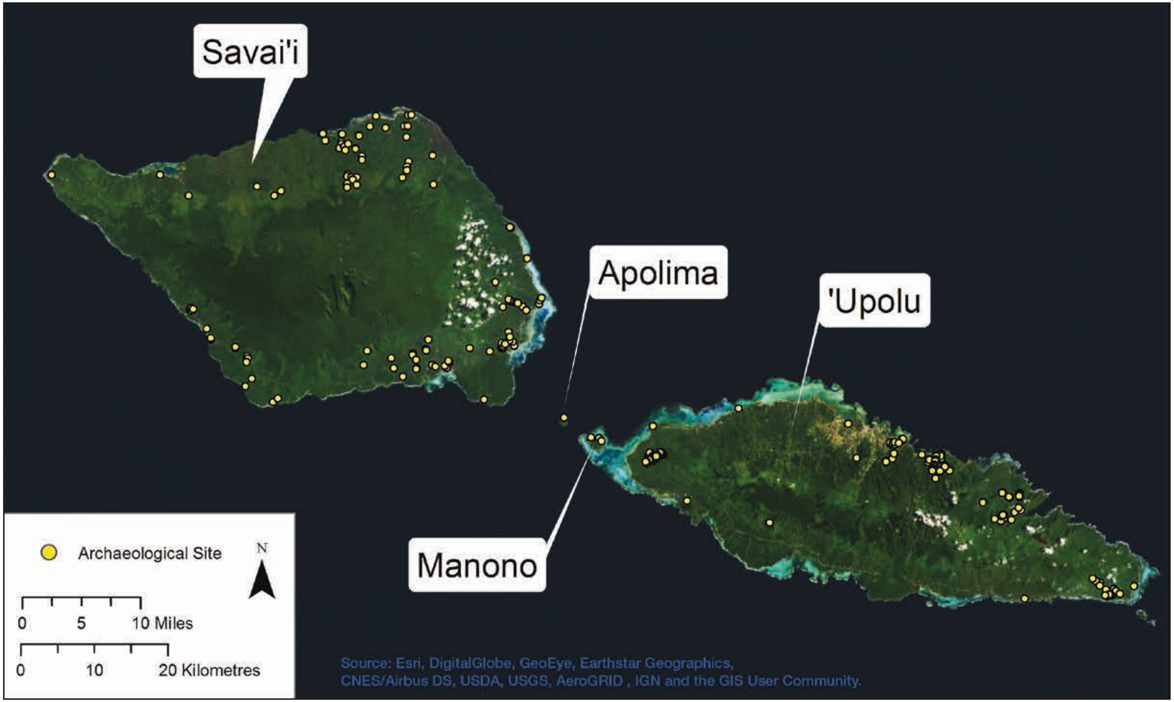

Figure 3. Distribution of archaeological sites on ʻUpolu, Savaiʻi and Manono Islands in the Sāmoa Archaeological Geospatial Database.

Allen 2017), there are a number of data limitations that presently constrain its utility. These limitations are not unique to this specific context but highlight the greater challenges of assembling previously generated data (where the data were not originally generated for use in a GIS) and chronometric data collected using different methods. Below we focus on two primary limitations: (i) the definition of archaeological units and ii) the generation of reliable chronological estimates.

Analytical Units Versus Managerial Units in Settlement Pattern Studies
The assembly of large amounts of previously recorded archaeological spatial and chronometric data presents a unique set of problems for ensuring comparability among analytical units that are ultimately defined as GIS geometries in the database. The problem is readily apparent when dealing with the most commonly assigned archaeological unit, "the site". The concept of "site" in CRM archaeology is for the most part a managerial unit: that is, for a variety of reasons, cultural heritage managers require inventories of significant properties or "sites" for particular areas. The archaeological objects that are brought together within these managerial units are often inconsistently defined such that it becomes extremely difficult, if not impossible, to use "the site" as a unit in any analytical capacity. Simple inconsistency in site definition could be ameliorated, but more troublesome is the typical lack of problem orientation guiding the choice of features to be aggregated into a site, which results in comparability issues between researchers (see Dunnell 1992; Dunnell and Dancey 1983; Morrison 2012; Morrison and O'Connor 2015). Unfortunately the site has been, and continues to be, the primary archaeological unit used in Sāmoa, Hawai'i, and much of the United States. Consequently, in the Sāmoa Archaeological Geospatial Database, the data compiled for American Samoa rely on the site as the primary unit, largely as a result of a heavy reliance on CRM documents, which are primarily descriptive and managerial in aspect.

The problem with the site concept is not unique to American Samoa; however, this situation highlights larger problems with the concept of "site" when used for analytical purposes. With these thoughts in mind, the site designations currently in place within the database are managerial rather than analytical in most instances and therefore require further efforts to disaggregate spatial geometries into lower-level units before many analytical tasks, such as comparing the spatial distribution of functional activities and assessing settlement boundaries, can be tackled.

One resolution to this problem for Polynesian settlement pattern research is the "siteless" survey (Dunnell and Dancey 1983), whereby the minimal unit of recording equates with the unit of discard, preferably the artefact or bounded architectural component (i.e., feature) (Morrison and O'Connor

2015). In many instances, it is possible to create comparable analytical units by "deconstructing" previously defined sites into individual features. While this remains a daunting task for the over 900 recorded sites currently in the database, in the following section we demonstrate the necessary steps for this type of analysis with an example from ʻAoa Valley and the surrounding area on Tutuila.

THE ʻAOA VALLEY CASE STUDY

ʻAoa Valley is located along the northeastern coast of Tutuila Island. The valley is characterised by a large and pronounced bay that fronts a well-developed central coastal plain. Six primary streams and an estuary can be found in the valley. Clark and Herdrich (1988) subdivided the main portion of the valley into three zones with varying ecological and archaeological characteristics: the lower valley, the middle valley and the upper valley.

In 1986 Clark conducted an exhaustive survey of the valley floor and a diversity of archaeological features was identified. ʻAoa Village and the majority of the valley (AS-21-5), as well as Faʻalefu Village (AS-21-6), were each given site numbers with designated archaeological localities within each of these sites. Nearly 60 archaeological sites ranging from isolated terraces to large clusters of surface features have been recorded in the valley and on surrounding ridges. These sites and descriptions, originally documented by Clark, are included in the Sāmoa Archaeological Geospatial Database and provide the data for this analysis. A more detailed discussion of the valley's chronology and archaeology can be found in Clark and Michlovic (1996) and Clark and Herdrich (1988). It is noteworthy that ʻAoa Valley has played an important role in the generation of many research questions that still remain important in Sāmoan archaeology, including the relationship between geomorphological evolution and landscape use (e.g., Clark and Michlovic 1996) and the timing of the cessation of pottery production across the archipelago (Clark 1996).

Generating Comparable Analytical Units

As discussed in the previous section, "sites" have not generally been defined according to analytical needs but instead often serve a managerial or administrative purpose. In the case of American Samoa settlement pattern analysis, it is often not analytically meaningful (aside from gross, and previously recognised, patterns) to analyse the spatial distributions of recorded "sites" given their difficult-to-compare, arbitrarily defined and non-problem-oriented nature. Importantly, Clark explicitly defined his criteria for aggregating features into sites. Regarding "site definitions" in the Eastern Tutuila Archaeological Survey, Clark and Herdrich (1988) note:

> Clusters of associated features—such as house foundations and other domestic features, or related defensive features—were regarded as single settlement units and therefore assigned one site number. Discrete and comparatively isolated structural remains (e.g., terraces, *tia ‘ave* [star mounds], paths, and walls) were given individual site numbers. Furthermore, to single out members of different site categories, specialized sites were assigned individual site numbers even if found in close spatial association with other features. These site categories are *tia ‘ave* and basalt quarries. In some cases, ditches and other features that are in proximity to and were probably functionally related to *tia ‘ave* have been grouped with the *tia ‘ave* [typo in original corrected] (p.10)

Clark’s careful recording and clear explicit description of these variably defined sites has allowed us to revisit his work in ‘Aoa Valley and the surrounding area (Fig. 4) and identify the features he recorded. Single locations were then given to each discrete feature described in the associated technical reports (e.g., Clark and Herdrich 1988), such that all spatial geometries now represent individual discrete artefacts (i.e., adzes or formal lithic tools) or individual structures (i.e., terraces, star mounds, house foundations) and are therefore analytically comparable for documenting patterns in landscape use and activity areas.

To explore spatial patterns in surface features within Clark and Herdrich’s (1988) ‘Aoa survey area, we use a geostatistical technique called *kernel density estimation* (KDE) to visualise spatial patterns in the data. KDE is useful for documenting geographic variability in point patterns (e.g., artefacts or features) by mapping their density as a spatial probability function or as expected counts derived from this probability estimate. KDE works by placing a curved surface over each point, called a *kernel function*, with a user-defined standard deviation, called a *smoothing bandwidth*, resulting in a map of probability density that smoothly decreases with distance from each point. The result can be thought of as an undulating surface with height equal to density (Baddeley *et al*. 2015: 168). For any given location within the study area, the kernel density estimate is given by:

$$\lambda(u) = \sum_{i=1}^{n} \kappa(u - x_i)$$

Where λ is the density of the feature class at location u and κ is an isotropic Gaussian kernel with smoothing bandwidth computed using a spatial variant of Silverman’s Rule of Thumb that is robust to spatial outliers (Baddeley *et al*. 2015: 168; see also Silverman 1986). KDEs are computed for house foundations, terraces, lithic tools and star mounds (*tia ‘ave* or *tia seu lupe*),

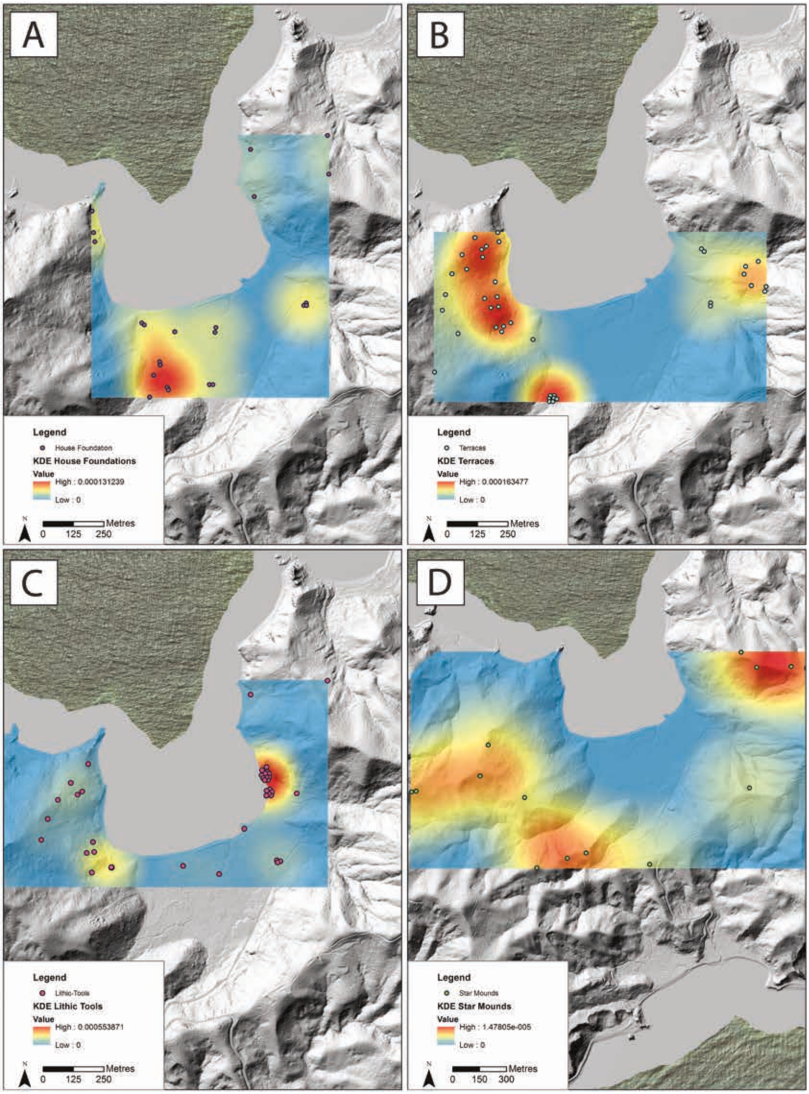

Figure 4. Kernel density estimation plots depicting expected counts per km² for A) house foundations, B) terraces, C) lithic tools and D) star mounds.

which are visualised as expected counts per km^2. Figure 4 displays the results of the KDE plots for the four feature classes used in the analysis, and general spatial patterns for each feature class are discussed further below. Other feature classes are present in the data but are not presented here.

House Foundations

House foundations are defined by Clark and Herdrich (1988: 11) as "represented by foundations with curbing or the surface scatters of *'ili'ili* (pebbles and/or coral rubble) of old floors". The distribution of house foundations at 'Aoa suggests that they were primarily concentrated within the central valley floor (Fig. 4, Panel A). However, there are a few located at higher elevations on top of Afimuao Ridge to the east. Distinct clusters of house foundations are found within Site 21-05, which corresponds to much of the valley floor. The distribution of archaeological house foundations suggests continuity between the location of the current village houses and those of the past, which is likely influenced by the benefits of living on relatively flat land with nearby coastal access (Morrison *et al*. 2010; Rieth *et al*. 2008).

Terraces

Terraces are well represented in the valley and on the surrounding ridges. The KDE displayed in Figure 4 Panel B demonstrates that terraces are concentrated along the slopes of the valley and generally at higher elevations than the house foundations. High concentrations of terraces are found along the base of the western slopes of the valley near Fa'alefu Village (22-06) and Lemafa Ridge. However, another cluster is located near the southwestern portion of the valley floor against the ridge slope. These terraces retain the slope of the surrounding ridges and likely functioned as places for agricultural activities.

Lithic Tools

Lithic tools are defined here as formal basalt artefacts, including complete and incomplete adzes, chisels and miscellaneous basalt tools (Fig. 4, Panel C). These artefacts are often in association with terraces or in clusters within Site 21-05 and especially along the base of the western slopes of the valley near Fa'alefu Village (22-06) and Lemafa Ridge. A dense cluster of lithic tools is also present in the northeast section of the valley floor within Site 21-05, Locality 03 near Laoulu Stream. The high abundance of formal tools in proximity to the stream mouth raises the possibility that many of these artefacts are in secondary contexts, having been transported by fluvial action to their current locations.

Star Mounds

The distribution of star mounds (*tia 'ave* or *tia seu lupe*) demonstrates that they are at high elevations on ridge tops, away from primary residences in the lower areas of the valley (Fig. 4, Panel D). The spatial segregation of star mounds away from other features indicates that these were special-use areas. This spatial pattern seems logical considering that star mounds are interpreted as places for the chiefly sport of pigeon-snaring and may have been important meeting places (Herdrich 1991).

'Aoa Valley Settlement Pattern Summary

Although the 'Aoa Valley settlement pattern study is primarily illustrative of the potential uses of the Sāmoa Archaeological Geospatial Database to understand broader issues in Sāmoan prehistory, certain conclusions regarding land use and spatial organisation can be discussed. House foundations are located primarily on the valley floor in flat locations that would have provided easy access to ocean resources and alluvial soils for cultivation. Clusters of terraces can be found along valley slopes and at higher elevations. These terraces retain slopes and produce flat locations for agriculture, thus increasing the total acreage of potential arable land. Formal lithic tools are associated with terraces and to a more limited extent with house foundation locations. The co-occurrence of lithic tools and terraces suggests that basalt tools were used during agricultural activities (e.g., for clearing land and processing crops). Finally, star mounds are located away from residential areas at high elevations on ridge tops, attesting to a specialised function and segregation away from other feature classes.

* * *

This article provides a description of the Sāmoa Archaeological Geospatial Database and a case study from 'Aoa Valley. While purposely limited in scope and primarily illustrative, the techniques applied in the 'Aoa Valley example can be expanded to other locations in the archipelago and eventually the entire archipelago. Forthcoming analytical efforts will focus on updating site inventories as archaeological projects in the Sāmoan Islands continue.

Avenues for Future Research

Future archaeological survey projects should describe the surface archaeological record at the discrete object/feature scale, which is necessary for both examining spatial correlations between functional activity areas and highlighting divergent patterns in land use, important goals of settlement pattern research. Consequently, deconstructing currently recorded archaeological sites already in the database into lower-scale feature entities will be an important preliminary task.

Rather than focusing on settlement organisation at the scale of individual valleys like ʻAoa, future research will delineate multiple scales of organisation using multi-scalar statistical approaches (e.g., Peterson and Drennan 2005), which offer the potential to document regional organisational patterns with archaeological data. Eventually, the database will be made accessible to researchers via an online platform as we continue to increase the data entries and refine the spatial resolution of the database.

Finally, note is made of the need to generate reliable chronologies for the archaeological features depicted in the database. Radiometric dating technology has significantly improved in its capabilities and level of precision during the last 60 years. Sāmoa's relatively deep history of archaeological research has resulted in a large corpus of radiocarbon dates, many of which are problematic by current standards (Rieth and Hunt 2008). Ultimately, redating efforts for key deposits or structures should occur, either using curated charcoal samples or through renewed excavations. Looking forward, there are relatively simple practices that archaeologists working in the archipelago (or elsewhere) must implement to ensure the creation of reliable chronologies. These include paying close attention to archaeological and depositional contexts to identify what specific events of interest are being dated (see Dean 1978). Charcoal dating samples should be identified to taxon, and short-lived plants or young plant parts should be submitted for dating (Allen and Huebert 2014; Rieth and Athens 2013). Results should be published in full, including provenience information, sample material (and analyst who made the identifications), the target event (with a defensible justification), laboratory data, calibration details, including calibration curve, Delta R values if used, and calibration program and version. Lastly, Bayesian model-based calibration has gained recognition in the Pacific as a powerful method for building chronologies (Allen and Morrison 2013; Burley *et al*. 2015; Dye 2015; Rieth and Athens 2017). The application of Bayesian statistical methods to Sāmoan archaeology has begun as well (Clark *et al*. 2016; Rieth and Morrison 2017). These data can be incorporated into future iterations of the Sāmoa Archaeological Geospatial Database and promise to greatly improve our understanding of the Sāmoan past.

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ABSTRACT

Jeff Clark's archaeological research on Eastern Tutuila Island provided the first regional scale settlement pattern data in American Samoa that could be meaningfully compared to earlier data drawn from projects on the archipelago's western islands, Savai'i and 'Upolu. Building on Clark's work, in this paper we generate a spatial and temporal geodatabase incorporating 900 archaeological sites and 520 age estimates spanning the entirety of the Sāmoan Islands. The Sāmoa Archaeological Geospatial Database is useful for addressing a number of regional research questions using spatial and temporal data at multiple geographic scales; however, preliminary work must first be conducted to covert "site" data into comparable lower-scale analytical units. To highlight this process, we provide an example drawn from Clark's archaeological surveys in 'Aoa Valley, Tutuila Island. Finally, we suggest that a "siteless" survey approach is necessary to generate comparable data for settlement pattern and landscape analyses.

Keywords: Sāmoa, geographic information systems (GIS), settlement pattern archaeology, Polynesian archaeology, geodatabase, landscape archaeology

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[1] Corresponding Author: International Archaeological Research Institute, Inc., 2081 Young Street, Honolulu, Hawai'i 96816, USA. Email: amorrison@iarii.org

[2] International Archaeological Research Institute, Inc., 2081 Young Street, Honolulu, Hawai'i 96816, USA. Email: Trieth@irarii.org

[3] Department of Anthropology, University of Oregon, 308 Condon Hall, 1218, Eugene, Oregon 97403-1299, USA. Email: rdinapol@cas.uoregon.edu.

[4] Anthropology, School of Social Sciences, University of Auckland, Private Bag 92019, Auckland 1142, New Zealand. Email: e.cochrane@auckland.ac.nz.

EXPLORING THE INTERSECTION OF SETTLEMENT, SUBSISTENCE AND POPULATION IN MANU‘A

SETH QUINTUS
University of Hawai‘i at Mānoa

The study of settlement systems is a hallmark of the archaeological enterprise in Sāmoa (e.g., Clark and Herdrich 1993; Green and Davidson 1969, 1974; Jennings and Holmer 1980; Kirch and Hunt 1993). Broadly, settlement systems encapsulate the behavioural dimensions that contribute to the distribution of features, subsistence patterns and other elements of the socioecological landscape. As such, these analyses require an examination of several interacting variables, including population size, site distribution and cultivation practices. Largely missing from settlement system studies in the archipelago has been population estimates. Those that have been completed have been limited in scope, relying on historic descriptions (Green 2007: 212), estimations of total arable land (Green 2007: 215) or the distribution of archaeological remains within small areas (Davidson 1974: 235–36; Jackmond and Holmer 1980: 151–52).

Investigations of population size and density are essential for understanding settlement systems, in that population size often interfaces with subsistence and settlement pattern decisions. The inclusion of demographic variables into a consideration of variable protohistoric (17th–18th century) settlement systems is accomplished here for the islands of Ofu and Olosega. These are small islands, 7.3 km^2 and 5 km^2 respectively (Fig. 1). Estimations of population are more easily accomplished for smaller islands, especially when those islands have been subject to intensive archaeological survey work, as is the case in Manu‘a.

Both feature high topographic relief, with the highest point of Ofu at 494 m and of Olosega at 639 m. Each island receives in excess of 3,000 mm of rain each year, but no permanent streams flow. Several intermittent waterways run after heavy rainfall and some retain water well after these rainfall events. The interior uplands of both are covered in dense vegetation distributed along an elevation gradient (Liu and Fischer 2007). Generally, more economic species (e.g., *Cocos nucifera*, *Artocarpus altilis*, *Aleurites moluccanus*, *Inocarpus fagifer*) are situated seaward of secondary-growth forest (e.g., *Rhus taitensis*, *Hibiscus tiliaceus*), which is itself seaward of what remains of native rainforests.

Ofu was settled some 2,650–2,700 years ago (Clark *et al.* 2016), and sites from this period are distributed along the leeward coastlines (Kirch and Hunt 1993; Quintus 2015). Archaeological remains from the first millennium BC

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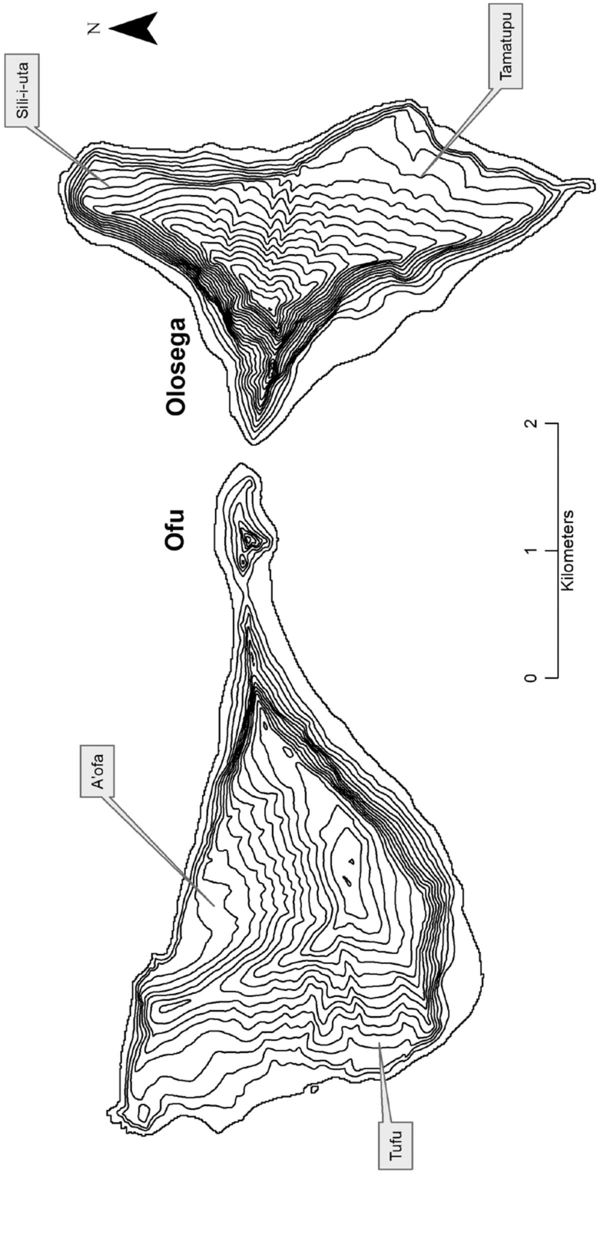

Figure 1. Ofu and Olosega with investigated, either by pedestrian survey or by LiDAR survey, high-feature density zones labelled. Contour lines are 20 m from a DEM derived from a LiDAR dataset.

have also been identified and dated on Olosega, but these have not yet been reported in detail (American Samoa Power Authority files; Clark pers. comm.). Habitation on the coast persisted through the first millennium AD with the initial permanent settlement of the interior uplands of Ofu at the beginning of the second millennium AD (Quintus *et al.* 2015a). Activities continued to be undertaken on the coast, but areas of the interior uplands became the major loci of human activities on Ofu and Olosega until European contact.

The results of several years of field research in the interior uplands focusing on the individual settlement zones of Tamatupu and Sili-i-uta on Olosega and A‘ofa and Tufu on Ofu (Fig. 1) have recently been published (Quintus 2012, 2015; Quintus and Clark 2012, 2016; Quintus *et al.* 2015b, 2016). What has not been considered is variation between these islands. The aim of this article is the evaluation of the interiors of Ofu and Olosega collectively to isolate and explain points of variation relating to settlement, subsistence and population. The intersection between population density and subsistence systems provides important information from which to understand population vulnerability (susceptibility to damage caused by perturbations) and resiliency (ability to persist through perturbation) in these small-island societies. At a general scale, such case studies provide important models for contemporary island societies adapting to socioecological change.

METHODS

The distribution of terraces and forest types, two proxies for productive strategies, are used to calculate two population estimates: hypothetical carrying capacity and settlement patterns. The calculation of carrying capacity (K), defined as the population that could potentially be sustained based on a modelled food-production system, is not an ideal way to estimate past population sizes (see Brush 1975). Not all subsistence-related activities can be included in most calculations given incomplete knowledge, and there may be a lack of correlation between K and actual population (Kirch and Rallu 2007: 8–9). Still, the calculation of a heuristic K provides some useful information regarding a maximum population (see Addison 2006; Burley 2007; Spriggs and Kirch 1992). The examination of the archaeological manifestations of residential activity through the assessment of the distribution and density of architectural features (i.e., terraces) should provide a more realistic population estimation, providing a check of the estimation of K, and has been used successfully in the region (Conte and Maric 2007; Hamilton and Kahn 2007; Molle and Conte 2015).

Vegetative patterning, and the spatial distribution of different vegetation formations as a proxy of past productive strategies, is used here to calculate carrying capacity (Liu and Fischer 2007). General vegetation classes, specifically those corresponding to remnants of past agroforestry (e.g., *Cocos nucifera*, *Artocarpus altilis*, *Cordyline fruticosa*) and secondary forest (e.g., *Hibiscus tiliaceus*, *Rhus taitensis*), have been shown to co-vary with archaeological remains (Quintus 2012, 2015). The extent of these vegetation classes are used as a proxy of the spatial extent of tree cropping (modified agroforestry) and shifting cultivation (secondary forest) in the past.[1] The lack of arboreal food plants in secondary forests suggest a different land-use history relative to modified agroforestry sections. That shifting cultivation plots revert to secondary forest is supported by ethnographic research (Kirch 1994) and contemporary botanical research in the region (Liu *et al.* 2011: 13; Webb and Fa'aumu 1999).Yield and caloric data is derived from adjacent areas of the region (e.g., Hamilton and Kahn 2007; Kirch 1994).

Population size and density are estimated from the number of total households, as calculated from a combination of total area of settlement, terrace number and the percentage of terraces interpreted as having residential functions. The distribution of terraces within particular zones of Ofu and Olosega has been discussed elsewhere (Quintus and Clark 2012, 2016), but what has not been considered is the distribution of archaeological remains across the entirety of the islands. This was not feasible until the acquisition of LiDAR datasets from which high-resolution digital terrain models (DTM) could be derived. These DTMs enabled a more efficient and effective evaluation of the total distribution of archaeological features, and terraces are especially visible on these images. Such images are used here to identify areas of high feature density (HFD), defined by the density of terraces (see Quintus 2015; Quintus *et al.* 2015b). Absolute terrace density was calculated based on intensive pedestrian survey data from A'ofa, Tufu, and Tamatupu and extrapolated for additional HFD areas that have not been surveyed on the ground. Residential terraces were defined based on the presence of coral and terrace area, as supported by ethnographic accounts (see below). These two characteristics also correlate with elevation (Quintus and Clark 2016), a critical test of their function since Sāmoan spatial logic, at least in late pre-European times, included a graded relationship (Shore 1996: 256) wherein residential features are located seaward of non-residential features and activities (i.e., shifting cultivation).While some might question the contemporaneity of terraces, and sufficient radiocarbon dates are not available to evaluate this, it is assumed that a new terrace would not be built unless no others were available for use. Still, the number of residential features was reduced by 10% to consider residential terraces that were not actively inhabited at a given time (based on assumed use in Jackmond and Holmer 1980: 151). Various historic-era household sizes have been proposed for Sāmoa, ranging from three to seven people per structure (Davidson 1974:

235–36; Jackmond and Holmer 1980: 151). For this analysis, two estimates were calculated based on a household occupancy of three and six. Given these assumptions, these estimates are at best a reflection of a maximum population during a slice of time shortly before or just after European contact in 1722.

POPULATION DISTRIBUTION AND DENSITY

Terraces are the most common feature type encountered in the interiors of Ofu and Olosega. As such, they provide an important point of comparison between the islands. Artificially flat surfaces with as many as three free-standing sides, these terraces likely functioned as foundations for various activities (i.e., sleeping, cooking, eating, working and, perhaps, cultivation). The discrimination of function has been difficult, though the presence of waterworn coral or basalt paving (*ʻiliʻili*) and large size have been used to define those of residential function,[2] as these pavings are documented for residential structures in the ethnohistoric and ethnographic literature (e.g., Buck 1930: 19; Stair 1897: 108–9; Turner 1861: 256).

Four zones of high feature density have been identified on Ofu and three have been recorded on Olosega (Fig. 2a). More dispersed features are located outside of these HFD zones, but I suggest that these relatively well-defined HFD zones form distinct settlement units (residential areas). Contrast is apparent in considering the sheer area of each island's interior covered by the HFD zones. The three HFD zones on Olosega encompass ~61% (~1.53 km^2) of the entire land area of the interior (~2.34 km^2), which does not take into account the question of whether the remaining land area could be feasibly used. In comparison, the four HFD zones on Ofu encompass only ~31% (~1.26 km^2) of the interior land of the island (~4.11 km^2).

These zones match well the distribution of areas with less than 20 degree slope (Fig. 2b), indicating that slope was a factor in the distribution of archaeological remains to some extent. However, there are areas of Ofu that could be conducive to human settlement (under 20 degree slope) where terracing is lacking, especially inland of the Tufu HFD zone. This contrasts with the situation on Olosega where Sili-i-uta is situated within a landscape that exhibits slope well over 20 degrees, the lone HFD in such a location.

The documented terraces (n = 399) from the intensively surveyed zones range between 14 and 2,035 m^2 with an average size of 218 m^2 and a median value of 162 m^2. Tamatupu is an outlier among the settlement zones in relation to the size of terraces, while the other three zones are relatively consistent (Fig. 3). These features also vary by surface treatment, namely the presence or absence of coral. Waterworn coral rubble, often used as a paving for residential structures (see above), is present on 62% of terraces (177 out of 286), when only considering features for which data are available to evaluate surface

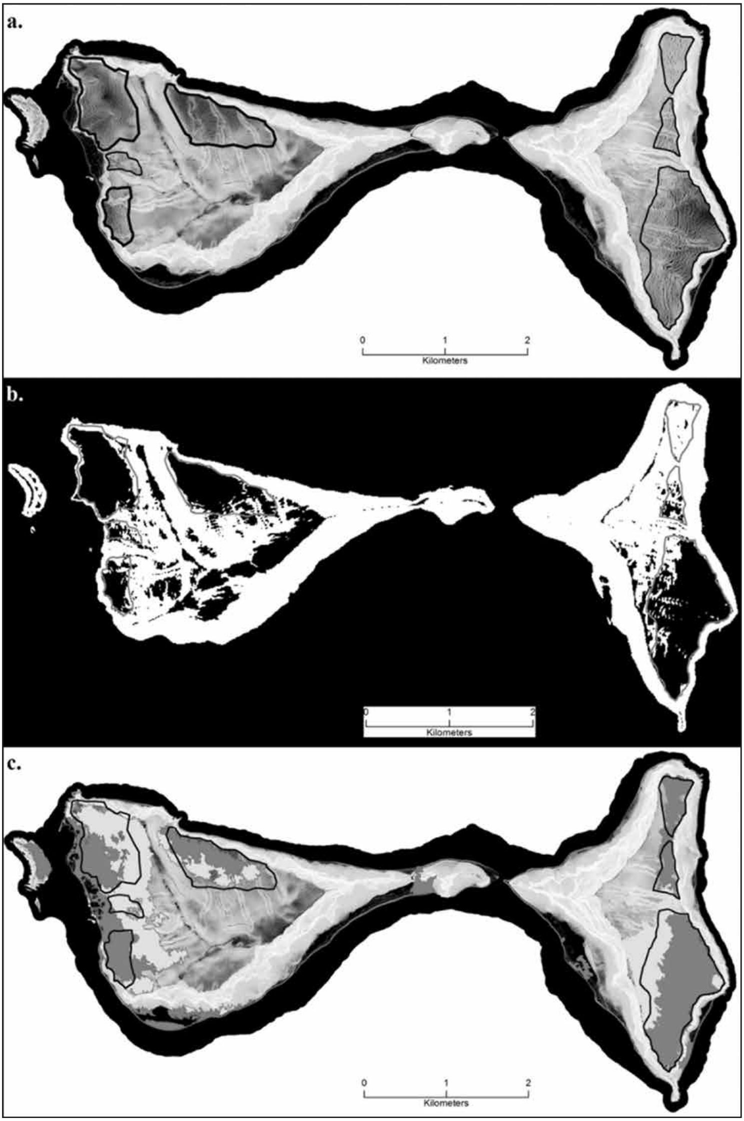

Figure 2. Patterns on Ofu and Olosega. a) Distribution of HFD zones. Darker colours are indicative of lower slopes. Those small polygons of contiguous low slope are terraces. b) Relationship between HFD zones (outlined in grey) and areas of below 25 degree slope (black). c) Relationship between HFD zones and economic (dark grey) and secondary (light grey) vegetation.

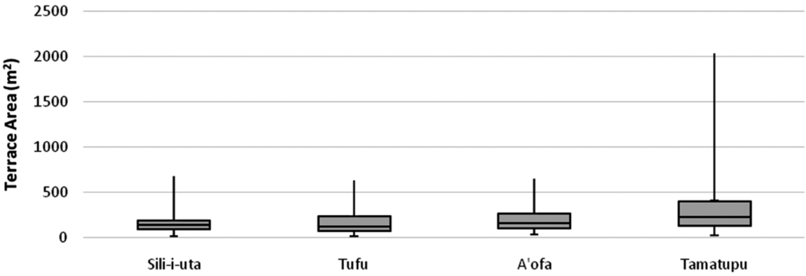

Figure 3. Differences and similarities in terrace size between the four investigated HFD zones. Box plots represent the median, quartiles and range of documented terraces for each HFD zone.

treatment or secondary features (Tamatupu, Tufu and A‘ofa). The proportion of terraces on which coral was found ranges among the three zones from 58% to 70%, with the lowest percentage in Tamatupu and the highest in Tufu. In all zones, those terraces on which coral was found are larger than those on which coral was absent (Quintus 2015; Quintus and Clark 2016). The presence or absence of coral and terrace area are the characteristics that have been used to broadly define feature function and differentiate between residential (e.g., features on which structures were built for sleeping or cooking) and non-residential (e.g., bush shelters or workshop areas) features (Quintus 2015: 214–18). Here, it is estimated that 51% of terraces served primarily residential purposes (defined as those over 200 m^2 with coral). It should be noted that those terraces with coral that were smaller than 200 m^2 and those without coral over 200 m^2 were not classified as residential.

VARIATION IN FOOD PRODUCTION

As noted above, different vegetation communities on the two islands, namely agroforests and secondary forests (Liu and Fischer 2007), have been shown to co-vary with archaeological remains (Fig. 2c; Quintus 2012, 2015). The modified agroforest vegetation zone is dispersed amongst archaeological remnants of residential features. This patterning, wherein tree crops are grown within and near to villages, is found throughout the region (Kirch 1994; Watters 1958), and because of this the vegetation group is used here to model the extent of tree cropping in vertically stratified gardens. Secondary vegetation is found immediately inland of agroforests along with a low density of archaeological remains. Given the unlikelihood of this vegetation patterning being the outcome of either storm destruction or natural fire, and position directly inland of archaeological remains, one reasonable explanation for the presence and location of secondary forest is that it marks the extent of shifting cultivation in the past. This patterning, wherein shifting cultivation is practiced inland of villages and arboricultural zones, is well documented ethnographically for the region (Kirch 1994).

Other forms of cultivation can also be inferred. Ditches are present on Olosega that appear to be boundaries on the landscape separating vegetation types and terraces of different characteristics. At least at Tamatupu, terraces upslope of the ditch (Feature 38) tend to be small and are less likely to exhibit coral on their surfaces (Quintus and Clark 2016). The ditch itself is located at the interface of modified and secondary forests, potentially the division between arboriculture (downslope) and shifting cultivation (upslope) (Quintus 2012). Another possible ditch is present at Sili-i-uta, visible in slope and hillshade maps derived from a LiDAR dataset (Quintus *et al.* 2015b), and this feature, too, is located at the upslope boundary of modified forest as proposed in Liu and Fischer (2007). Both of these ditches spread across of the length of their associated HFD zones, with the example from Tamatupu measuring around 1.2 km long and the possible example at Sili-i-uta some 400 m. One function of these features was as sediment and runoff traps to ensure eroded sediments from upslope were not deposited on residential features downslope (Quintus 2012). This interpretation is further evidenced by cuts in the downslope bund of the ditch at Tamatupu in low-lying areas and streams.

Ditching is also found on Ofu, although at a more localised scale. Instead of separating large expanses of land as on Olosega, ditching on Ofu bounds plots or parcels ranging in size from 172 to 3,063 m^2 (Quintus 2015: 180, 198). The sloping nature of the parcels and the lack of structural remains on the surface suggests that they were cultivated, with the ditches serving to bound and protect those cultivated parcels by channelling high-energy surface runoff and sediment away from cultivated plots (Quintus *et al.* 2016: 284–86). Reducing overland runoff might have reduced erosion of the soils in cultivated plots as well.

The hypothesised spatial extent of productive techniques is used to model potential production capacities that will allow for coarse comparison of strategies.[3] Yields from shifting cultivation (n ~114.5 ha on Ofu; n ~52 ha on Olosega) can vary based on rainfall, slope and other factors, but an average of 11 t/ha is used to estimate the yields from multi-cropped (e.g., taro, yam, banana) shifting cultivation plots in colluvial slope environments (Kurashima and Kirch 2011: 3664). A fallow value of 50% is used for shifting cultivation. This takes into account the fact that some land would not be in production while other land would still be in production but not actively cultivated (perennial crops). Certainly, actual fallow periods could and would fluctuate widely. Yields from vertically stratified gardens within residential zones (n ~81 ha on Ofu; n ~107 ha on Olosega) are more difficult to estimate, especially since the exact nature of these strategies is unknown (i.e., the mixture of different crops). Instead of assessing the yield of individual crops, an estimate from agroforestry zones of 12.46 t/ha is used (based on Hamilton and Kahn 2007: 146). This estimate takes into account mixed crops grown in agroforestry zones on the West Polynesian island of Futuna, the closest analogy available. It is assumed that 20% of land presently under modified forest cover would have been taken up by structures when the area was inhabited (from Kirch 1994: 181, based on work in Futuna). Ditch-and-parcel strategies, found only on Ofu (n ~3.3 ha), are likely to have been more intensively cultivated, as inferred from the fact that these are close to residential complexes and are permanently marked plots. I use the figure of 11 t/ha for this strategy as well, to highlight that crops grown in these locations may have been similar to shifting cultivation plots, but a low fallow figure of 10% is applied because it is likely these plots were more intensively cultivated than others. The results of this analysis are presented in Table 1. What is most apparent from these results is the differing ratio of calculated yields from shifting cultivation to vertically stratified gardens on Ofu (0.78) and Olosega (0.27).

Table 1. Production estimates based on the distribution of vegetation.

		Strategy	% Fallow	Cultivated Land (ha/yr)	Yield mt/ha/yr	Total Yield mt/yr	% of Total
Ofu							
Modified Forest	81 ha	Arboriculture	20	65	12.46	810	55
	3.3 ha	Ditching	10	3	11	33	2
Secondary Growth	114.5 ha	Slope Cultivation	50	57.25	11	630	43
Olosega							
Modified Forest	107 ha	Arboriculture	20	86	12.46	1,072	79
Secondary Growth	52 ha	Slope Cultivation	50	26	11	286	21

CARRYING CAPACITY AND ESTIMATION OF POPULATION SIZE

The distribution of terracing, and hypothesised differences in food production, hint at variation in population sizes and densities. Prior attempts at such estimates have been limited to general calculations based on land area and European approximations, with the entire population of Manu'a (Ta'ū, Ofu and Olosega) estimated to range from 1,100 to 1,400 people (see Green 2007: 212, Table 11.4). The question of potential population size is addressed here by calculating carrying capacities and considering settlement patterns.

The production estimates for Ofu and Olosega were used as the basis for a first-order calculation of K. These results are presented in Table 2 based on a caloric return of 1,230 kcal/t for each cultivation strategy (estimated return from colluvial slope category in Kurashima and Kirch 2011: 3672) and an average 2,700-calorie diet (based on USDA-recommended values for active adults aged 19–30). If we assume that terrestrial production constitutes ~80% of the diet, a value derived from adult-human stable-isotope studies for the second millennium AD on the island of Tutuila (Valentin *et al.* 2011), the production system of Ofu could support a population density of ~315 people/km^2 and Olosega a population density of ~424 people/km^2.

Table 2. Carrying capacity calculations based on production estimates cited above.

	System	Estimated Yield	Caloric Value	Caloric Output	Carrying Capacity	Total	Density (people/km^2)
Ofu							
	Arboriculture	810	1,230	996,300	1,011		
	Slope	630	1,230	774,900	786		
	Ditching	33	1,230	40,590	41		
	Total Population					1,838	252
	Total with Proteins					2,297	315
Olosega							
	Arboriculture	1,072	1,230	1,318,560	1,338		
	Slope	286	1,230	351,780	357		
	Total Population					1695	339
	Total with Proteins					2,119	424

The results of this carrying-capacity estimate were evaluated and supplemented by an examination of terrace density and house counts. Based on data from the four HFD zones subject to the most intensive survey, the number of terraces per hectare ranges from 3.3 to 5.2 terraces. This number was then modified to consider only residential features, using the definition of residential terraces presented above (average of 51% of total terrace dataset). Based on this, the density of residential terraces ranges from 1.68 to 2.65 terraces/ha with an average of 2.13 terraces/ha. The average is used to calculate the number of total households by multiplying the area of each settlement zone by the average density of terraces: a total of 273 residential terraces are calculated for Ofu and 326 for Olosega. An occupancy rate of 90% is used in this preliminary analysis following previous work in the archipelago (Jackmond and Holmer 1980: 151), a figure that likely results in a high estimation. Radiocarbon ages are absent from Olosega and single radiocarbon determinations from individual terraces on Ofu tell us little about actual use life (but see Quintus 2015). Based on this analysis (Table 3), the population density on Ofu ranged from ~101 (3 per household) to ~202 (6 per household) people/km^2 and on Olosega from ~176 (3) to ~352 (6) people/km^2. The maximum population density on either island was likely between these figures as the occupancy rate of 90% may never have been achieved. The estimate based on the assumption of a 90% occupancy rate and a household size of three would be similar to an estimate based on the assumption of a 40%–50% occupancy rate and a household size of six. Regardless of actual population size, the comparison is useful and relevant as long as the variables are held constant for both islands.

The estimate based on the assumption of six individuals per household and a 90% occupancy rate constitutes ~64% of estimated K for Ofu and ~83% for Olosega. These ratios are similar to those historically known for some Polynesian Outliers (Bayliss-Smith 1974), though carrying capacity was calculated differently in that instance. Both settlement patterns and carrying capacity are suggestive of a higher population size and density for Olosega relative to Ofu, even if the actual figures are approximations.

Table 3. Demographic estimates based on distribution and density of terracing (details in text).

	Total Area (ha)	Residential Terraces	10% Reduction	Population (3)	Population (6)	Density (3)	Density (6)
Ofu	136	290	261	737	1,474	101	202
Olosega	153	326	293	879	1,758	176	352

The Population size estimates reported here for Ofu and Olosega are also substantially larger than those recorded after European contact. Based on his assessment of the early historic record, Green (2007: 212) reported that populations in Manu‘a rose in the period from 1840 to 1853 from 1,174 to 1,275. If that was true, Manu‘a would be an outlier in the Pacific where population crashes were common following European contact (see Kirch and Rallu 2007). Alternatively, in light of this analysis, increased populations in Manu‘a after 1840 might be the manifestation of a small population rebound following earlier severe depopulation. Instead of stability between the pre- and post-contact periods, the results here, if correct, indicate a population reduction of well over 50% in Manu‘a following European contact. A population reduction of this magnitude by the mid-19th century is consistent with descriptions of potential disease in Manu‘a in the late 18th century (La Pérouse 1798 [III]: 62).

DISCUSSION

Similarities in settlement systems between Ofu and Olosega are not surprising given how close they are geographically and how close they were socially (Mead 1969). The range of feature classes is similar for each island, and terraces constitute the majority of landscape modifications. These features had similar attributes and, presumably, similar functions. Still, proximity did not preclude the development of variation that aids in elucidating the potential relationship between the people that inhabited these islands (Table 4). Populations were modifying steeper slopes on Olosega relative to Ofu, evidenced by the percentage of the total inland area taken up by HFD zones and the location of Sili-i-uta as an outlier. Their production systems were qualitatively similar, but analyses presented here hint of quantitative differences in the use of strategies. Most noticeably, the cultivation of tree crops appears to have contributed more substantially to production on Olosega than on Ofu. Finally, both carrying-capacity estimates and settlement patterns seem to indicate a higher population size and density for Olosega relative to Ofu.

Table 4. Major differences between Ofu and Olosega.

Attribute	Ofu	Olosega
Largest terrace	681 m²	2,035 m²
% of interior in HFD area	31	61
Settlement pattern estimated as % of carrying capacity	64	83
Ratio of shifting cultivation to arboriculture	0.78	0.27

Generally, higher population size and density correlates with different forms of community organisation (Carneiro 1986). In essence, higher population size would translate to the availability of a larger labour force that could be drawn upon by community leaders, and higher density would require different mechanisms of organisation. This is particularly evident on Olosega by community-wide labour constructions in Tamatupu, such as star mounds and ditching, and more star mounds are found in association with Tamatupu relative to any other area of either Ofu or Olosega. Star mounds are associated with chiefly competition and, therefore, political competition (Herdrich and Clark 1993), and the sheer number of these monumental features on the ridgeline adjacent to Tamatupu speaks to the labour expended by the population toward this activity (Quintus and Clark 2012). Consistent with this, the largest terrace identified in Tamatupu (2,035 m^2) is roughly three times the size of the largest terrace outside of Tamatupu (681 m^2). Power is also apparent in the construction of a single long ditch stretching the length of Tamatupu as this would likely have required more sustained intra-community labour investment and buy-in from residents given its spatial extent and probable need for continued maintenance. This combined evidence hints that the Tamatupu settlement was politically prominent at one time.

Therefore, the subsistence system of Olosega apparently was capable of supporting a large population density and materialised political processes, but such densities and processes may not have been sustainable. Ethnohistoric records document Olosega as the instigator of or involved in aggressive actions by the late 18th and early 19th century (Krämer 1902–03 [I]: 597–98, 600–601; Wilkes 1852: 157; Williams 1837: 414), even though conflict in Manu‘a is thought to be minimal compared to the western islands of the archipelago (Goldman 1970; Mead 1969). This protohistoric conflict might relate to external factors (e.g., influx of Christianity), but a consideration of how production strategies and population density reduced settlement resiliency by creating vulnerability to periodic tropical cyclones provides another plausible hypothesis for such aggression.

Tree Crops and Rigidity: A Preliminary Hypothesis

The cultivation of tree crops appears to have been the chosen mechanism of increased production on Olosega, supporting higher population densities as it allowed exploitation of the arboreal niche. (after Latinis 2000) in the context of limitations to land availability (see Kirch and Yen 1982). As Huebert (2014: 289–90) notes, the cultivation of tree crops provides high yields for limited labour (see also Yen 1974: 278) and tree crops were an avenue to increasing food production since these trees increase the vertical capacity of production (Huebert 2014: 20–21). At least in Near Oceania, these tree gardens are a significant component of production systems that support villages in the thousands (Terrell 2002: 198).

Based on the foregoing, I hypothesise that tree cropping on Olosega might have been a strategy that could be integrated within and around residential settings, transmitted to subsequent generations and expanded upon. Such a strategy is important in densely occupied areas since the loss of areas suitable for shifting cultivation through residential expansion could have been offset by further investments in tree cropping. However, this strategy could also present problems. Paulson (1993: 45) notes that as much as 100% of the breadfruit and banana crops were destroyed during Cyclone Ofa in the early 1990s. More recently, a cyclone in 2005 resulted in severe damage (i.e., uprooting or snapping) to 57% of all trees on Ta'ū, with trees such as breadfruit and coconut being particularly susceptible to damage (over 70% severely damaged) (Webb *et al.* 2014: 35).Though some trees might survive, recovery of these systems happens on a scale of years to decades (Clarke 1992; Colding *et al.* 2003; Paulson 1993). This, in turn, means that reliance on tree crops increases the vulnerability of a population to stochastic environmental perturbations.

While the cultivation of tree crops on Olosega might have initially increased subsistence system diversification and risk management (after Latinis 2000), tree cropping in the late pre-contact and protohistoric period may have been geared toward product maximisation (after Allen 2004) to support both increased population and apparent social processes (e.g., construction of monumental architecture).This type of formation of feedback loops between subsistence and population can create rigidity traps. Rigidity traps, or lock-in strategies, are an outcome of decisions that create path-dependent trajectories, in this case the need to practice space-saving and high-yielding production strategies, which become increasingly inflexible over time (Hegmon *et al.* 2008; Holling and Gunderson 2002; Schoon *et al.* 2011). I hypothesise that a rigidity trap developed on Olosega as increased population density required further investment and increased reliance on tree crops as a strategy of increased production.

Path dependency becomes problematic when populations are overly reliant on one strategy (Kidder and Liu 2017). Reliance is an outcome of the lack of other options, especially as time passes. If the distribution of secondary forests accurately reflects the distribution of shifting cultivation, land suitable for expansion of shifting cultivation on Olosega was limited to areas of high slope (over 30 degrees). The strategy of cultivating steeper slopes would have been met with diminishing returns as soils eroded from these hillslopes, and experimentation with this strategy might be one reason why community-length ditching was necessary to protect residential areas. In this environmental context, investments in tree cropping were a robust strategy in light of an increasing and expanding population, robust in the sense of ensuring the maintenance of performance characteristics (Hegmon *et al.* 2008: 321). But, increased robustness to some changes (i.e., population increase) created vulnerabilities because of overreliance and increased inflexibility. The solving of one problem can lead to another. In this case, increased dependency on tree crops translated to increased population vulnerability to cyclone damage.

Even while capable of supporting a higher population size and density, the system of cultivation on Olosega as defined here would have been more susceptible to production variation relative to that on Ofu because of the periodicity of cyclones, though this is not to say that there was a food shortage or demographic collapse. Instead, variation could have translated into a decreased ability of elites to mobilise surplus to fund initiatives in this small-scale society. Fluctuations that cause the shortage of either social or subsistence production can be met with alternative methods of food acquisition. This case of variation in population and production might have created conditions for increased conflict in the late prehistoric and early protohistoric periods (18th and 19th centuries), conflict that is recorded ethnohistorically and ethnographically. In this way Ofu and Olosega would appear similar to cultural sequences in several regions of Polynesia where late period conflict was the result of production variation (Kirch 1994, 2010; Ladefoged 1995). However, in the present case it is the population that controls the higher productivity environment that instigates conflict. This is the result of the social creation of vulnerability instead of the response to the variable productive potential of different environments, as is the case in Hawaiʻi and Rotuma.

This interpretation is based on the correlation between high population density and tree cropping on Olosega. Certainly, additional fieldwork and archaeobotanical data is needed to test these interpretations. The hypothesis presented here generates a new set of testable expectations regarding productive landscapes, settlement distribution and population estimates as they pertain to resilience and vulnerability. While the distribution of modern vegetation might be used as a rough proxy for a slice in time, there is also the potential for substantial error and limited ability to understand diachronic change. It is expected that tree cropping would expand over time, in concert with increased population density. This situation is also true of settlement patterns. The calculation of total residential terraces here was based on a robust dataset of features from these islands, but could and should be augmented and modified based on targeted household excavation to examine feature function and use life. One expectation from this hypothesis is that the settlement of Sili-i-uta occurred after considerable investments in the Tamatupu zone.

* * *

Variation in cultural practices will develop based on minor ecological differences and the cumulative effects of human decision-making. These cumulative effects can have a substantial impact on the nature of resiliency and vulnerability in island environments. On Ofu and Olosega, populations solved similar problems with, at times, different solutions. Those different solutions fed back to create conditions impacting the context of future decision-making. Importantly, population and production dynamics appear to have created a rigidity trap that might have made communities on Olosega more vulnerable to local environmental perturbations. These pre-contact, small-island societies serve as important models for contemporary populations in the region. As people continue to respond to changing landscapes, it is necessary to remember that even robust solutions to particular problems often have unforeseen consequences beyond the sight of a single human generation. Resilient solutions require the retention of flexibility in cultural practice, enabling response to a broad range of outcomes.

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NOTES

1 A 2011 version of this vegetation survey did not use the same classification system as the 2007 survey. The 2007 survey is used here since the 2011 classification system did not consider the class of agroforestry (Liu *et al.* 2011: 9). The agroforestry component of modified forest was confirmed by Satele (1999) for Sili-i-uta.

2 Activities such as eating and sleeping are defined as residential. A single terrace could support multiple structures serving different functions.

3 The coastal flats would also have been used by producers, but the area available for cultivation was minimal compared to the interiors. These areas are not considered here.

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ABSTRACT

The archaeology of Sāmoa has been structured around the investigation of settlement patterns and systems since the 1960s, and such investigations have been variously used to explore questions of temporal change relating to, among other things, political structure and subsistence. This same intellectual structure is applied here to the evaluation of variation between the geographically close islands of Ofu and Olosega, extending previous approaches by considering population estimates. These analyses, which include a calculation of carrying capacity and population estimates based on settlement patterns, suggest that Olosega supported a higher population density than Ofu, perhaps because of investments in tree cropping on the former. Variation in settlement distribution, subsistence strategies and population density has important implications for population resiliency and vulnerability in small-island societies.

Keywords: Sāmoa, population estimation, settlement patterns, vulnerability, Manu'a Islands

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[1] Correspondence: Department of Anthropology, University of Hawai'i at Mānoa, 2424 Maile Way, Honolulu, Hawai'i 96822, USA. Email: squintus@hawaii.edu

USING UNSUPERVISED CLASSIFICATION TECHNIQUES AND THE HYPSOMETRIC INDEX TO IDENTIFY ANTHROPOGENIC LANDSCAPES THROUGHOUT AMERICAN SAMOA

STEPHANIE S. DAY
North Dakota State University

Locating ancient and historic settlements and other anthropogenically modified areas that have been abandoned is a challenging task. These areas are likely small, and they are typically obscured by vegetation and the redistribution of sediment. In many locations, the terrain may be difficult for investigators to traverse, and anthropogenic features may be subtle. A variety of remote sensing technologies are now improving our ability to locate prehistoric anthropogenic landscapes around the world. While much of the current remote sensing in the archaeological literature focuses on satellite imagery (i.e., Garrison *et al.* 2008; Gupta *et al.* 2017; Lasaponara *et al.* 2016; Law *et al.* 2017), the use of aerial LiDAR is also widespread. Aerial LiDAR is particularly ideal in places where dense vegetation obscures the ground surface from satellite imagery and where anthropogenic modifications have left a topographic signature, both of which are true in many locations throughout the Pacific (Chase *et al.* 2010; Freeland *et al.* 2016; McCoy *et al.* 2011; Parcak 2009).This includes the islands of American Samoa.

The ability of aerial LiDAR to capture high-resolution data on the earth's surface, even through dense vegetation, has shifted how we understand the natural variability of a landscape and the modifications that people make to it. In American Samoa, most prehistoric landscape modifications focused on creating flat terraces in the steep interior for residential and non-residential (e.g., agricultural) activities (Quintus 2015; Quintus *et al.* 2015). Additional modifications were made by creating large steep-sided mounds with flat tops, referred to as star mounds, which were used for chiefly sports and ceremonial purposes (Herdrich 1991), as well as ditches used for routing water and sediment or as land boundaries (Quintus 2015; Quintus and Clark 2012), and walls for dividing fields (Quintus *et al.* 2017). Of all of the prehistoric anthropogenic modifications in American Samoa, terraces are the most widespread and are present in nearly all known settlements; star mounds, ditches and walls are not. Flat surfaces are therefore the focus of this paper and will be referred to as terraces throughout. It is important to note that other flat surfaces, including those that were not artificially created, will be identified with this methodology, yet on this steep terrain these are still potential areas of anthropogenic activity.

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Flat terraces disrupt the natural slope by representing a notch cut into it. While this modification certainly impacts local slope, it also impacts other topographic measures, including the one addressed here: hypsometry. Hypsometry is defined as a measure of elevation relative to sea level. Geomorphologists have used this measure to examine hillslope processes by creating a non-dimensional curve and hypsometric index (HI). On a hillslope scale, high HI values are associated with unstable basins or diffusive processes while lower HI values (<0.5) are stable or dominated by fluvial processes (Schumm 1956; Strahler 1964; Willgoose and Hancock 1998). HI is defined as

$$HI = \frac{E_{mean} - E_{min}}{E_{max} - E_{min}} \qquad \text{(Eq. 1)}$$

where E_{mean} is the mean elevation, E_{max} is the maximum elevation value and E_{min} is the minimum elevation value. On a completely flat surface, HI is undefined because $E_{mean} = E_{max} = E_{min}$. For any even slope where there is no variation HI will be 0.5 because E_{mean} will be exactly equidistant between E_{max} and E_{min}. Departure between these two values occurs when any variation exists in the slope. In the case of terraces, the HI value will vary based on the computational area and location being considered. If evenly distributed terraces are being considered over a large sloped area, the HI value will be 0.5. This is because although the elevations are distributed differently, E_{mean}, E_{max} and E_{min} do not change. If a smaller computational area is used and only a portion of the terrace is considered, the HI values will vary from nearly 1 at the downslope edge to nearly 0 at the upslope edge depending on if E_{mean} approaches E_{max} or E_{min} (Fig.1). The idea of creating a small moving window and measuring the HI value within that window was first introduced as a measure of topographic roughness and is also referred to as the relative topographic position or topographic position index (Jenness 2004). In this paper, it is used to identify patterns of anthropogenic landscapes specifically focused on the signature of terraces and other flattened surfaces. This index may provide an advantage over a simpler slope classification as it can account for areas that were artificially flattened but do not adhere to the typical very low slope definitions used for terraces.

In addition to taking advantage of HI to identify anthropogenic landscapes, I also attempt to automate the process by creating a combined dataset that is then used for an unsupervised classification. Other researchers have applied supervised classifications to highlight different anthropogenic landscapes in American Samoa (e.g., Quintus *et al.* 2015; Rieth *et al.* 2008). Unsupervised classification provides a unique advantage over supervised classification

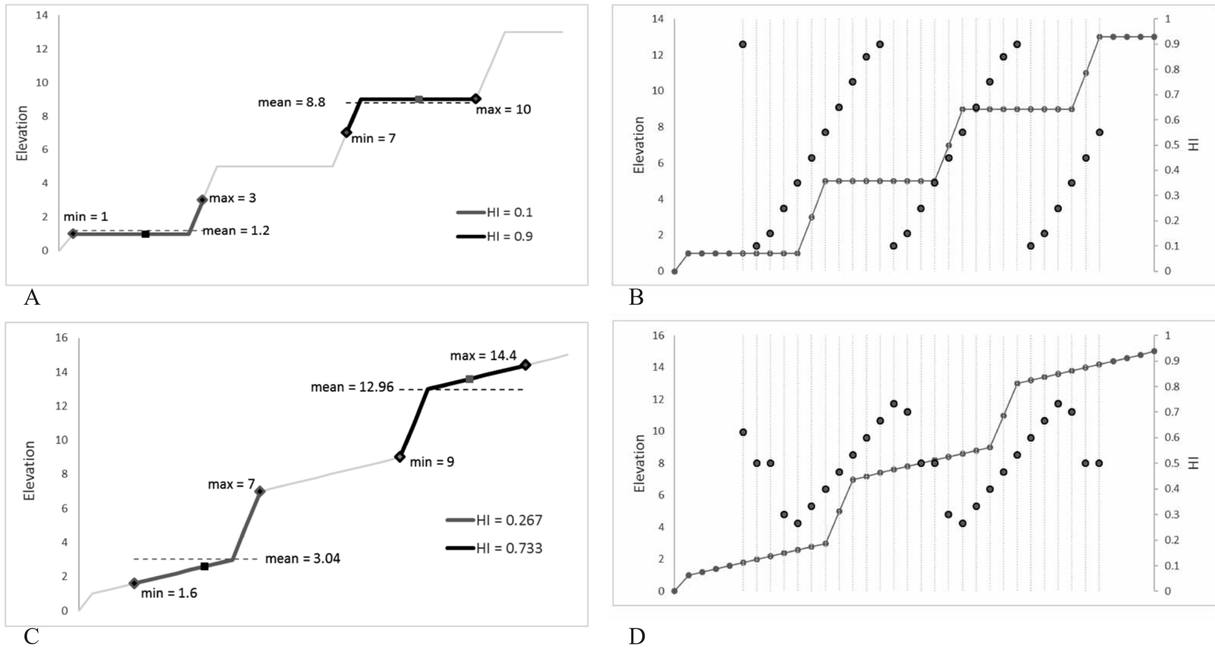

Figure 1. If the hypsometric index (HI) is calculated using a moving window over a small area of a terrace, the HI values will vary across the surface of the terrace. In the charts above, HI was calculated over a ten-unit window across an idealised terrace surface. For a given terrace surface HI calculated near the upslope edge will approach 1 while HI calculated near the downslope edge will approach 0. For A and C the heavy lines indicate the area over which the HI value was calculated for the point marked with a box. The mean, maximum and minimum values are provided. B and D show how the HI value changes moving across the terrace surface. Comparing the flat and sloped terrace surface shows that HI varies across the terrace more strongly if the tread is very flat, yet even for steeply sloped terraces HI values vary from front to back.

because it can be used in areas where specific class locations or breakpoints are unknown. In the case of American Samoa, large-scale anthropogenic areas are well documented on some islands (Ofu and Olosega: see Quintus 2011, 2015, 2018; Quintus and Clark 2012, 2016; Quintus *et al.* 2015) and poorly defined on other islands (Tutuila: Clark and Herdrich 1988, 1989, 1993; Frost 1976, 1978; Kikuchi 1963; Pearl 2004). I can identify the classification parameters first by using known anthropogenic areas and then extend the method to other areas.

Site Description

American Samoa is made up of five main islands and two coral atolls. The islands are part of the Sāmoan Archipelago, which also includes the islands of the Independent State of Samoa. The islands are all volcanic in origin, with a clear west-to-east trend of younger islands. Tutuila, the oldest and largest island in American Samoa, is also the most dissected. Well-developed channels have carved the uplands creating a rugged inland topography. Aunu'u, which lies to the southeast of Tutuila, was likely formed at the same time as Tutuila (Natland 1980) and is included in the Tutuila dataset for this paper. Ofu and Olosega lie 96 km east of Tutuila and formed at approximately the same time geologically. These islands are separated by a narrow channel, which today is spanned by a bridge. Unlike Tutuila, many areas of the uplands of Ofu and Olosega have not been dissected by channels, leaving large areas of sloped interior. Furthest east is Ta'ū, which lies 10 km southeast of Olosega. Ta'ū is the youngest island in American Samoa and as such is the least dissected. Only a few young channels exist on this island, leaving much of the interior undissected. It is in these evenly sloped, undissected areas of the interior that anthropogenic landscapes are most likely to be found. Channel valleys were difficult places to settle as these areas generally are steep and subject to more erosion.

This study focuses on the islands of Tutuila, Ofu and Olosega. Ta'ū is excluded because aerial LiDAR data are not available for the entire island, and the most well-documented anthropogenic area has walled terraces rather than the classic cut-fill terraces present on the other islands in American Samoa (Quintus *et al*. 2017).

METHODS

LiDAR data collection was funded by NOAA and the American Samoa Government, and collected in 2012 by Photo Science Inc. LiDAR point clouds were then processed to create one-metre bare-earth digital elevation models (DEMs). All the following products used in this project were derived from these DEMs using ArcGIS v10.3.

Hypsometry

As described above, hypsometry is a way of simplifying landscape variability in such a way that it can be described by a curve or by a single number. While hypsometry is typically calculated on the scale of an entire landscape, hillslope or watershed, here I am using it on a smaller scale to examine topographic roughness. This approach allows us to examine change across the landscape and to locate areas potentially modified by humans.

Each input for the hypsometric index equation (Eq. 1) was found using the focal statistics tool. This tool uses a moving window to calculate the mean, minimum and maximum values of the DEM for a defined window. For this project, 10 × 10, 20 × 20 and 30 × 30 m windows were used, as these window sizes scale approximately with the features of interest. After the raster products were derived, the raster calculator was used to calculate HI values for each cell.

Variability of HI values was also computed. HI values are likely to have high variability in anthropogenic landscapes with closely spaced terraces and lower variability on ridge tops or unmodified slopes. Variability was measured using the focal statistics tool to measure range and standard deviation within a 100 × 100 m window. The 20 × 20 m HI values were used to measure this variability because this window size preserves the large details of these anthropogenic features while smoothing the subtle variation expected in the natural landscape. Additionally, each factor in the HI equation was squared, and an HI-squared value was calculated. This value emphasises subtle differences in HI. The HI-squared parameter can be particularly beneficial in areas where the differences in HI are subtle, such as on sloped terraces.

Classification

To perform the classification, five composite band raster datasets were created. These composite raster datasets are made up of four to six bands of raster data selected from derived data sets including the 10 × 10 m moving window HI, the 20 × 20 m moving window HI, the 30 × 30 m moving window HI, the 20 × 20 m moving window HI squared, the slope, the 100 × 100 m moving window of the standard deviation of the 20 × 20 m moving window HI, and the 100 × 100 m moving window of the range of the 20 × 20 m moving window HI (Table 1).

Unsupervised classification was performed using all five composite datasets for Ofu and Olosega as well as Tutuila. The iso cluster unsupervised classification tool in ArcGIS was used to classify the data. This type of classification groups pixels that have similar values in each band of the composite dataset. The number of classes needed to best capture anthropogenic landscapes was tested on Ofu and Olosega, where anthropogenic areas have been well documented (Quintus 2011, 2015,

Table 1. Composite raster datasets tested.

Band[1]	Composite 1	Composite 2	Composite 3	Composite 4	Composite 5
10 × 10 HI	x	x			
20 × 20 HI	x	x	x	x	x
30 × 30 HI	x	x			
20 × 20 HI2				x	x
Slope	x		x	x	
20 × 20 HI 100 St Dev	x	x	x	x	x
20 × 20 HI 100 Range	x	x	x	x	x

[1] Bands are arranged on the table in the order they were added to the composite raster.

2018; Quintus and Clark 2012, 2016; Quintus *et al.* 2015). It was found that using three to five classes was most appropriate, because when more classes were used two or more classes in combination captured the known anthropogenic areas, and fewer classes combined non-modified areas with areas of anthropogenic modification. Visual inspection was used to identify what class or classes corresponded to known anthropogenic areas, or in the case of Tutuila, areas that appeared to be anthropogenically modified based on the DEM and associated derived products.

After classification was complete, confusion matrixes were created for each classification completed for Ofu and Olosega (Story and Congalton 1986). Accuracy, precision, true positive and true negative were all calculated from the confusion matrixes on the full island scale. In addition, the true positive rate was calculated for each individual anthropogenically modified area as described by Quintus (this issue).This step highlighted how different classifications were better for different anthropogenic areas.

RESULTS

Based on visual observation, moving-window hypsometry highlighted terraced areas. This made them easier to identify when compared with the DEM and hillshade alone. Areas of known or probable prehistoric anthropogenic landscapes could be identified even when examining the data over large areas because of the stark contrast between the flat terrace and the sloped areas between (Fig. 2). The classification results below quantify how successful moving-window hypsometry is at identifying anthropogenic landscapes. Results from Ofu and Olosega are discussed separately from Tutuila, as the locations of prehistoric modifications are better documented on these two islands.

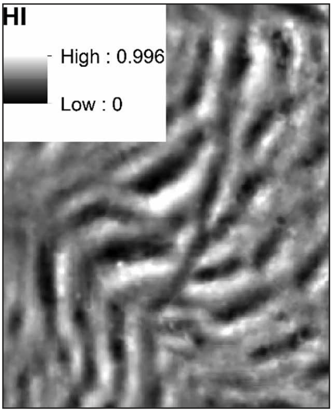

Figure 2. This area showing terraces on Olosega demonstrates the contrast between high-HI areas near the upslope areas of the terrace and low-HI areas at the downslope edge of the terrace.

Ofu and Olosega

The total area delineated as interior anthropogenic landscapes for Ofu and Olosega makes up 23% of the island area where there is no modern anthropogenic modification (interior anthropogenic area = 2.7 km^2, modern anthropogenic area = 0.73 km^2, total island area = 12.5 km^2). A total of 14 classifications were completed, for five composite datasets and the slope classification, to automatically identify the areas of anthropogenic landscapes. All but four classifications overestimated the total anthropogenic area finding that 20 to 36% of the island where there is no modern anthropogenic modification has evidence of prehistoric modification. Accuracy and precision ranged from 58 to 78% and 16 to 53% respectively for all classifications (Table 2). While slope had the highest accuracy along with all other composite datasets that included slope (1, 3 and 4), the precision for slope alone was slightly lower than those composite datasets where slope and hypsometry was combined. In addition, the composite data sets that included slope also had higher true positive and true negative rates than slope alone.

The composite datasets that did not include slope (2 and 5) had the lowest rates of accuracy, precision, true positives and true negatives when considering all anthropogenic areas on the islands combined. When the true positive rate for each anthropogenic area is considered individually those composite datasets without slope have the greatest true positive rates at both Sili-i-uta and Sili-i-uta South; in the case of Sili-i-uta, composite datasets 2 and 5 had a true positive rate 20% higher than found for all other composite datasets (Fig. 3).

Table 2. Classification results for Ofu and Olosega.

Composite Dataset	Number of Classes	Accuracy	Precision	True Positive Rate	True Negative Rate
1	4	78%	53%	50%	87%
1	3	77%	50%	74%	78%
2	5	66%	33%	49%	71%
2	4	60%	21%	26%	70%
2	3	59%	17%	21%	70%
3	4	78%	53%	52%	86%
3	3	76%	49%	76%	76%
4	4	78%	52%	50%	86%
4	3	76%	49%	75%	77%
5	6	68%	32%	35%	78%
5	5	66%	34%	50%	71%
5	4	60%	16%	18%	73%
5	3	58%	17%	22%	69%
Slope[1]	2	78%	51%	69%	80%

[1] Slope was classified as above or below 20º.

The combined effectiveness of the four composite datasets that were the best for each anthropogenic area, classifications 2/5, 3/3, 3/4 and 5/5 (where the convention is: composite #/# of classes), was examined (Fig. 4). Using this combined dataset, 4 to 31% of each anthropogenic area was classified appropriately by all four datasets, and 65 to 93% of the anthropogenic area was identified correctly by at least one dataset.

Tutuila

On Tutuila, only a limited number of known interior prehistoric anthropogenic areas exist (Clark and Herdrich 1993; Pearl 2004), with the assumption that many more likely exist than have been formally identified. As a result, the calculation of formal confusion-matrix statistics is impossible; rather, these data can be used to reveal general anthropogenic trends and identify areas of likely anthropogenic landscapes.

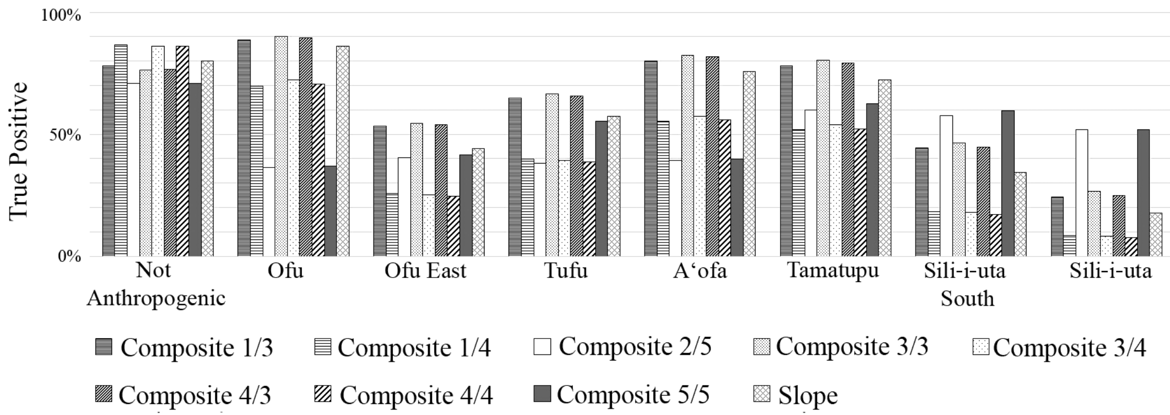

Figure 3. Calculating true positive rates by anthropogenic area shows that while composite datasets that include slope do a better job overall of predicting anthropogenic areas, certain anthropogenic landscapes which do not adhere well to the slope model are better predicted by a composite dataset that excludes slope, and rather relies on hypsometry alone.

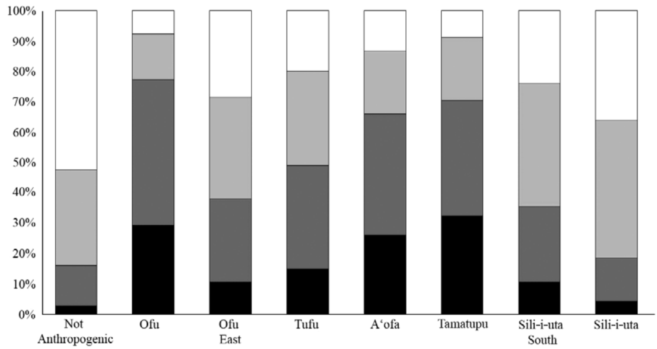

Figure 4. Classifications 2/5, 3/3, 3/4 and 5/5 were combined to find the total area in each anthropogenic area captured by one, two, three or all four of these datasets. Moving down through each column, the darker shades of grey indicate the number of datasets identifying that fraction of the total anthropogenic area where black is all four datasets and white is none of the datasets. Note that for "Not Anthropogenic" ideally none of the datasets would identify that area as anthropogenic.

The same set of composite datasets was used for classification on Tutuila as those used on Ofu and Olosega. The only modification made was that composites 2 and 5 were only classified using five classes as this was revealed to be the most effective. Unlike on Ofu and Olosega, it was not clear which class corresponded to the likely anthropogenic areas for composites 2 and 5 with two potential candidates for both classifications; therefore two classes are reported for both of these classifications. For all classifications, 7 to 23% (averaging 12.7%) of the island is classified as likely anthropogenic landscapes (Table 3).

A combined dataset was created for Tutuila using all available composite dataset classifications. In total, ten datasets were combined, but because two were based on the same classification (yet represent two separate classes) the maximum number of datasets that could classify a given area as anthropogenic is eight. Figures 5 and 6 show the cumulative percent of island area represented as anthropogenic by a decreasing number of classifications. Four or more classifications identify 12% of the island as anthropogenically modified, and they appear to capture all known anthropogenic areas as well as most areas observed as likely anthropogenic based on the hypsometry moving-window dataset and the hillshade.

Table 3. Results from Tutuila classification.

Composite Dataset	Number of Classes	Class Selected as Settled	Percent Settled
1	3	1	14%
1	4	1	10%
2	5	3	8%
2	5	4	7%
3	3	1	14%
3	4	1	10%
4	3	1	14%
4	4	1	10%
5	5	2	23%
5	5	3	18%

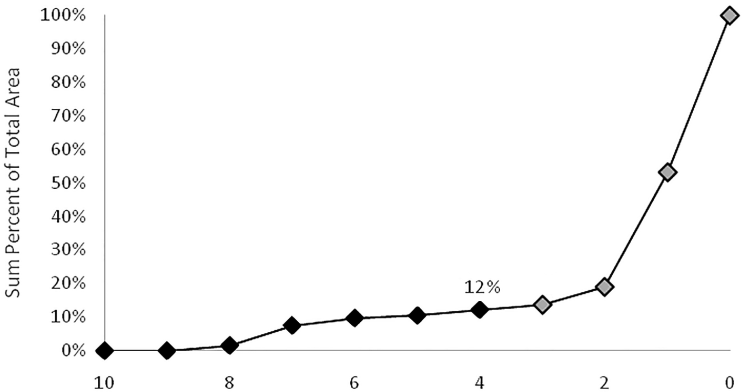

Figure 5. All classifications were combined on Tutuila to highlight areas that were most likely anthropogenic. The graph above shows the total area of the island classified as anthropogenic by a decreasing number of classifications. For this analysis it was determined that the areas that were most likely to be true positives were those identified as anthropogenic in at least four classifications. Those areas with three or fewer classifications were determined to be likely unmodified areas.

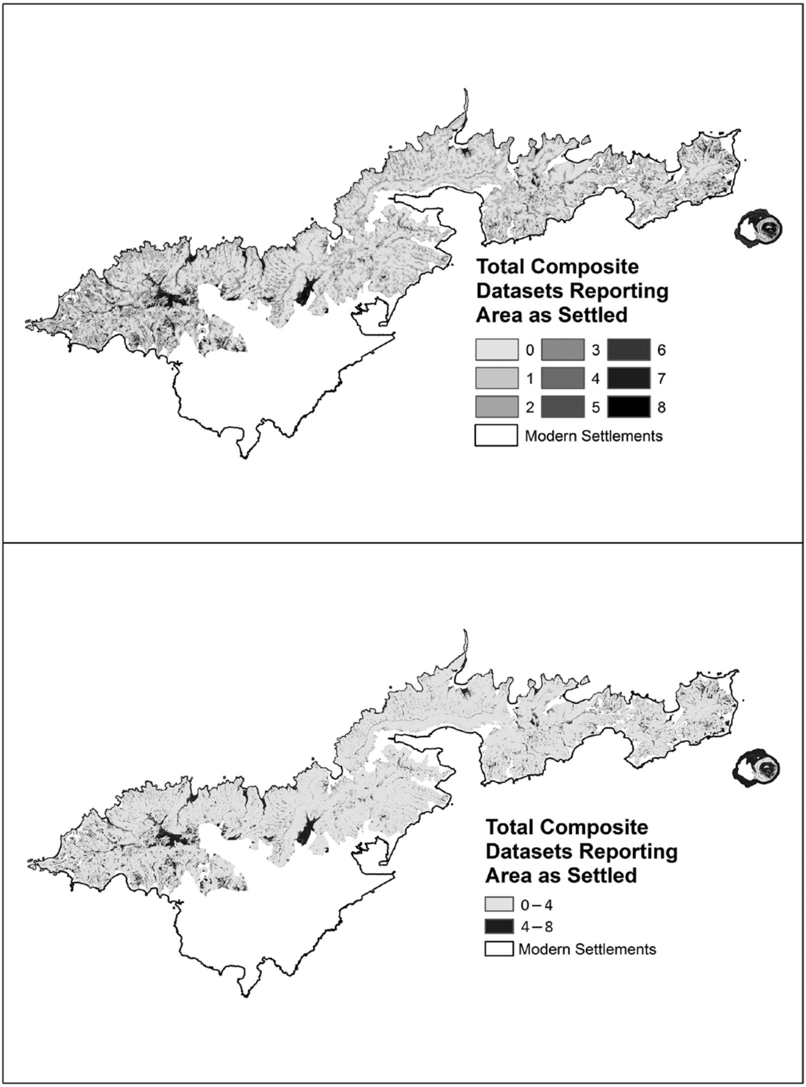

Figure 6. These maps show the results of combining classifications on Tutuila. Those areas classified as settled by four or more classifications are the areas most anticipated to be anthropogenic landscapes.

DISCUSSION

The use of a moving-window hypsometric index to model topographic roughness is an effective tool for identifying anthropogenic modification on complex landscapes. Simply as a visualisation tool, this technique highlights the changes in slope in anthropogenic areas. In addition, unsupervised classification is effective at delineating anthropogenic areas. While there was no classification that captured the complete known anthropogenically modified area, each known anthropogenic area was identified partially, and the high accuracy achieved is a strong indicator of success. Currently there is no method that consistently and completely identifies anthropogenic modification and therefore this method has advanced our ability to quickly identify anthropogenic landscapes with accuracy. In areas where the distribution of anthropogenic modification is unknown this technique can provide a first pass at identifying areas of interest that require further investigation, yet it is critical to note that those areas not identified may also have features of interest and should be surveyed where possible or before any modern modification to a potential site occurs.

Classification on Ofu and Olosega

For most anthropogenic landscapes, the inclusion of slope in the composite dataset appeared to improve identification, but for those anthropogenic areas like Sili-i-uta (where slopes are higher) excluding slope from the composite dataset greatly improved classification. Because most interior anthropogenic landscapes can be defined as areas of low slope, it is unsurprising that when slope is included in the composite dataset it becomes the strongest classification indicator. While the exclusion of slope in the composite dataset does reduce the true positive rate for anthropogenic landscapes that adhere to the defined slope relationship, it markedly increases the true positive rate for those areas that do not have large areas of low slope.

Combining classification results may be useful in identifying diverse anthropogenic landscapes and improving confidence in some areas. Where classification results are combined those locations present in all classifications are very likely to be true positives. On Ofu and Olosega, where four datasets were combined, only 2% of the area that is currently identified as unmodified interior was identified as anthropogenically modified by all classifications. Because field surveys do not exist for all areas of Ofu and Olosega, it is possible that these areas that were consistently identified as likely anthropogenic by all classifications are unidentified anthropogenic areas such as settlements, star mounds or fortifications that have a similar topographic signature. For all known anthropogenic areas at least 50% of the area was identified by two or more classifications.

Based on visual inspection of these data, the areas that were most likely to be identified by all classifications were near the centre of the anthropogenically modified area in the most seaward position. The areas of the anthropogenically modified area least likely to be identified are those areas furthest upslope or along the edges of the modified area (Fig. 7). This trend follows well-documented Polynesian settlement dynamics where the most prestigious areas of a settlement are either in the centre of the settlement or in the centrally located most seaward position (Mead 1969; Quintus and Clark 2016; Shore 1982). These areas also typically have the largest features. It appears that on Ofu and Olosega all datasets are capable of identifying these documented settlement cores, which have been noted as likely residential areas, yet have less success near the periphery, which is likely dominated by agricultural

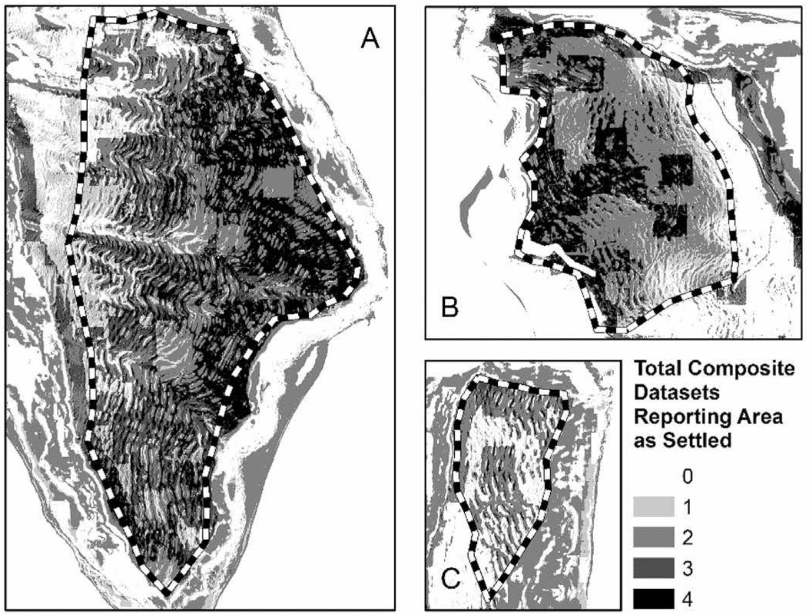

Figure 7. The greatest number of classifications identify the most seaward and central areas of the anthropogenic area, while the periphery is less well identified. This holds true for all known anthropogenic landscapes. The examples provided are: (A) Tamatupu: ocean east of anthropogenic landscape, (B) Ofu: ocean west of anthropogenic landscape and (C) Sili-i-uta: ocean north and east of anthropogenic landscape.

activity (Quintus and Clark 2016). The extent to which classification can identify these types of dynamics is unclear, yet because the data appear to follow well documented trends this may suggest that classification could provide insight into how anthropogenic areas developed.

Classification on Tutuila

As noted earlier, there are few well-documented prehistoric interior anthropogenic areas on Tutuila. Three settlements (Lefutu, Old Vatia and Levaga Village) have been described, and others have been speculated but remain undocumented (Clark and Herdrich 1988, 1989, 1993; Frost 1976, 1978; Kikuchi 1963; Pearl 2004). Part of the difficulty with identifying anthropogenic landscapes in the interior of Tutuila is the size of the island. Tutuila is 11 times the size of Ofu and Olosega combined. In addition, deeply dissected river valleys make the terrain more rugged than on Ofu and Olosega. As a result, having a methodology to identify areas where anthropogenic landscapes are likely is critical for guiding field research and identifying the likely location and extent of anthropogenic modification.

On Ofu and Olosega, classification of the composite datasets appeared to be effective in identifying areas of likely anthropogenic modification. Because there are a limited number of known anthropogenic landscapes on Tutuila, it is impossible to complete a confusion matrix or generate the precision and sensitivity of the model; rather, the model provides data on the likely distribution of anthropogenic alteration on the island. On Tutuila, the model suggested about 12% of the island has evidence of interior anthropogenic modification. This is 45% less than the known anthropogenic area on Ofu and Olosega, where (as noted earlier) the classifications typically overpredicted anthropogenic area. If total anthropogenic area corresponds with population (Quintus this issue) it might suggest that population density in the uplands of Tutuila was lower than on Ofu and Olosega, yet because of island size total populations in the interior may have been about five times greater than on Ofu and Olosega, assuming comparable agricultural practices. In addition to having a smaller area anthropogenically modified on Tutuila, potential anthropogenic areas also appear to be more dispersed. This is particularly true on the eastern portion of the island, where most research has been done. The western portion of the island is less incised and has larger areas of low slope, which are ideal for anthropogenic modification. While these western anthropogenic areas are the most extensive on Tutuila, the largest anthropogenic area is still approximately the same size as the largest anthropogenic area on Olosega, because the rugged topography on Tutuila limits further growth.

* * *

While the methods reported here will not replace careful pedestrian survey, they may help focus initial survey to areas that are most likely to be anthropogenic. In addition, these methods can provide initial estimates of the size and distribution of anthropogenic areas. When compared to a simple slope-based classification, classifying using composite datasets that include the hypsometric index improves predictions of anthropogenic landscapes. The inclusion of the hypsometric index is particularly useful in areas where slopes are greater than expected for an anthropogenic area. While this methodology was tested exclusively in American Samoa, it is likely that it will work in any area where anthropogenic modification has resulted in topographic change.

While most anthropogenic areas on Ofu and Olosega are already well documented through careful digital and/or pedestrian survey, the results of this classification suggest there may be at least one more anthropogenic area. All known anthropogenic areas were identified to some degree, with the cores being the best identified and periphery areas being only sporadically identified. On Tutuila, the absence of detailed data did not allow for a full confusion matrix of results, yet the classification did highlight several areas of known or suspected anthropogenic modification. Among the results, it is clear that anthropogenically modified areas on Tutuila are generally smaller than those on Ofu and Olosega and more dispersed over the large island. This is likely a result of the rugged, deeply dissected topography.

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ABSTRACT

Aerial LiDAR data offers a valuable tool in locating ancient anthropogenic landscapes around the world. This technology is particularly ideal in places where thick vegetation obscures the ground surface, reducing the utility of satellite imagery. On the islands of American Samoa, many interior anthropogenic landscapes remain unsurveyed, largely because the terrain makes it difficult and there is only general knowledge of where the anthropogenic modification may have existed. Aerial LiDAR flown in 2012 is proving to be a valuable tool in locating these prehistoric anthropogenic areas, yet improvements can be made on the methodology. This paper provides an unsupervised classification method to identify anthropogenic landscapes based on slope and hypsometric index: a topographic measure of roughness. Areas of American Samoa with known anthropogenic modifications were used to develop the classification techniques, which were then extended to areas where anthropogenic landscapes are undocumented and unexplored. The findings presented here suggest that interior anthropogenic patterns may be strongly dependent on island topography.

Keywords: LiDAR, unsupervised classification, hypsometry, American Samoa

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[1] Correspondence: Department of Geosciences, North Dakota State University, Dept. 2745, P.O. Box 6050, Fargo, North Dakota 58108-6050, USA. Email: stephanie.day@ndsu.edu

SĀMOA'S HIDDEN PAST: LiDAR CONFIRMS INLAND SETTLEMENT AND SUGGESTS LARGER POPULATIONS IN PRE-CONTACT SĀMOA

GREGORY JACKMOND
National University of Samoa

DIONNE FONOTI
National University of Samoa

MATIU MATAVAI TAUTUNU
National University of Samoa

In this communication we report the findings of extensive inland settlement in Palauli District, Savai'i, made possible with the use of LiDAR-guided[1] fieldwork. The surveys were conducted in April and June 2017 by the authors with students and other staff of the Centre for Samoan Studies, National University of Samoa. The findings have relevance to earlier scholarly debates on the location of settlements and the population of Sāmoa before European contacts in the 18th and 19th centuries, for which there was no consensus. Some, such as Watters (1958) and Pirie (1964), asserted that the nucleated coastal settlement patterns in Sāmoa observed and described in the 19th century were likely to be representative of those in the ancient past, a perception held by most Sāmoans today. In this view, villages have always been concentrated along the coast, often nucleated around *malae* 'central meeting spaces' (Pratt 1893: 201) with one or more large meeting houses (*falefono, fale talimālō*) of the highest-ranking chiefs located beside or within them. It was assumed that a very few villages extended inland, and those were thought to have been refuges in times of strife and not permanent settlements (e.g., Wright 1963). These assumptions were contradicted by Golson (1969) and Davidson (1969) who refer to the archaeological evidence that existed then to assert that inland settlement was extensive in some areas. Settlement pattern studies of Letolo, Sāpapali'i and Mt Olo (Jennings and Holmer 1980; Jennings *et al.*1976, 1982) have also shown settlements ranging from the coast to several kilometres inland throughout Palauli and Sāmoa, and other earlier studies by Buist (1969) and Davidson (1969) have hinted at the same. Recent studies of settlement patterns and land use on the small islands of Manono in independent Samoa (Sand *et al.* 2012, 2013) and the Manu'a group, American Samoa (Quintus 2015; Quintus *et al.* 2015, 2017) reveal extensive land use, as would be expected given their limited areas.

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However, there have been few surveys of inland areas on the large islands of ʻUpolu or Savaiʻi, and none since the late 1970s (Jennings and Holmer 1980; Jennings *et al.*1976, 1982). Some of this evidence suggests that the population may have been greater than estimates made in the 19th century, although McArthur (1967: 104, 115) disagreed. More recently, a detailed consideration has been made by Green (2007) of the archaeological evidence of settlement and Sāmoa's population prior to European contact. He suggested that further research would likely reveal a much larger population in previous centuries than the population of around 50,000 recorded for the archipelago by missionaries in the mid-19th century. The LiDAR-guided field research reported here adds weight to Green's proposition, as well as to the body of evidence that settlement patterns and land use in the past differed from observations recorded in the 19th century.

ARCHAEOLOGICAL FIELD SURVEY FINDINGS IN PALAULI (2017)

In April and June 2017 a research team from the National University of Samoa's Centre for Samoan Studies commenced an archaeological survey in the inland areas of the villages of Vaitoʻomuli and Faʻaala, Palauli District, on the island of Savaiʻi. The last time an archaeological survey was conducted in Palauli was in the late 1970s by archaeologist Gregory Jackmond, who had mapped an extensive ancient settlement (Fig. 1) of over 200 hectares, inland of Vailoa Village, on the Letolo plantation in Palauli District, Savaiʻi (see Green 2007: 220–21; Scott 1969). The mapped settlement area surrounds the great Pulemelei stone mound there (see Martinsson-Wallin 2016). Earlier work in the Palauli area was included in a rudimentary survey of Savaiʻi, which located several sites in the Palauli area ranging from isolated mounds to scattered settlements (Scott 1969).

Background to the Research Project

The 2017 survey is part of a two-year project funded by the U.S. Department of State's Ambassadors Fund for Cultural Preservation that was led by the authors. Palauli East and Sātupaʻitea East are located on the island of Savaiʻi and are parts of two of the 11 traditional districts (*itūmālō*) of Samoa. They were chosen to further investigate Jackmond's findings from the 1970s and to follow up on work done by Helene Martinsson-Wallin, Paul Wallin and others in 2002–2004 on the Pulemelei Mound (see Martinsson-Wallin 2016). The first objective of the survey was to improve the estimates of the historical size and population of Palauli East. The second objective was to collect information on the size and location of ancient Sāmoan settlements made up of archaeological features such as house platforms (*tūlagafale*), pavements (*paepae*), star mounds (*fetumaʻa*), earthen ovens (*umu eleʻele*), walls (*pā*) and walkways (*āualasavali*) to compare with previous surveys in

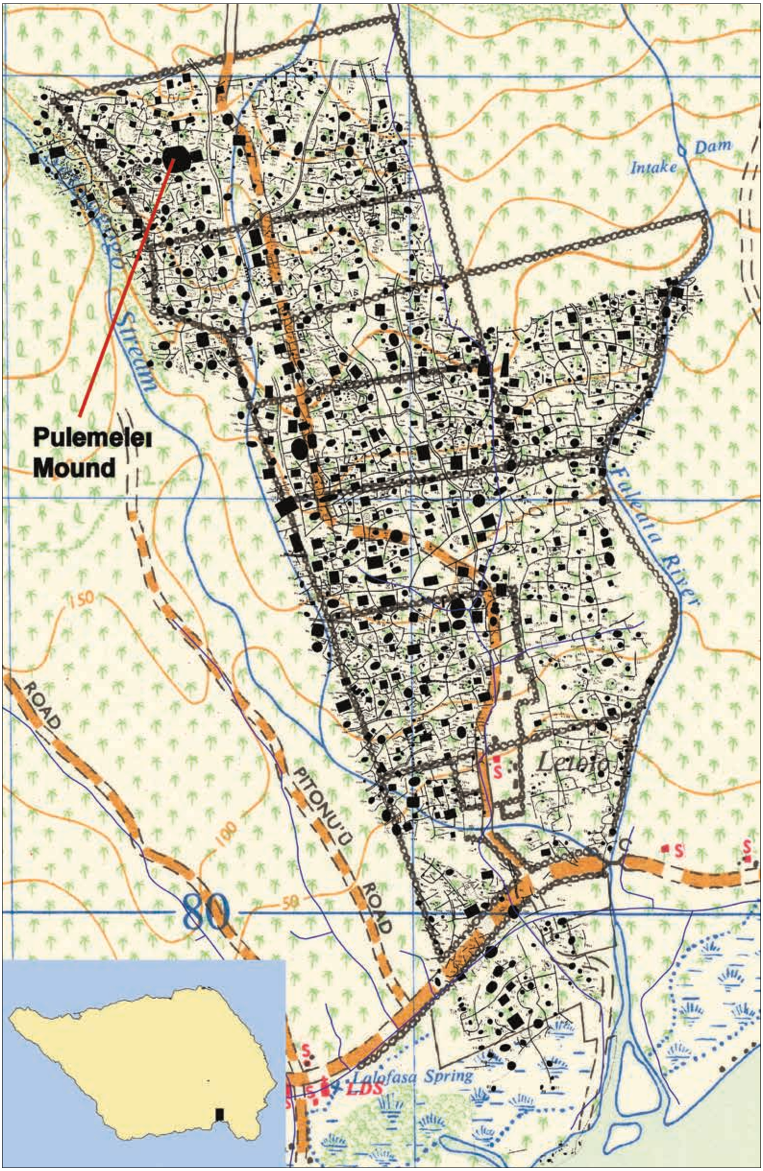


Figure 1. Letolo Plantation Survey, 1978.

both Savai'i and 'Upolu. A longer-term objective is to assist the Government of Samoa in developing heritage protection polices and legislation that are lacking at present (see Sciusco and Martinsson-Wallin 2015). The research is part of a wider long-term project to locate known archaeological sites, survey and document previously undocumented sites, and map them using GIS with attached information about the sites, including archaeological analysis, historical sources and oral traditions or other information.

Survey Area

The survey focused on Palauli East District (*itūmālō*) which comprises the territories of three contiguous villages, Vailoa, Vaito'omuli and Fa'aala, located on the coastline (Fig. 3). One village, Sātufia, belonging to the westward district of Sātupa'itea, bisects Palauli East and Palauli Le Falefā, close to the boundary of Letolo (Fig. 2).[2] Today the three villages of Palauli East are centred on the coast along the road. Behind the village, gently sloping plantation land mixed with forest rises to steeper areas further inland. Several old intrusive lava flows lie mainly above and to the east of Fa'aala. There are three rivers (Vailoa, Faleata and Seugagogo) with intermittent flows into Palauli Bay, depending on rainfall (Fig. 2). Some of the households of these villages have moved inland along the plantation roads onto land previously only used for agriculture. Six years ago the population of the district was recorded at 2,478 (Samoa Bureau of Statistics, Population and Housing Census, 2011). The archaeological surveys of selected sites in the district were done with the cooperation and permission of the *matai* 'chiefs' of the villages who took a growing interest in the work. Many of them were aware of stone structures inland but tended to think of them as belonging to the time of their grandfathers rather than the more distant past, and related the remains of large walls in the interior to well-known legends of a Tongan occupation of Sāmoa in the past.

LiDAR-Derived Imagery

At the time of Jackmond's Letolo survey in 1978, mapping was made easier by the fact that cattle on the plantation kept the vegetation down, avoiding the need to undertake extensive clearing. The field survey reported here was guided by LiDAR imagery and aerial photographs. The LiDAR data used was part of the Airborne LiDAR Bathymetric and Topographic Survey of Samoa conducted in the period 6 July to 9 August 2015 for the Ministry of Natural Resources and Environment (MNRE) (Table 1). The LiDAR data were collected by Fugro LADS Corporation Pty Ltd. using the Fugro LADS Mk 3 and RIEGL VQ-820-G LiDAR systems.

Table 1. Specifications of the LiDAR survey.

Aircraft Used and Call Sign	Beechcraft King Air A90 – N96Y (Dynamic Aviation)
Transit Speed / Height	175 knots *I* Up to 26,000 ft
Aircraft Endurance	Up to four hours
Survey Operations	Primarily conducted at 1,800 ft @ 145 knots Small area conducted at 1,400 ft @ 145 knots
Fugro LADS Mk 3 LiDAR Specifications:	
Laser Rate	1,500 Hz
Laser Spot Spacing	Primarily conducted at 5 × 5 metres (P5) Small area conducted at 4 × 4 metres (P4)
Swath Width	360 metres (P5), 273 metres (P4)
Line Spacing	330 metres (P5), 253 metres (P4)
Digital Camera	Redlake MegaPlus II ES 2020
Image Resolution	>4 pixels/m at an altitude of 1,600 ft
Capture Rate	1 second/frame (1 Hz)
RIEGL VQ-820-G LiDAR Specifications:	
Laser Rate	284 KHz
MTA Zone	2
Laser Power	Full power
Field of View (FOV)	42^{o} FOV – gives 32.1 % (170 m) sidelap for LiDAR
Laser Spot Spacing	Nominally 11 points per square metre
Scan Speed	157 lines/second
Swathe Width	Nominally 530 metres at 1,800 ft.

The Centre for Samoan Studies acquired the images of the survey area (with permission from the Government of Samoa) as classified LAS files. The LAS files were first processed into digital elevation models (DEMs) which retained the class 2 (ground) points using the “las2dem” conversion tool in the LAS tools for QGIS (GIS software). Next, the DEMs were rendered into sky-view factor tiffs using the Relief Visualization Toolbox (e.g., Fig. 6b).

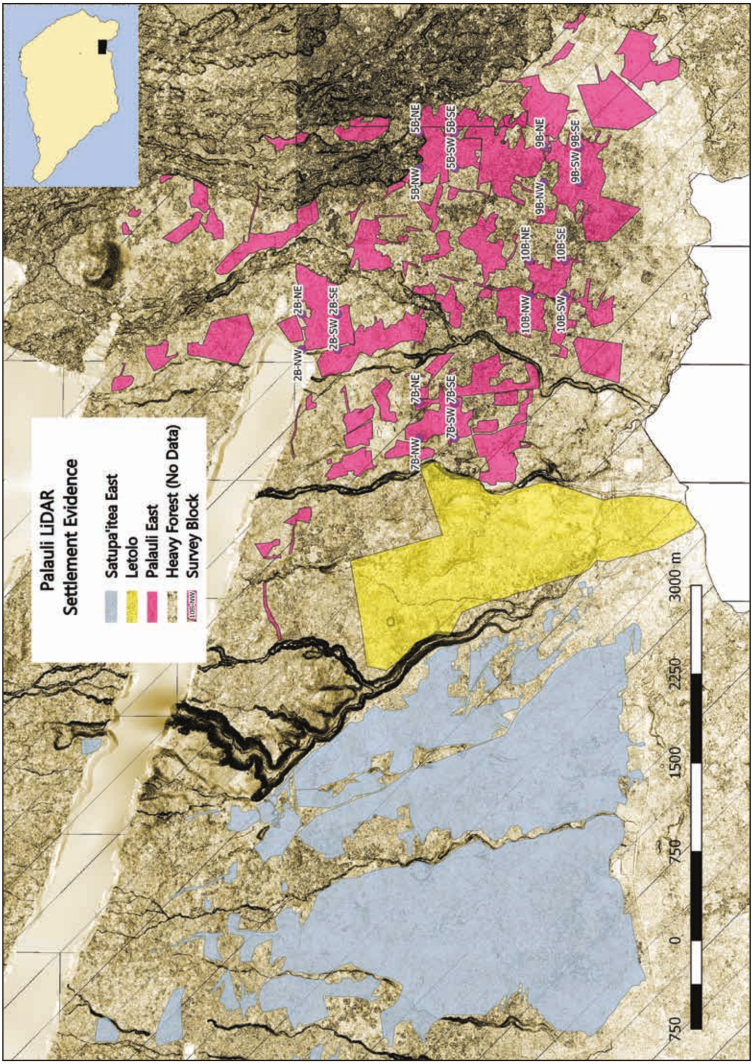


Figure 2. Area surveyed in 2017 showing prehistoric habitation with LiDAR or ground survey (3,500 hectares).

These images of the area comprising the traditional districts Palauli East and Sātupa‘itea East and part of Palauli West (Fig. 2) indicated the existence of an extensive indigenous population zone stretching from the coast to three or more kilometres inland throughout most of the district. Although deep forest cover obscures the LiDAR readings in some areas, those portions of the forest that have been cleared for agricultural purposes show a dense and extensive habitation zone consisting of house platforms, walls, earthen ovens and numerous walled and elevated walkways stretching at times both parallel to the coast and inland for several kilometres. LiDAR-derived images show only a small portion, approximately one-third or less, of the walls, platforms, earth ovens and walkways that have been found by ground survey.

Survey Methods

The team, comprising five lecturers and 14 students, canvassed five large swathes of bush measuring 300 × 300 m inland of each village using Samsung S6 smartphones to record data, take GPS waypoints, photograph features and track their progress. The survey was originally planned as a rough exploratory survey, using a modified checkerboard pattern of non-adjacent blocks. Before blocks were selected for the final intensive ground survey a preliminary reconnaissance was conducted of the possible survey areas using LiDAR, aerial photos and a quick on-the-ground GPS point survey to gauge the feasibility of a ground survey. The selected blocks were then surveyed (see below) to get an idea of the platform density and layout in the Palauli area to compare with what was previously found at the ancient villages of Letolo (1978) and Sāpapali‘i (1976), and the modern village of Fa‘aala (1979) in Savai‘i and the Mt Olo survey in ‘Upolu (1976). Given the limited time for the survey and the experience level of the survey team, the original grid pattern was slightly modified, and surveying priority was given to areas of low vegetation which ensured the best possible positive outcome. Five 300 × 300 m blocks (10 seconds of longitude by 10 seconds of latitude) were eventually selected for the survey (Fig. 3). An intensive ground survey was conducted of the selected blocks.

Teams of three students and one instructor performed a preliminary survey of the selected survey blocks by walking transects and recording the measurements and locations of all archaeological features encountered using standalone Samsung S6 smartphones (not connected to the internet) equipped with the following apps:

(i) *Docs To Go* (spreadsheet) to record all measurements,

(ii) *GPS Status* (compass) to measure headings and orientations for recorded features and photographs,

(iii) *SavePoint* to record GPS waypoints for all features (within an accuracy of 3 m),
(iv) *Camera* to photograph all features and record GPS waypoints of the photographs,
(v) *QField* to view exact locations in the field using selected aerial photographs and LiDAR-derived images of the survey area.

All information was then transferred into QGIS to develop maps and an integrated working database of the survey areas.[3]

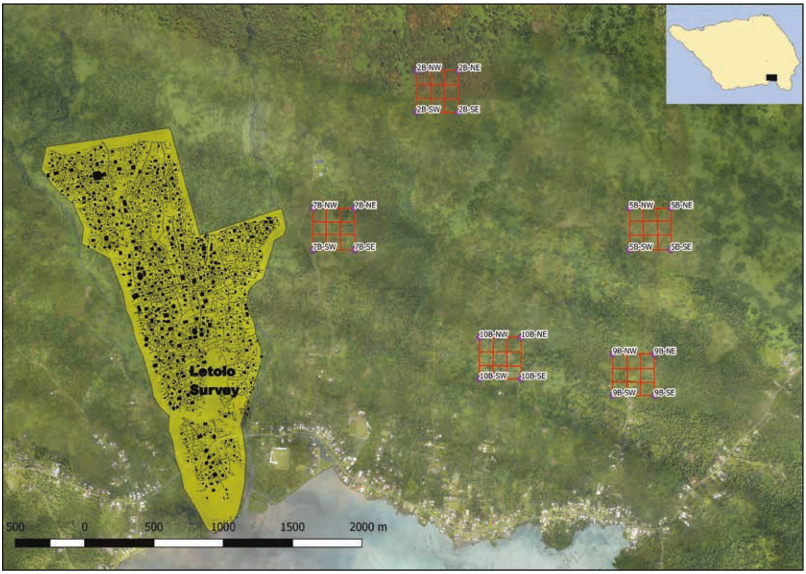


Figure 3. Survey areas in 2017 showing 300 × 300 m survey blocks and location of modern villages. The 1978 Letolo Survey is highlighted in yellow for reference.

The first fieldwork session in April 2017, closest to the modern villages, recorded 233 archaeological features after four days in the inland areas of the two villages. Using Hillshade LiDAR images as a comparison (Fig. 4a), the field team was able to locate and record approximately three to five times as many sites (platforms, walls, *umu*, walkways) in the field survey as were apparent on the Hillshade LiDAR-derived images. Later in June with a now more experienced team and better sky-view LiDAR-derived images (Fig. 4b) the teams returned to the Palauli area to continue their survey.

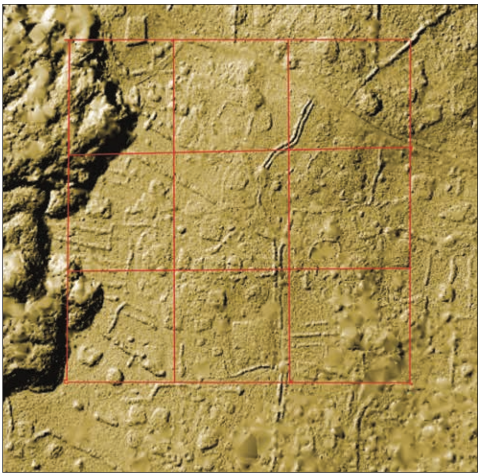


Figure 4a. Hillshade LiDAR (Block 5B).

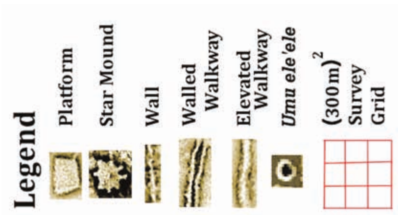


Figure 4b Sky-view LiDAR (Block 5B).

Table 2. Block 10B data.

Apr 4–6 Stats	Vaito'omuli (Block 10B)
Platforms	56
Walls	36
Walkways	5
Umu ele'ele	2
Stone Piles	0
Star Mounds	2
Other	0
All Sites	101

Platforms:	Length	Width	Area
Avg.	13	9	134
Max.	30	22	660
Min.	3	2	6
Median	12	9	102
STDEV	6	4	117

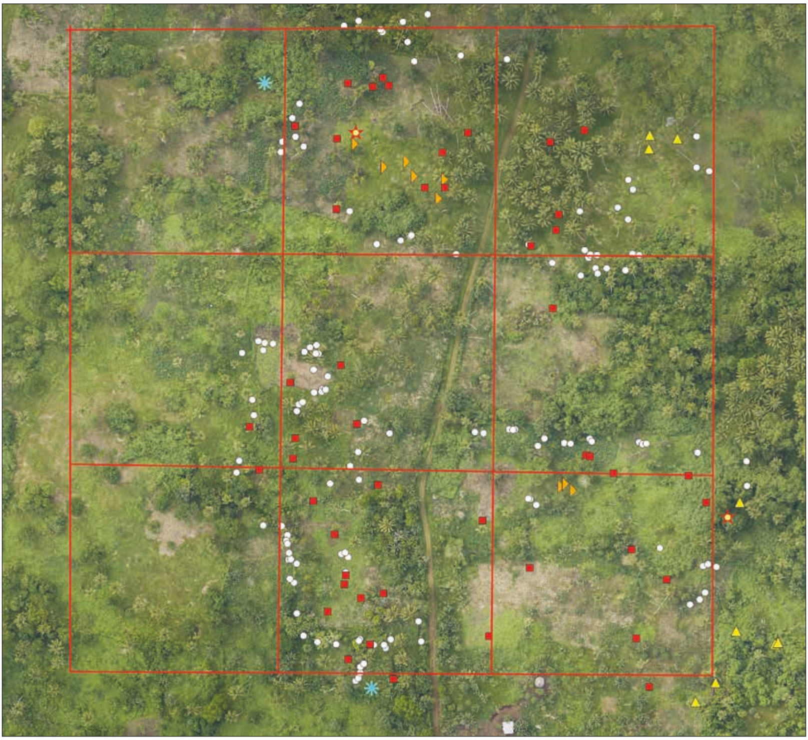
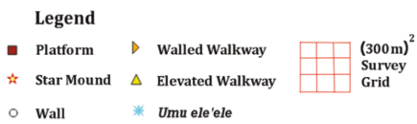


Figure 5. Archaeological features recorded during the April 2017 survey: QGIS Map – Block 10B.

Table 3. Block 9B data.

Apr 7–8 Stats	Fa‘aala (Block 9B)
Platforms	50
Walls	46
Walkways	25
Umu ele‘ele	7
Stone Piles	0
Star Mounds	0
Other	4
All Sites	132

Platforms:	Length	Width	Area
Avg.	13	9	143
Max.	33	25	825
Min.	3	2	6
Median	12	9	99
STDEV	6	5	154



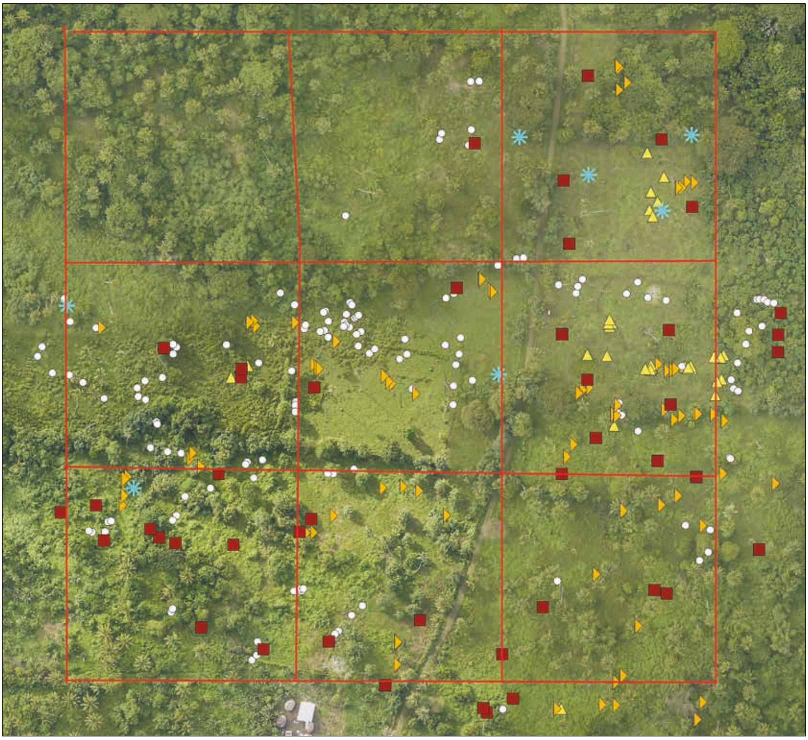
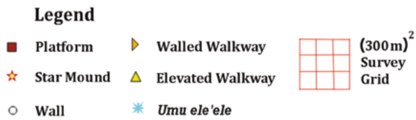


Figure 6. Archaeological features recorded during the April 2017 survey: QGIS Map – Block 9B.

Table 4. Block 7B data.

Jun 19–20 Stats	Vailoa (Block 7B)
Platforms	33
Walls	20
Walkways	15
Umu ele'ele	15
Stone Piles	25
Star Mounds	1
Other	6
All Sites	115

Platforms:	Length	Width	Area
Avg.	12	9	166
Max.	54	41	2214
Min.	3	3	9
Median	9	7	64
STDEV	9	7	373



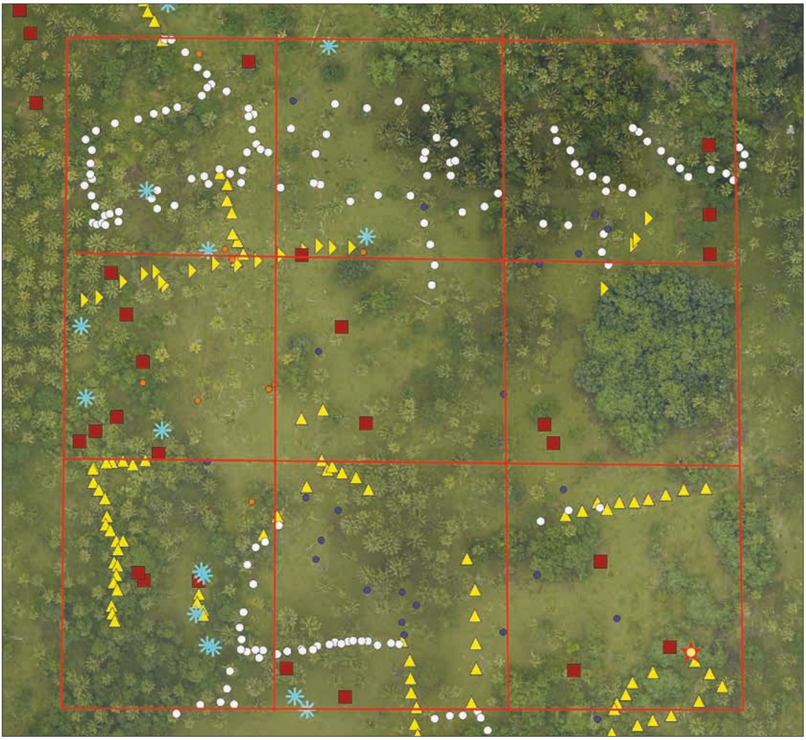


Figure 7. Archaeological features recorded during the June 2017 survey: QGIS Map – Block 7B.

Table 5. Block 5B data.

Jun 22–26 Stats	Fa‘aala (Block 5B)
Platforms	40
Walls	27
Walkways	27
Umu ele‘ele	5
Stone Piles	5
Star Mounds	0
Other	0
All Sites	104

Platforms:	Length	Width	Area
Avg.	13	11	164
Max.	30	21	630
Min.	5	4	20
Median	13	10	134
STDEV	6	5	133

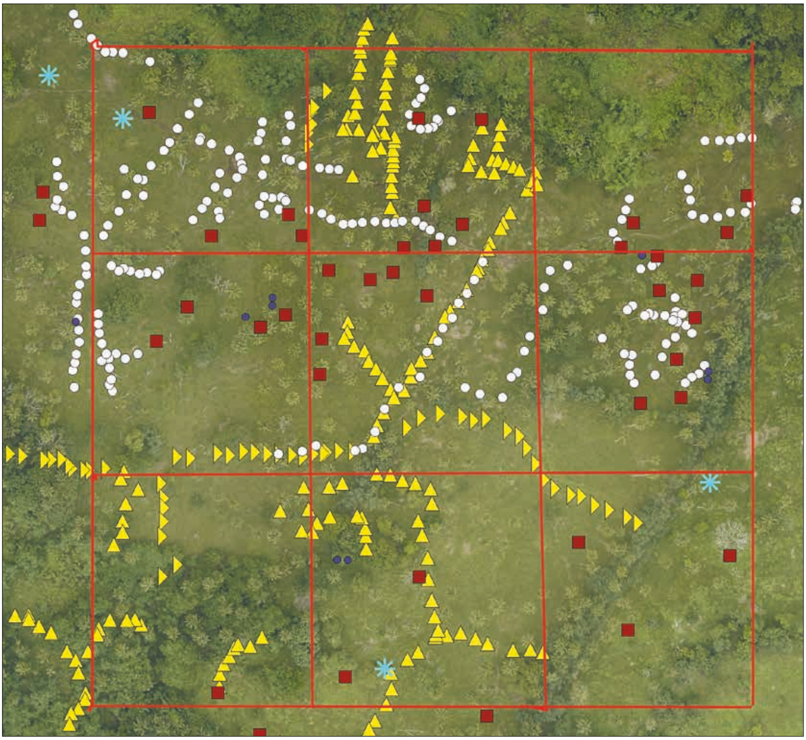


Figure 8. Archaeological features recorded during the June 2017 survey: QGIS Map – Block 5B.

Table 6. Block 2B data.

Jun 27–29 Stats	Vaito'omuli (Block 2B)
Platforms	31
Walls	10
Walkways	13
Umu ele'ele	2
Stone Piles	9
Star Mounds	0
Other	0
All Sites	65

Platforms:	Length	Width	Area
Avg.	12	8	121
Max.	25	20	500
Min.	4	3	12
Median	12	8	82
STDEV	5	4	111

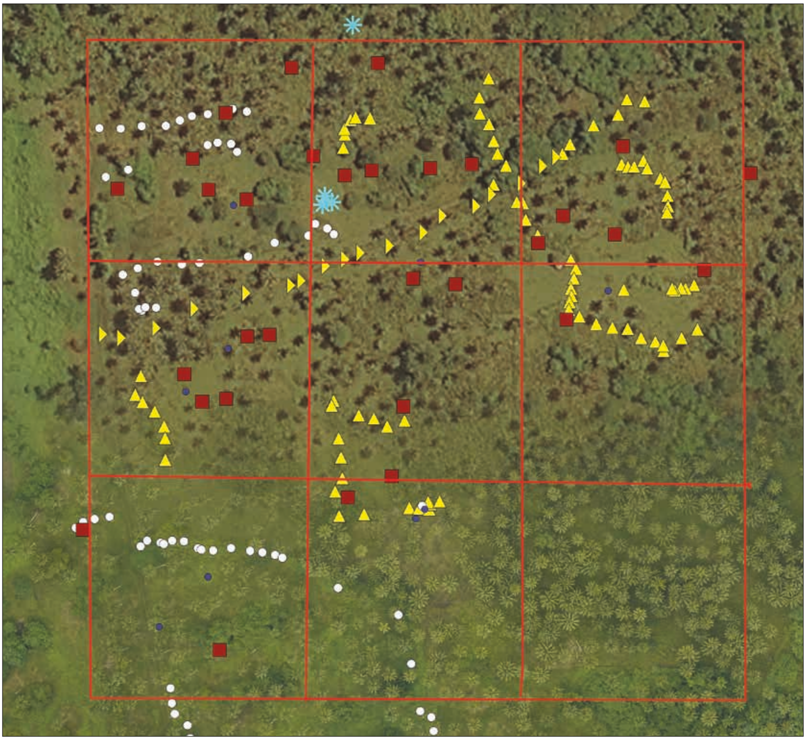


Figure 9. Archaeological features recorded during the June 2017 survey: QGIS Map – Block 2B.

Survey Findings

During the eight days of fieldwork the team recorded an additional 284 archaeological features in three separate blocks ranging from two to three kilometres inland from the coast where conditions were rougher and the fieldwork slower (see Fig. 3). The general features discovered during the ground survey match those previously described (Buist 1969; Green and Davidson 1964; Jennings 1976; Jennings and Holmer 1980; Jennings *et al.* 1982; Scott 1969). Some of the feature names are modified here in an effort to add clarity to their descriptions[4] (see Tables 2–6, Figs. 5–9 for more detailed information).

* * *

The LiDAR images of Palauli East, backed up by our intensive ground survey, show that the settled area documented in 1978 extends far beyond Letolo and proves the existence of extensive indigenous population zones in Palauli stretching from the coast to three or more kilometres inland. These findings, as well as preliminary investigation using other LiDAR-derived images for Savaiʻi and ʻUpolu now being analysed, confirm the evidence from the earlier ʻUpolu and Savaiʻi surveys, as well as recent small-island surveys previously cited, that it was likely that extensive inland settlements existed throughout the archipelago in centuries prior to the 19th century.

More detailed archaeological investigations may be able to show whether documented sites represent different phases of occupation. Such investigations will require years of further research and may eventually provide answers to questions about the pre-contact population of Sāmoa. For example, using the present survey, and assuming contemporaneous inhabitation, a conservative average of 60[5] house platforms can be estimated per 10 hectares surveyed. Taking only one-tenth of those platforms (6) as occupied at any one time, with only five occupants per house platform (6 × 5 = 30) and multiplying by only 2,000 hectares (4 × 5 km) (of the over 6,300 hectares available in the Palauli area (7 × 9 km) gives us an estimated population of at least 6,000 (6 platforms per 10 hectares; 2,000/10 = 200 of the 10-hectare blocks; 200 × 30 = 6000), that is about twice the population of 2,478 recorded in the 2011 Census. This suggests the possibility that Sāmoa had a population several orders of magnitude greater than the previous estimates we cite above.

The continuous mass of settlement expansion in all directions in Palauli does not appear to be contemporaneous given the above population estimate for only 10% habitation and historical evidence of modern platform occupation (Jennings *et al.* 1982). However, it will not be easy to provide a chronology for these locations, as the deep horizontal strata used in archaeology for the relative temporal placement of objects may be lacking. With this in mind, objects right next to each other spatially can be hundreds or even thousands of years apart temporally, due to the Sāmoan practice of recycling previously occupied house platforms, terraces and walls, either in part or as a whole. When building "new" structures any available materials, old platforms, walls or piles of stone may be used, modifying again the complex temporal and spatial interactions of these structures.

With all of this to consider, settlement patterns in Sāmoa are extremely complex. Through our work in Palauli we are just starting to get a glimpse of the ramifications of our findings. They raise many questions beyond settlement, land use and population. What was the purpose of the long walled and elevated walkways? Were the star mounds built for the purpose of catching pigeons or did they have other significance? Were the many large ground ovens (*umu ele'ele*) built to extract sugar from the roots of *tī* plants (*Cordyline* sp.) or for other purposes? Was a large earth mound of approximately the same vertical dimensions as the Pulemelei the base of an interrupted work in progress? To understand the meaning and temporal aspects of what we have found in Palauli (and other inland areas of Sāmoa currently being investigated) will undoubtedly take many more years of work.

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NOTES

1 LiDAR stands for light detection and ranging, a remote-sensing method (that uses the same principle as radio detection and ranging—RADAR—except that it uses a laser instead of radio waves) using light in the form of a pulsed laser to measure ranges (variable distances) to the earth's surface.

2 Palauli District, Savai'i, has three traditional subdistricts: Palauli East, Palauli Le Falefā and Palauli West.

3 No excavations were performed during this field survey. Because of dense vegetation and time constraints only about 65–75% of each survey block (300 × 300 m) was covered during the field survey; unsurveyed areas are evident in the figures by the lack of mapped sites (features).

4 "*Umu-tī*", meaning an earthen oven used to cook the *tī* plant, has been referred to in more general terms as an *umu ele'ele*, literally "earthen oven"; roadways are referred to by the more generic term of "walkways", and rather than attempt to set some arbitrary size limit between platforms and mounds, all are referred to as simply platforms.

5 For example: Block 10B: 56 platforms found in area surveyed / 0.7 part of block surveyed = 80 platforms; Block 9B: 50 platforms found in area surveyed / 0.7 part of block surveyed = 71 platforms; Block 7B: 33 / 0.7 = 47; 5B: 40 / 0.7 = 57; 2B: 31 / 0.7 = 44; (80 + 71 + 47 + 57 + 44) / 5 = 59.8 for a 9-hectare block. Therefore we estimate approximately 60 platforms per10 hectares.

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ABSTRACT

This communication presents results from LiDAR-guided field research in 2017 which revealed the existence of continuous indigenous population zones stretching from the coast to three or more kilometres inland across the district of Palauli East, Savai‘i. The findings amplify archaeological evidence of a small number of inland settlements (recorded in the 1970s and earlier) on the main islands of ‘Upolu and Savai‘i as well as recent studies of the small islands of the Manu‘a group and Manono. They build the case that in centuries prior to the 19th century inland settlement was far more extensive and villages were not, as had been widely assumed, mainly located on the coast. The findings also support contentions that Sāmoa may have had a much larger population in previous centuries than that indicated by missionary estimates of the mid-19th century.

Keywords: Sāmoa, settlement pattern archaeology, pre-contact populations, LiDAR imaging, Polynesia

CITATION AND AUTHOR CONTACT DETAILS

Jackmond,[1] Gregory, Dionne Fonoti[2] and Matiu Matavai Tautunu,[3] 2018. Sāmoa's hidden past: LiDAR confirms inland settlement and suggests larger populations in pre-contact Sāmoa. *Journal of the Polynesian Society* 127 (1): 73-90. DOI: http://dx.doi.org/10.15286/jps.127.1.73-90

[1] Corresponding author: Research Archaeologist, Centre for Samoan Studies, National University of Samoa, P.O. Box 1622, Apia, Samoa. Email: g.jackmond@nus.edu.ws

[2] Archaeology and Cultural Heritage, Centre for Samoan Studies, National University of Samoa, P.O. Box 1622, Apia, Samoa. Email: d.fonoti@nus.edu.ws

[3] Samoan Language and Culture, Centre for Samoan Studies, National University of Samoa, P.O. Box 1622, Apia, Samoa. Email: m.tautunu@nus.edu.ws

SĀMOAN SETTLEMENT PATTERN AND STAR MOUNDS OF MANONO ISLAND

CHRISTOPHE SAND
Institute of Archaeology of New Caledonia and the Pacific (IANCP)

DAVID BARET
Institute of Archaeology of New Caledonia and the Pacific (IANCP)

JACQUES BOLÉ
Institute of Archaeology of New Caledonia and the Pacific (IANCP)

ANDRÉ-JOHN OUETCHO
Institute of Archaeology of New Caledonia and the Pacific (IANCP)

MOHAMMED SAHIB
National University of Samoa

The Sāmoan Archipelago is known in the archaeological literature of the Pacific as having some of the most densely structured pre-contact landscapes observable in surface surveys. Multiple enclosure walls, raised house mounds, ceremonial platforms, roads, and fortified ridges with high walls and deep ditches still dot the plains and hilltops of some of the islands (Green 2002a; Jennings *et al.* 1976; Jennings and Holmer 1980; McGerty *et al.* 2002; Quintus 2011; Taomia 2002). In every case where extensive mapping has been fulfilled, the visible settlement pattern highlights a dense human occupation, extending to nearly every liveable ecological environment. One of the major challenges that archaeologists have faced in the last half century is the possible chronological diversity and political dynamics that these cultural landscapes might encapsulate at the local level (Green and Davidson 1969, 1974). This topic is furthermore complicated by the complexity of sequencing oral traditions in a meaningful chronology, the still-unclear understanding of the impact of first European contacts on Sāmoan demography (Green 2007), and the consequent changes that Sāmoan societies witnessed before the first permanent occupation of the archipelago by missionaries (Davidson 1969).

In this paper, we would like to present—as a gift to the long contribution of Jeffrey T. Clark to the archaeology of Sāmoa—a case study on the settlement pattern of the small island of Manono, located between ʻUpolu and Savaiʻi (Fig. 1), and the question of star mounds, a topic that Clark tackled in a number of papers (Clark and Herdrich 1993; Herdrich and Clark 1993; Quintus and Clark 2012). The mapping of part of the northern portion of the island and focused excavations on some of the main archaeological structures identified have generated new data about Sāmoan settlement patterns.

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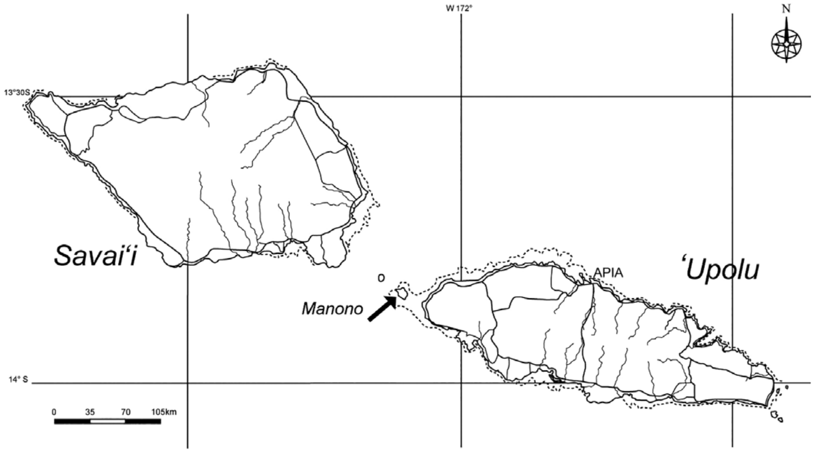

Figure 1. Position of Manono Island between Savai'i and 'Upolu.

Archaeologists have known of the presence of star mounds on Manono since the 1960s. Star mounds are a uniquely Sāmoan type of raised platform with a series of arms/branches/rays developing out of the central core of the structure (e.g., Davidson 1974; Herdrich 1991; Herdrich and Clark 1993; Ishimura 2006). These mounds are usually located inland in isolated areas and under forest cover, and have been identified as former locations of ritual pigeon-catching meetings for Sāmoan elite, combining sports, *mana* 'power and prestige' and feasting (Herdrich 1991). Usually, star mounds appear to be isolated features in the landscape (Herdrich and Clark 1993: 55–56; Ishimura 2006: 237). Because of this, we did not anticipate that the complete mapping of Manono's hilltop would lead to the discovery of 13 star mounds, aside from the single already known structure. This forms a cultural landscape that has to this day no equivalent in the archaeological literature of 'Upolu and Savai'i but is reminiscent of recent discoveries on Olosega Island in the Manu'a group (Quintus and Clark 2012, Fig. 2). After having summarised the general chronological background for Manono, and detailed the main features identified on the northern slope of the island and on the hillfort, we will present the typological diversity and some tentative data on the general chronology of the star mounds surveyed. This will allow us to question anew the significance of the cultural changes that appear to have characterised the century preceding the arrival of Christian missionaries in Sāmoa in the 1830s.

MANONO'S ARCHAEOLOGICAL SETTING

Manono Island is a small raised volcanic cone about 2.5 km long and 1.8 km wide, the highest point at 90 m corresponding to the lip of one of the old craters. The island is located at the northwestern limit of 'Upolu's lagoon, being today 3.6 km from the western point of the main island (Fig. 2). Its formation is linked geologically to an alignment of volcanic cones that dot the Savai'i–'Upolu axis, related to volcanic activity over a magnetic "plume-driven" hotspot (Dickinson 2007; Hart *et al.* 2004). Excavations completed as part of the archaeological program on Manono have confirmed the progressive tilting of the northwestern part of 'Upolu, at a rate of about 1.1–1.2 mm/yr (Sand *et al.* 2016). At first settlement about 2,700 years ago, Manono was a peninsula of 'Upolu, before the process of submergence progressively sank most of the coastal plains. As a consequence, a number of ceramic sites are today located under water. This drastic change in the landscape, with the disappearance of most of the coastal flats over time, forced the inhabitants to progressively intensify their use of the hillsides of the island. Only a few ceramic sherds have been uncovered in the back-coast areas during the survey and excavations, indicating that this part of the island was not frequently used during the roughly first millennium of settlement.

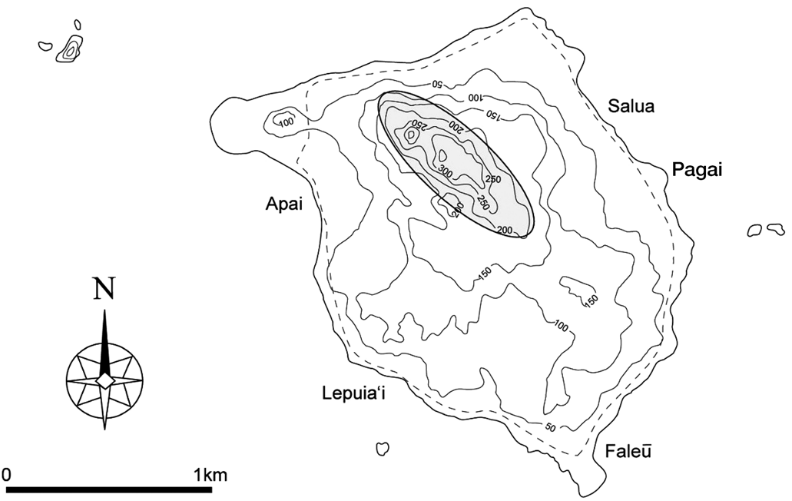

Figure 2. The island of Manono, showing the location of the central fortification (true north, altitude in feet).

Population increase, combined with the natural process of land shrinking, must have led to the progressive occupation of all the coastal areas during the second part of the first millennium BC, potentially fostering land divisions. The first demonstrable use of marked stone boundaries between compounds can be dated to about 2,000 years ago, indicating a change in the patterning of Manono's landscape, possibly linked to tensions about landownership between groups (Sand *et al.* 2015). As is also observable on nearby 'Upolu (e.g., Jennings and Holmer 1980), the tradition of enclosing compounds may have led in the succeeding millennia to the progressive building of multiple walled enclosures on the hillside slopes, starting at the foot of the hill cliff and reaching the seashore. These enclosures are of high diversity in shapes as well as sizes, and their setting is partly related to the natural topography.

Our project mapped around Salua Village alone, a total of about 100 enclosures on the northern side of Manono's hillslope down to the seashore, corresponding to an area of about 30 ha. The associated mounds, present in a number of the enclosures, can be of large size, in some instances with surfaces in excess of 300 m^2. No star mound was identified during the survey in any of the enclosures of the slopes below the hillfort at the top of island, but mapping identified a number of pathways leading from the seashore to the different access gates of the hillfort, winding between sections of enclosures. None of the higher points of the slopes appear to have had a clear defensive purpose, but some might have been used as observation posts. Although some of the enclosure walls have been reworked recently, as part of the modern use of the slopes for agriculture and cattle grazing, the main pattern is clearly linked to the pre-Christian use of the slopes. Dating of shells collected in different structures of the hillside, as well as excavations in some of the platforms, have dated this archaeological landscape to the second millennium AD (Sand *et al.* 2013, 2015).

THE HILLFORT OF MANONO

The hilltop of Manono (Figs 2 and 3) is located in the centre of the northern half of the island and covers an area of ~9 ha. The ground surface is fairly uneven and can be subdivided into three main parts. The archaeological settings and features of each will be described in turn.

The Western Side of the Hillfort

The highest area is located on the west of the hill and corresponds to an old crater, with an 85 m flattened top of a roughly rounded shape. Its centre has a round artificial mound about 23 m in diameter and up to 2 m high, partly surrounded by a ditch and having an access ramp on its southeastern side

Figure 3. The hillfort of Manono, with individual location and numbering of each star mound (magnetic north). Also note the two rounded Tongan-style *sia heu lupe* mounds (01 and 02).

(ST.01). The centre of the mound has a depression within it. To the south of this structure lies a second, more oval-shaped mound (ST.02), about 23 × 20 m wide, surrounded by a ditch with an access ramp located to its north. Its northern side is about 1 m high, but on its southern flank, facing downhill, the base of the slope lies 3.5 m below the main central surface (Sand *et al.* 2012). Typologically, the two mounds have all the features of Tongan *sia heu lupe* or ceremonial pigeon-snaring mounds: a high flattened platform with a central depression and an access ramp surrounded by a ditch (Burley 1996; Kirch 1988). To our knowledge, these are the first clearly identified such features in Sāmoa (but see Golson 1969: 15). Excavations of different portions of the slopes of ST.02 show that the sides of the mound had been faced with a wall of small-to-medium-sized stones. A depression is also present in the centre of this mound, defined by an alignment of vertical slabs forming a 5 m large polygon (Fig. 4). The dating of samples from the excavation of different parts of this central platform puts its construction and use in the 18th century (Sand *et al.* 2018). To the north of the two structures lies a low star mound (ST.03), and on a lower elevation a narrow platform closes the ridge to the west and south, without any stone retaining walls being apparent along the cliff.

Figure 4. View of the central depression marked by standing slabs of the *sia heu lupe* mound ST.02 at the end of the excavation. Photo by C. Sand, 2015.

The Central Area of the Hillfort

A sharp limit with another crater area is apparent, creating the central part of the hilltop, linked to the western area by a "raised road" (as characterised in Buist 1969: 38–39) (Sand *et al.* 2012). This stepped area, called Le Mauga, is the most densely structured portion of the hilltop, with no less than 17 platforms of different sizes and a total of seven star mounds, mostly concentrated in the southern half of Le Mauga. A number of walls divide the area into different compounds. The central feature and the highest structure of the site is a high quadrangular stone platform called Tafavalu, about 50 × 35 m at its base and 40 × 25 m at its summit, reaching about 6 m in height, without counting the star mound (ST.21) which tops it. Its total volume can be estimated at 8,000 m^3. A set of charcoal and shell samples from excavations at the foot of the platform have returned dates restricted to the first half of the second millennium AD (Sand *et al.* 2018), placing construction close to the date identified for the monumental Pulemelei platform in nearby Savai'i Island (cf. Martinsson-Wallin 2007). It is on this structure that the largest star mound recorded to date on Manono, ST.21,was later constructed, a feature that was archaeologically first recorded in the 1960s (Davidson 1974: 227–28). To the west of the central area, a large platform looking towards 'Upolu was built on a natural high outcrop reaching 3 m in height, allowing a complete outlook towards the whole southern half of the island and beyond. The northern and southern cliffs have been fortified by stone retaining walls, reaching 6 m high in some areas, with a number of compounds added on the top of the slopes, probably for defensive purposes.

The Eastern Point of the Hillfort

The ground surface of the eastern part of the hill is formed by a lava flow with numerous boulders and basalt cliffs, cut in its middle by a deep natural gorge. The amount of large natural boulders on the surface, as well as the rough terrain, have prevented the building of numerous square platforms, which number only six in total. A total of six star mounds have also been identified in this area. The whole eastern part of the hill is protected by a stone retaining wall, which reaches on its northern cliff a height of over 7.5 m. The most developed defensive feature is located on the southeastern point of the hill, where the natural gorge widens towards the eastern lower plateau leading to Faleu Village. This would in the past have been the weakest defence zone of the hill. To prevent access as much as possible, the occupants of the fort constructed three parallel defensive walls to close this potential weakness. The highest is the outer wall (ST.51), reaching up to 6 m, and of a total volume of at least 5,000 m^3, followed by the central wall (ST.52), which reaches 4 m high and is of a total volume of over 1,500 m^3, and the inner wall (ST.45–46), positioned on the plateau, being only 3 m at its highest point.

CHARACTERISTICS OF MANONO'S STAR MOUNDS

A total of 14 clearly shaped star mounds, characterised by the presence of arms/branches/rays, have been recorded inside the hillfort of Manono (Fig. 5). The Sāmoan name for this distinctive archipelago-wide platform tradition is confusing. Buck (1930: 321–22) did not refer specifically to star mounds when he termed pigeon-catching mounds *tia seu lupe*, while Herdrich (1991; see also Herdrich and Clark 1993) referred to star mound structures as *tia 'ave*. For this paper the English term star mound will be used.

The 14 star mounds show a diversity of forms and sizes, with significant differences between individual structures (Table 1), as has already been observed in other syntheses on the topic (e.g., Herdrich 1991). All structures are bound by stone retaining walls, built with volcanic blocs of different sizes. The inner fill is mostly made of earth and pebbles. The only exceptions are ST.12, an older house foundation, and ST.21, built on top of Tafavalu Mound, both of which have mainly stone fill. Excavation in one of the branches of star mound ST.18 (Fig. 6) has revealed that the basal fill included large volcanic blocs, reaching a diameter of 50 cm. The maximum length of the built structures ranges from 16 m to 30 m and the number of arms from only 6 to up to 12. The height of the arms often varies for each platform and each

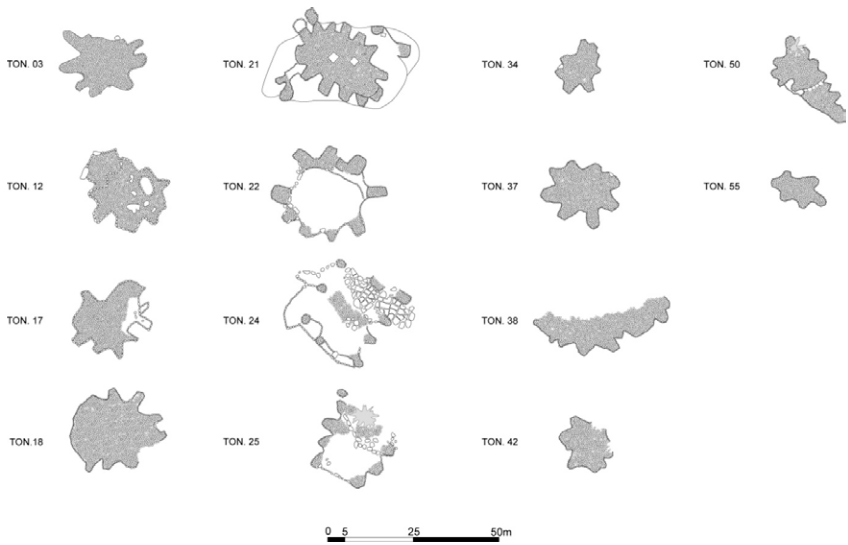

Figure 5. Form of the 14 star mounds mapped on the hillfort of Manono.

Table 1. Details of the Manono star mounds.

Structure	Length	Width	Height	Arms
ST.03	25 m	18 m	30 – 100 cm	7
ST.12	26 m	20 m	70 –110 cm	9
ST.17	25 m	21 m	80 – 140 cm	8
ST.18	25 m	23 m	90 – 200 cm	8
ST.21	30 m	20 m	150 – 220 cm	12
ST.22	30 m	20 m	40 – 130 cm	9
ST.24	27 m	22 m	50 – 70 cm	9
ST.25	23 m	23 m	80 – 130 cm	7
ST.34	16 m	12 m	60 – 120 cm	8
ST.37	23 m	20 m	50 – 200 cm	8
ST.38	40 m	10 m	70 – 180 cm	6
ST.42	17 m	15 m	100 – 150 cm	7
ST.50	30 m	13 m	100 – 180 cm	11
ST.55	17 m	9.5 m	50 – 130 cm	6

Figure 6. Branches of the northern side of star mound ST.18, where the archaeological test-pit excavation was carried out. Photo by C. Sand, 2015.

arm on each feature, ranging from a mere 30 cm to over 200 cm in some instances. One unique feature type is defined by the presence of only the arms, with the central part of the star mound being void of any earth or stone fill (ST.22, ST.24 and ST.25) (Fig. 7).

A tentative chronological positioning of the star mounds was achieved through different means. A layer below the construction of ST.18 was dated by unidentified charcoal to 368 ± 20 BP (Wk-43789), calibrated at 2 sigma with OxCal v4.2.4 to 500–420 (60.7% probability) and 380–320 (34.7% probability) cal BP, indicating that this star mound was built after the 16th century. Some of the branches of ST.03 have been constructed over the ditch that served to raise the *sia heu lupe* mound ST.01. ST.01 was probably erected at the same time as nearby mound ST.02, dated from the 18th century (Sand *et al.* 2018), indicating that ST.03 dates to a later time. A former large house mound (ST.12) associated with the fort's original structure was reshaped into a star mound by adding nine arms. Finally, the construction of the large star mound ST.21, built on top of the high platform called Tafavalu, dates to the second half of the second millennium AD based on dates from Tafavalu.

Figure 7. Example of a stone-faced arm of star mound ST.22, showing the downward profile towards the empty central space of the structure. Photo by C. Sand, 2015.

Four main size groupings of mounds and one outlier are distinguishable in the set of star mounds on Manono. The first is restricted to the two largest mounds, ST.21 and ST.50, with maximum lengths of about 30 m, a height of around 2 m and at least 12 and 11 arms, respectively. These are positioned on two distinctively high points of the hilltop. The second group is comprised of five mounds (ST.12, ST.17, ST.18, ST.37 and ST.42), about 25 m in maximum length and an average height of over 1 m. The shape of these mounds is varied, though all but ST.42 have eight or nine arms. The third group is formed by three low mounds between 16 m and 25 m in maximum length (ST.03, ST.34 and ST.55), with an average height of less than 1 m and between six and eight projections. The fourth type is also represented by three mounds (ST.22, ST.24 and ST.25) and is characterised by the absence of a central fill of the platform, the star-mound shape being identifiable only by the presence of a set of seven to nine branches surrounding a flat area about 20 m in diameter. The absence of a built central platform indicates clearly that the essential component of these star mounds was indeed the branches, even for a 30 m diameter-wide structure like ST.22. To these four main groups can be added star mound ST.38, a 40 m long elongated platform with apparent arms on its down-slope side.

DISCUSSION

In West Polynesia, traditional landscapes have been studied by archaeologists over the last few decades with a settlement pattern approach (Clark and Herdrich 1993; Clark *et al.* 2008; Davidson 1974; Green 2002a), where landscapes are associated with social, political and symbolic activities. Field studies have highlighted the distinctiveness of the Polynesian landscape structure between islands and island groups, depending on the geographical configuration as well as the sociopolitical historical dynamics identifiable at the local level (e.g., Best 1993; Kirch 1988; Sand 1998). In some cases, regional political influences appear to have dramatically impacted the way people have organised their settlement patterns at key historical periods. One classic example was the spread of the Tongan Maritime Chiefdom from Tongatapu Island throughout parts of the Fiji–West Polynesian region in the middle of the second millennium AD (Clark *et al.* 2008). This led in the central and northern parts of the Tongan Archipelago (Ha‘apai, Vava‘u and Niuatoputapu), as well as on ‘Uvea (Wallis Island), to the sudden appearance of a number of new built features, such as raised elite burial mounds enclosing vaults and high-status pigeon-snaring mounds, in conjunction with new sociopolitical rules and a Tongic linguistic influence (Burley 1996; Kirch 1988; Sand 1998, 2008). In oral traditions these late pre-contact Tongan influences in the region appear to have eclipsed the significant influence of the Sāmoan Archipelago over much of the central Pacific in the preceding centuries, with some networks reaching up to the Melanesian arc. The former Sāmoan influence can, for example, be deduced from the extent of Sāmoan-derived adzes found in the Western Pacific (Clark 2002), as well as the essentially Sāmoic classification of the Polynesian languages spoken in the numerous Polynesian Outliers scattered throughout the Melanesian archipelagos and in Eastern Polynesia.

The regional character of the hilltop fortification tradition in the central Pacific questions the idea of a unique origin for this type of setting (Best 1993; Green 2002b). Pet pigeons were also a regional cultural tradition, first documented by Europeans in nearby Futuna in AD 1616 (O'Reilly 1963). In this regional context, it is essential to highlight that the star-mound tradition appears, on the contrary, to be a local Sāmoan feature that did not spread to other archipelagos. Prior archaeological data collected on the hillfort of Manono Island, and that presented in this paper, provide a unique opportunity to analyse the chronology of these ceremonial structures. While still in use at the time of the missionaries' arrival (Ishimura 2006), their real age has been questioned by a number of archaeologists, as different field data appear to restrict most of the sites to the 18th and 19th centuries (e.g., Davidson 1974: 228; Herdrich and Clark 1993: 55; Ishimura 2006: 237; Martinsson-Wallin and Wehlin 2010). Such a chronological sequence is consistent with the data from Manono, all of which point to construction of star mounds in the late pre-Christian period. The link with the Tongan *sia heu lupe* tradition of elite pigeon-snaring remains to be better understood, but the data from Manono clearly show a time gap between one of the rounded Tongan-typology mounds (ST.01) and the nearby classic Sāmoan branch-indented mound (ST.03), the arms of which partly cover the ditch resulting from the erection of the rounded mound. Changing patterns of settlement organisation are also visible for star mound ST.21, built over the older Tafavalu platform (Fig. 8), and ST.50, erected on one of the massive defensive walls of the hillfort, which speaks to the dynamic nature of settlement in this part of Manono.

The Manono data are also consistent with propositions of Herdrich and Clark (1993) that relate to the ecological constraints linked to the use of these catching platforms. One of the main characteristics highlighted in the natural setting of star mounds is the location of the platforms in woody forest environments where pigeons live (cf. Herdrich 1991). In the Tongan counterpart of pigeon-snaring rituals, the *sia heu lupe* were often built in a setting of *vao tapu* 'sacred forests' (Guiot 1998: 195–96), adding to the ceremonial nature of the catch. This essential element is resonated in the Manono setting, as the 14 star mounds have all been exclusively built on the central plateau composing the hillfort. Compared to the massive collective effort that was represented in the building of the different fortification walls,

Figure 8. Partial view of the eastern rays of high star mound ST.21, built on top of the Tafavalu platform. Photo by C. Sand, 2015.

as well as the central Tafavalu ceremonial platform, none of the star mounds of the site are of a megalithic nature. Further, half of the platforms are of small elevation and three of the mounds appear to have been built in a rough manner, without taking the time to fill the central part of the structure, leading to an architecture where only the branches are elevated. As part of its evident use as a protective refuge and military defensive position, one of the main purposes of a hillfort is to allow a distinct view of its surroundings as well as to be viewed from far away.[1] This is something that is today not possible, as the hilltop is completely covered by a forest of high trees. The star mounds of Manono must however have been built when this tree cover was already partly in place, allowing for the nesting of wild birds. Consequently, at the time of construction/use of the different star mounds, the hilltop would have already lost its military character and occupation,[2] allowing, for example, a former house mound to be reshaped into a star mound (ST.12).

The shift in landscape patterning on Manono, leading to the abandonment of the hillfort as a defensive location, might have been related to the transformation of the policies of the archipelago's chiefdoms. It can be asked if the main reason for this change was the structuring of a new political system (e.g., Herdrich and Clark 1993), known in Sāmoan oral traditions as O le Tafa‘ifa time (Meleisea 1995).The very late development of the Sāmoan star-mound tradition in Sāmoa's cultural chronology may also have been related to the rise of the four royal titles political policy, in which Manono was an important element (Tupua Tamasese 1995). Accordingly, the star-mound rituals could have been linked to the advent of new competing elites during the 18th century, in a political context where "Samoan society was experiencing increasing differentiation and decentralisation" (Herdrich and Clark 1993: 61). This change must today be reconsidered in its wider historical context, as similar processes appear to have happened in the same period in Tonga (Clark 2017: 292–97) and Futuna (Sand 2017). How much these transformations were a consequence of an early set of epidemics linked to diseases introduced by early European contacts, destabilising the region's political equilibrium, remains to be addressed in more detail through future studies (see Cruz Berrocal and Tsang 2017).

The archaeological data recovered from Manono still remain to be fully analysed in the wider perspective of long-term Sāmoan history. This paper has contributed to this task by highlighting one of the multiple avenues of research that the island's settlement pattern encompasses, focusing on the distinctive star mounds. Awaiting possible counterclaims by future studies elsewhere in Sāmoa, Manono has today the highest concentration of these mounds on one site anywhere in the archipelago. These exhibit diversities in size, height and projections between individual mounds, with some structures being devoid of any central fill and identifiable only by the presence of arms. Archaeological analysis allows us to ascertain that their building chronology is restricted to the late pre-Christian period of Manono. Very late pre-Christian development of the star mounds in Sāmoa's cultural chronology needs today to be analysed in relation to the political changes witnessed by the western part of the archipelago from the 18th century onward, as known through oral traditions.

* * *

The study of the archaeological landscape of the northern part of Manono Island in Sāmoa has highlighted the presence of a dense pre-Christian settlement pattern. The central ridge of the island constitutes a large hillfort, protected in some areas by walls up to 7.5 m high and dotted with numerous platforms. While the central locus of the fort must have been for a long time the monumental platform of Tafavalu, it is the density of the distinctive star mounds that are a unique characteristic of the site. The mapping and analysis of the 14 star mounds surveyed, as well as the identification of two Tongan-type *sia heu lupe* mounds in the western part of the hillfort, have allowed the identification of variability between these structures. Archaeological data, as well as the need of tree cover for dove nesting on the abandoned fortified hilltop, reinforce the conclusion that star mounds were a feature of the last cultural period of the pre-Christian chronology in Sāmoa and allow us to hypothesise that the pigeon-catching ritual associated with these structures might have been at least partly linked to the rise of new competition between political elites. Difficult questions remain to be answered, like the significance of the number of arms in each structure (Herdrich and Clark 1993: 60) or the link between size, height and status. Surprisingly, some Manono star mounds appear to have been built in haste, by focusing exclusively on the raising of arms. With archaeological data continuing to accumulate, it appears that this late part of the Sāmoan chronology needs to be analysed and understood in more detail, as the central Pacific witnessed the first period of contacts with Europeans, whose introduced diseases soon started to disrupt the path of cultural evolution. The transformation brought about by the first set of epidemics appear to best explain the massive change in settlement patterns observable between the archaeological surveys and the missionaries' descriptions of mainly seashore settlements in the 19th century.

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This paper has been written especially in honour of our colleague and friend Jeffrey Clark. We have never succeeded in meeting in the field, in Manono or in American Samoa, but we hope that he will be interested by this archaeological data on one of the smallest inhabited islands of the Sāmoa Archipelago. *Fa'afetai*.

NOTES

1 To this must be added a more symbolic outcome: that of reinforcing the prestige of the local groups through monumental architecture.

2 Early texts mention the existence of "stone walls on Manono" during Sāmoan conflicts of the second half of the 19th century (Davidson 1974: 241), but these need not be on the hillfort itself.

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ABSTRACT

The small island of Manono, positioned between ʻUpolu and Savaiʻi in the Sāmoan Archipelago, is known in oral traditions of West Polynesia as having had an important political role during the immediate pre-Christian period. An archaeological programme carried out between 2012 and 2015 has mainly concentrated on the mapping of parts of the northern half of the island, around Salua Village. This has allowed us to study in detail a portion of the slope as well as the central plateau of Manono, known to preserve a star mound first mapped in the 1960s during the large-scale programme organised under the direction of R.C. Green and J.M. Davidson. Our mapping of the 9ha fortified ridge has identified another 13 star mounds of different shapes and types, representing the largest concentration of this specifically Sāmoan layout known to date in this part of the archipelago. These are associated with another two structures of distinctively Tongan typology, referred to as *sia heu lupe*. Initially we present the general settlement pattern of the northern part of Manono Island. This is followed by a review of the main characteristics of the 14 mapped star mounds and data on their chronology. The diversity of size, height and number of arms is addressed, showing significant differences in work expenditure between individual platforms. This variability is best illustrated by the identification of three star mounds that lack central fill and are only recognised as wild pigeon-snaring structures by the presence of raised branches/arms. Finally, the Manono settlement pattern data are positioned in relation to the larger study of the pre-Christian history of Sāmoa.

Keywords: Sāmoan Islands, Manono Island, Polynesian settlement patterns, hillfort, star mound, pre-Christian period

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[1] Corresponding author. Email: christophe.sand@iancp.nc

[2] Institute of Archaeology of New Caledonia and the Pacific (IANCP), BP 11423, 98802 Nouméa, New Caledonia.

[3] Centre for Samoan Studies, National University of Samoa, P.O. Box 1622, Le Papaigalagala Campus, Toʻomatagi, Samoa. Email: m.sahib@nus.edu.ws

ROW AS ONE! A HISTORY OF THE DEVELOPMENT AND USE OF THE SĀMOAN *FAUTASI*

HANS K. VAN TILBURG
NOAA Office of National Marine Sanctuaries

DAVID J. HERDRICH
American Samoa Historic Preservation Office

MICHAELA E. HOWELLS
University of North Carolina Wilmington

VA‘AMUA HENRY SESEPASARA
American Samoa Department of Marine and Wildlife Resources

TELEI‘AI CHRISTIAN AUSAGE
American Samoa Historic Preservation Office

MICHAEL D. COSZALTER
University of North Carolina Wilmington

Every April in American Samoa, 10 to 15 village longboats manned with 45 village members line up outside of the deep-water harbour port of Pago Pago for their fiercest competition of the year (Fig. 1). These *fautasi* cost tens of thousands of dollars to purchase and maintain, and the race outcomes are intricately tied to financial benefits, village pride, community identity and a deep historical tradition of seafaring. The construction of these vessels throughout their history, locally, in New Zealand, and more recently the United States, and their transition from wooden clinker-built boats to sleek fibreglass creatures, reflects American Samoa's engagement with the world's economy and with colonising forces.

The *fautasi* procurement, training and races represent the single biggest community-based cultural event in American Samoa. Although these races have great significance locally, the history and development of these boats have been effectively ignored by researchers. Krämer (1994) does not mention them in his two-volume ethnographic description of the Sāmoan Islands, Buck (1930: 371) only mentions them in passing, and Holmes (1957: 307), calling them "*fa‘atasi*", refers to them simply as "European long boats". It seems that they were viewed as tainted by Western cultures, and were considered as less important than previous, more traditional vessels. As a result, the cultural complexity and adaptive ingenuity of Sāmoan innovation has been under-appreciated and under-examined. Here we discuss the cultural evolution of Sāmoan seafaring technology from pre-Western contact to the contemporary boats racing today.

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Figure 1. Modern fibreglass *fautasi* racing to the finish line in Pago Pago Harbour, American Samoa. Photo by David J. Herdrich.

This article traces the development and creation of the *fautasi* from its roots in smaller, slower boats with paddles rather than oars to the Sāmoan-driven integration of Western technologies to improve the speeds of their boats. We argue that the almost complete absence of contemporary *fautasi* in the anthropological literature reflects an ethnocentric perspective where Western cultures are lauded for technological advancements, while non-Western cultures are perceived as spoiled from their "natural" states should they adopt such technologies for their own purposes. We argue that Sāmoan cultural adoption of technological features of Western vessels fits with Sāmoan history of long-term trade relationships throughout the Pacific. These stem from cultural innovations in indigenous craft culture in the Asia-Pacific region. These indigenous crafts, the forests of their source material, construction sites near the shore, boat sheds, launching areas, navigation routes and waypoints were once major elements within the maritime cultural landscape of marine transportation.

INDIGENOUS CRAFT CULTURE

Seafarers and coastal populations celebrate their maritime heritage in many ways, including the construction of traditional watercraft and the continuation of ocean activities like traditional navigation, boat races and sailing regattas. These experiences create an active connection to the sea, critical to maintaining the cultural identities of many marine-based societies. The construction of watercraft based on indigenous designs is often central to cultural activities, in addition to basic utility in travel for such activities as trade, war and fishing.

Hundreds of years ago in the Pearl River Delta, the Chinese built long, slender teak boats with ornate dragonheads and tails. These were associated with the traditional summer solstice festival of *Duanwu* or *Zhongxiaojie* commemorating filial piety. Dragon-boat festivals and paddling races spread with the migration of Chinese overseas and are regulated today by national and international governing organisations (International Dragon Boat Federation 2016). In California, the Native American Chumash Tribe has revived the construction of the *tomol* canoe built from cut-plank redwood sewn with animal sinew. Paddlers regularly voyage on the ancient sea routes from Santa Barbara to the Channel Islands, reconnecting with their seafaring ancestors and their maritime heritage of that special location (McGinnis *et al.* 2006: 3). The knowledge of voyaging techniques and the history and achievement of open-ocean navigation are also important elements of Hawaiian cultural identity. This was encapsulated in the 1976 construction of the Hawaiian voyaging canoe *Hōkūle'a*. Her completion helped initiate a Pacific revival in traditional canoe construction, non-instrument navigation and ocean voyaging (Finney 1994).

These examples highlight the importance of sharing maritime heritage through traditional watercraft and perseverance of traditional ocean activities. Vessel construction and ocean activities are dynamic in nature, and therefore it is not surprising that new materials and technologies have influenced traditional behaviours. The use of new materials has an immediate impact on the persistence of traditional construction techniques, but may have less influence on the nature or significance of the cultural activity itself. For instance, the twin hulls of the performance-accurate replica *Hōkūle'a* are constructed from fibreglass-covered marine plywood, and ocean passages have been made with Dacron sails (New Sails of *Hokule'a* 2004). Modern Chinese dragon boats are formed by lightweight fibreglass shells (Dragon Boat Dimensions 2017). This does not, however, seem to alter the central form of the craft, nor necessarily negate the cultural importance of Hawaiian voyaging or Chinese dragon-boat racing. In these cases, new materials and technologies have been adapted by living maritime cultures into evolving traditional ocean activities.

The people of Sāmoa (comprising both the Independent State of Samoa and the U.S. Territory of American Samoa) posses s a long history and connection to the waters surrounding their islands. According to current archaeological evidence, voyagers first arrived in Sāmoa at approximately 800 BC (Clark *et al.* 2016; Petchey 2001). The traditions and lifeways developed over 2,800 years are generally known as *fa'a Sāmoa* 'the Sāmoan way'. *Fa'a Sāmoa* places particular emphasis on the importance of family and of village, and continues to shape and inform the population today. A core component of these traditions centred on the building of ocean canoes for food, travel, trade and sport.

The construction and use of Sāmoan canoes for interisland voyaging, fishing and near-shore transport was central to island settlement and habitation. Over time there has been a variety of Sāmoan watercraft. The *paopao* was the smallest Sāmoan paddle dugout canoe with two booms attached to the outrigger, for inshore fishing in lagoon or harbour waters; the larger *soatau* paddle dugout canoe had more than two booms connected to the outrigger; the *'iatolima* or largest dugout canoe had a mast and sail and five booms attached to the outrigger pontoon; the *va'a alo* or bonito sewn-plank canoe featured two outrigger booms for deep-sea fishing; the *amatasi* sewn-plank sailing canoe with its wide platform on the booms was used for interisland travel; and the '*alia* double-hulled canoe was employed in long-distance open-ocean voyaging (Buck 1930: 370–416; Haddon and Hornell 1936: 223–47; Neich 1985: 51–54). Relatively modern craft circa mid-19th century include the *taumualua*, a large sewn-plank paddling canoe with no outrigger, the first of its type; and sometime later the *fautasi*, a long, lightly built wooden-planked craft with oars instead of paddles (Emerson 1934: 1550; Haddon and Hornell 1936: 240).

Today the majority of traditional Sāmoan watercraft have vanished, leaving only the *paopao,* the *'alia* (no longer canoes but small twin-hulled aluminium powerboats for local transport and near-shore fishing) and the oared *fautasi* (fibreglass racing shells). However, *fautasi* races are considered the largest annual cultural event in the Sāmoan Islands. The *fautasi* races are held on Flag Day (17 April) in American Samoa, and on Independence Day (1 June) in the Independent State of Samoa. These events have been a continuing tradition for over 100 years. Villages and families strongly identify with their respective competitive teams and winning vessels. The modern construction and form of these *fautasi* is no accident, and yet their antecedents are not included in descriptions of any earlier watercraft. Where, then, do these *fautasi* craft and the *fautasi* races find their cultural roots in Sāmoan history?

The emergence of the *fautasi* provides a Pacific case study of post-Western-contact technological and cultural expertise and adaptation. It combines the skills of the Sāmoan boat builders and the integration of beneficial technological features introduced by European sailors and American whalers. Anthropologists seeking knowledge only from traditional pre-contact societies rather than these hybrid post-Western-contact watercraft have overlooked *fautasi*. However, the emergence of the *fautasi* during this time of rapid change for Sāmoan culture invites further examination.

TAUMUALUA: INGENUITY AND ADAPTATION OF AN OUTRIGGERLESS CANOE

Prior to the emergence of the *fautasi*, a slightly different canoe dotted the Sāmoan horizon. This canoe, the *taumualua*, emerged during the period of revolutionary change and internal strife between Sāmoan lineage groups in the mid-19th century, a time complicated by the increasing influence of *pālagi* (foreigners) in the form of missionaries, beachcombers and the introduction of Western weapons. Part of these struggles included sporadic warfare between the forces of Ātua and Ā‘ana and Malietoa, all rivals for leadership among the Sāmoan islands of ‘Upolu, Manono, Apolima and Savai‘i.

In February 1848, the British ship HMS *Calypso*, commanded by Captain Worth, arrived in Sāmoa, a relatively small warship carrying 20 guns, a sixth-rate wooden sailing vessel deployed for remote patrol duties to the distant Pacific Station (Krämer 1994: 302). When British property was reportedly damaged at the outbreak of the Sāmoan naval war of Taumua o Fua (1848–1851), Worth imposed a fine on the followers of Malietoa. He blockaded the war party within its fortified position at Mulinu‘u promontory (near Apia) with the Royal Navy marines and a single longboat. This boat had a lighter, faster design than Sāmoan war canoes, resulting in reported astonishment and dismay on the part of the Sāmoan warriors. The opposing war parties of Ā‘ana and Ātua “took a hint from this circumstance, and resolved to build similar war-boats; and an American resident at Aana, Mr. Eli Jennings, undertook the work” (Ella 1898: 247).

This story of HMS *Calypso* and Captain Worth may be apocryphal myth-making as Worth himself makes no mention of the longboat blockading action in his narrative (Worth 1852). Nonetheless, the story offers a possible description of the innovation of an apparently new “double-ended” boat design (*taumua* ‘bow’; *lua* ‘two’), a wider outriggerless or monohull paddled craft exceeding the lengths of previous boats. Multiple observers noted the popularity and usefulness of the new watercraft at the time. “They use these on their expeditions from settlement to settlement on what they call *malangas* [*sic*], or travelling parties, and also in war. When fully manned, these boats are a fine sight" (Smith 1898: 155). They were also raced in regattas held in Apia (*Samoa Times and South Sea Advertiser* 1890: 3; *Samoa Times and South Sea Gazette* 1878: 3).

In reference to their construction, numerous thinly veiled ethnocentric reports by Western observers attributed *taumualua* origins to whaleboat designs. These writers did not make a distinction between Western longboats and even lighter-built Western whaleboats. "Within the last few years the native carpenters have been trying their hand at boat-building, and it is astonishing to see how well they are succeeding in copying the model of an English or American whaleboat, sharp at both ends, or having 'two bows,' as they call it. Some of them are fifty feet long, and carry well on to one hundred people" (Turner 1861: 268).

The transition to a model with no outrigger does not necessarily represent any loss of traditional boat-building skills. Instead, it continues the tradition of sewn-plank construction. For instance, Haddon and Hornell (1936: 240) wrote how "the hull was made with irregular lengths of dressed planks sewn together on the inside with sennit lashings passed through marginal edges as with the *va'a alo*". The finished hull had a smooth carvel surface, all the lashings being on the interior surface of the boat.

> The stem (*taumua*) as well as the *taumuli*, or stern, were carried upwards some height and curved. The canoe had a depth of hold of about three feet, and was formed of pieces of wood seven to eight feet long, sown together with sennit in the same manner as in the *alia* canoe. These planks are dubbed out with the adze to about one and a-half inches in thickness, the inner surface having a bevelled and raised ridge on each edge, through which the lashings were passed, as is to be seen in the *va'a-alu-atu* [*sic*] of to-day. These vessels had ribs to strengthen them inside, about four feet apart. The seats for the paddlers are about three inches below the gunwale. The canoes were much ornamented with shells, &c., the bow and stern pieces being made of *malili* wood, whilst the hull itself was made of *ifi-lele* [*sic*] or sometimes of *fetau*. They were decked fore and aft for some eight feet. They carried one sail only, of the usual triangular shape, common all over Polynesia, the apex of which was downwards, and this was made of mats. The mast was set on top of the thwarts, and not on the bottom of the canoe, and was kept in position by stays. The sail was called a *la*; the mast a *tila* or *fangā* [*sic*]. For steering they used a large paddle fourteen feet long and twelve inches broad in the blade. (Smith 1898: 158)

Monohull craft had been observed elsewhere in Oceanic cultures. Some observers postulated that this new model, with its traditional construction, could have come to Sāmoa via the Solomon Islands of Melanesia, the Tuamotu Islands or Fiji. "Indeed the 'two bows' [*taumualua*] is so unique that hardly anyone will at first think of an imitation, particularly considering that from time immemorial Melanesians have had boats without outriggers. Since in boat building Fijian influence is so very pronounced, why should not the two bows have come about through similar influences?" (Krämer 1994: 302).

Haddon and Hornell (1936: 240) looked beyond the simple dichotomy of Sāmoan versus Western construction and described the specific fusion of cross-cultural methods in greater detail: "To stiffen it [sewn hull planks], the European system of fitting frames was adopted. These, however, were secured not by bolts but by sennit lashing secured to cleats projecting horizontally from the inner surface of the hull planking, a method familiar to the builders as that already in use in double canoes." They found this *taumualua* nautical evolution to be "a local adaptation of the European whaleboat … European and Samoan features were blended with notable success, and the result was a distinct triumph for Samoan adaptive ingenuity." Later the European method using metal fasteners and regular linear hull strakes would be put into use, a broad and general transition in wooden construction which took place in many locations with the adaptation of small-boat iron-fastening technology.

THE ROOTS OF *FAUTASI*: A NAVAL ARMS RACE IN SĀMOA

The timing of these innovations and adaptation is also important in Sāmoan history, coming in the middle of a period of intense warfare between the Malietoa, Ātua and Ā'ana people. In a 2009 interview on the island of 'Upolu, His Highness Tuiatua Tupua Tamasese Efi, speaking for his family, referred directly to this intervention.

> We had been … struggling for quite a long time, you know, to find our bearings. We got beaten by these guys [Manono/Malietoa forces] time and time again, until Eli Jennings comes into the picture, and he builds these boats … It's a double-hulled boat, the way it was built. I think they had bamboo breastworks, but it could carry 200 soldiers. And it could carry, very importantly, cannon. And that was the first time we had beaten these guys for a long time … The reason why I'm grateful to the Jennings is that we wouldn't be around, you know, if we had been crushed again in that naval battle which was fought in Safata … . (His Highness Tuiatua Tupua Tamasese Efi 2009)

Here the Head of State for Samoa refers to new monohull craft incorporated into a double-hulled design, joining the larger Western-style monohulls as a catamaran. The catamaran design, of course, is well known as traditional island construction and the core feature of the long-distance *va'atele* or voyaging canoes that made ancient migration and settlement throughout the Pacific possible. However, these larger double-hulled vessels built by Eli Jennings were entirely different from Pacific canoes, featuring a hand-cranked central paddlewheel, log barricades, iron prows and cannon (Pritchard 1866: 63, 74).

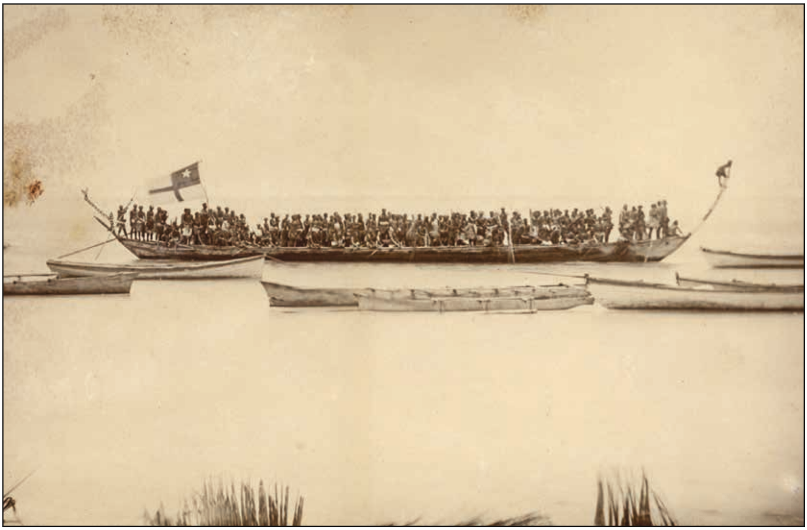

Figure 2. Sāmoan *taumualua* with about 100 paddlers, c. 1893. Western-style longboats and Sāmoan outrigger canoe in the foreground. Alma Lyons Green Collection, Feleti Barstow Public Library, Polynesian Photo Archives, American Samoa.

This emerging ability to significantly lengthen outriggerless boats proved immediately useful in military contexts. The armed *Le Taumuasila* paddlewheel ram appears to be a startling but short-lived derivation of the new elongated watercraft, one that may have played an important role in the 1848–1851 Sāmoan war. Other experiments were conducted regarding the importance of elongated double-ended monohull craft. "The town of Sapapalii, in the Faasaleleaga, is now building the largest war canoe ever constructed in Samoa. This war vessel is double, each craft being 96 feet in length, 10 feet in width, and 6 feet in depth of hold. She will carry 250 warriors, and will be a valuable auxiliary to the Government schooner Laetitia" (*New Zealand Herald* 1881: 6).

Jennings was by no means the only Western carpenter in Sāmoa. Captain Worth, on board the HMS *Calypso* in 1848, noted scores of foreigners in a variety of roles. There is no way to tell if the story of Eli Jennings is also apocryphal myth-making, though a consensus of recorded views credit Eli Jennings with a specific and timely role in the introduction of the *taumualua* form and the initial demonstration of its versatility.

The *taumualua* appears, in this historical context, as an important design predecessor, but at what point did the *taumualua* become a *fautasi*? *Taumualua* built in the traditional Sāmoan method were still quite different from the documented wooden *fautasi* of the 20th century. In general, *taumualua* were 18 to 21 metres (60 to 70 feet) in length and 2.1 to 2.4 metres (seven to eight feet) in beam (width), had long curved, upright, decorated stem and sternposts and were propelled using paddles, not oars (Fig. 2).

TAUMUALUA TO *FAUTASI*

The emergence of the *taumualua*, falling between the more traditional Sāmoan watercraft and the new oared *fautasi* built with Western methods, served as a transitional step. It appears to be a case of change to the overall form of the elongated outriggerless fast hull first, followed by the adaptation of specific construction techniques and new materials. From our review of newspaper records, *taumualua* seem to have vanished from existence after 1893, replaced with the appearance of a *fautasi*-like craft shortly thereafter.

Key technological innovations match the transition from the *taumualua* to the *fautasi*. The *fautasi* was strake-built iron- or copper-fastened, with an attached rudder rather than steering blade that was firmly fixed to the sternpost by pintle and gudgeon, and that used oars rather than paddles. However, in the current literature these innovations do not appear to be associated with any particular historical event, nor noted in any detail beyond simply stating: "Later still, these boats apparently evolved into the even longer whaleboat-style *fautasi*" (Neich 1984: 193).

The lineal progression from *taumualua* to *fautasi* is challenged by no one, seemingly being a change in the technology of construction but not in the essential form of the craft. The adoption of the fixed rudder was a widespread innovation, an acknowledged improvement over the cumbersome and less-wieldy steering oar.

The timing of the transition from paddles to oars is also unclear. At some point between the creation of the new form in 1849 and clear descriptions of oars for rowed craft in 1894, Sāmoans had intentionally changed from paddling craft facing forward to craft using pulling at the oars or sweeps, facing the stern. The power developed from the use of the oars and oarlock and fulcrum was easily apparent. A two-mile boat race at the harbour of Pago Pago between a local *taumualua* with a 50-paddler crew and a six-man pulling boat from the USS *Tuscarora* made this clear. Although the Sāmoan paddle craft charged ahead at first, the oared vessel easily overtook the *taumualua* in the long run (*Evening Star* 1875: 1). A later description of a whaleboat-type trip in Sāmoan waters includes a hybrid use of both, oars being employed for open water and paddles being "safer and easier to use … for going in or out

Figure 3. Followers of Matā‘afa Iosefo Laiufi surrendering weapons to the USS *Badger*, 1899. Thomas Andrew Collection, Museum of New Zealand, Te Papa Tongarewa. (available at: https://collections.tepapa.govt.nz/object/211673)

of treacherous reef openings" (Turner 1894: 199). This indicates a recognition of the use of both technologies under different circumstances.

The need for speed during armed conflict may help to explain the incentive behind a transition from *taumualua* to *fautasi*. However, Buck offers an additional motivation associated with the cessation of armed conflict:

> As inter-district wars died down, the *taumualua* in turn gave way before the *fautasi*, a boat built purely for transport … The *fautasi* are also community boats which require large crews. They are unsuited to the needs of the few. (Buck 1930: 371)

Buck's emphasis on the peacetime association of the *fautasi* is challenged by the fact that oared longboats with attached rudders were also built specifically for warfare. In an 1895 newspaper article we find that "unusually large whaleboats" were becoming popular in Sāmoa, including one "60ft long with 7ft 6in beam and 3ft depth [that] pulls 28 oars". Further, that "A larger boat of the same type was recently built by Bailey for Samoan natives, who use them for cruising from one locality to another on visits and also for transplanting war-parties" (*Auckland Star* 1895: 4). If the story of the HMS *Calypso* (above) is to be believed, one of the very early impressions of Western longboats themselves originated from a military context. Furthermore, photographs taken at the end of the war of 1899 show Matāʻafa's forces, in what are clearly *fautasi,* surrendering their arms to the American vessel USS *Badger* (Fig. 3). The Sāmoan boats were identified as "Samoan War Canoes", which leaves little doubt that *fautasi* were used in military naval contexts (*Detroit Free Press* 1899: 29). So, while there are no descriptions of *fautasi* being barricaded on the sides like some *taumualua*, speed of transport and the capacity for large crews of *fautasi* was equally advantageous for both civil and military uses.

BUILDING THE *FAUTASI*

Prior to the use of the term *fautasi* itself, the use of that design can be inferred through the combination of oars (rowing, not paddling), length and the use of metal fasteners (Western-built, not lashed), built for specific purposes in the Sāmoan market. The first reference to a boat approaching the style and length of a *fautasi* that we are aware of occurred in 1894 in the *Samoa Times and South Sea Advertiser*:

> A very handsome, useful, rowing boat has been lately launched to the order of Sagapolo [*sic*], a [high] chief of Saluafata. …Her dimensions are; 45 feet in length by 7 feet beam, by 2ft. 9. [depth of hold] amidships, and 4 feet bow and stern—material kauri—copper fastened. This boat with care should last a lifetime, and in any future regatta will doubtless make her mark. (*Samoa Times and South Sea Advertiser* 1894: 2)

Though shorter than some of the *taumualua*, this early description of a *fautasi*-type vessel combines oars with confirmed Western boat construction (copper-fastened) and an appreciation for the speed of the design. The reference to kauri wood, *Agathis australis*, specifically identifies this particular boat as New Zealand-built. In a broad sense, it combines Western construction methods with the greater length of the Sāmoan *taumualua* craft, indicating Sāmoa's connectedness and adaptation to the industrialised world. We hesitate to refer to this boat directly as a *fautasi* but only *fautasi*-type because there was another rowing boat that was closer to this length which Sāmoans refer to as a *tulula*. There is reference in 1894 to armed *tulula*, "*tulula ma auupega*", in a proclamation dated 23 April 1894 in Apia during a period of tension between various Sāmoan factions and their Western sponsors (Gibson and Moltke 1894).

The following year there appear distinct references to longer oar-powered boats of similar design, which we believe does mark the origin point of boats that would soon be referred to as *fautasi* and appeared to a reporter at the time to be a "war canoe". The concave-shaped keel, deeper at bow and stern than amidships, may have provided these ever-lengthening vessels with the necessary support against inevitable stresses. Some boats of this new style of construction were built in New Zealand for the Sāmoan market, as recorded in the *Auckland Star* newspaper:

> In Mr. C. Bailey's boat-building yard … there are now about half-a-dozen boats under construction for the Islands. The most noticeable of these is an extremely novel craft. This is a long, sharp-ended cutter, 64ft in length, with 7ft 6in beam, to pull 34 oars, which has been built to the order of a number of natives on the island of Savaii, Samoa. Large pulling boats are much in request amongst the natives of Savaii and other islands in Samoa at present, owing to the exigencies of war which may break out again at any time, and several more orders are expected to come up here for similar boats. The boat has a big rise and fall, and is fitted with a rudder, instead of having the usual steer oar. She is fitted with seventeen thwarts, and will carry close on a hundred men. With her thirty-four oars going, the boat will look more like a war canoe than anything else. (*Auckland Star* 1895: 3)

The Sāmoan demand was high for these watercraft of increasing size. An oared boat 18 metres (60 feet) in length and fitted to pull 28 oars was variously described as "A Huge Boat" and as "A Monster Whale Boat" by European writers who viewed such boats as "unusually large" (*Bay of Plenty Times* 1895: 7; *Star* 1895: 1). One writer from Honolulu's *Evening Bulletin* tells of their surprise at the length of the boats: "A short time ago we were surprised to hear of a boat 40 feet long, but now-a-days boats of 60 feet,—and we hear of one 94 feet,—are common" (*Evening Bulletin* 1895: 6).

The predominance of foreign-built boats in foreign-published newspapers should be taken with a grain of salt, and the assumption that all *fautasi* were shipped to Sāmoa from beyond the islands, simply because those notices dominate the foreign sources, should be carefully examined. Firstly, the newspaper articles often note that it is Sāmoans who are ordering the boats and are, presumably, providing the "unusual" specifications. In addition, there is evidence that these boats were also being built in Sāmoa. The same 1895 *Evening Bulletin* article cited above stated, "We hear that a boat 100 feet long is being built by the Kenisons in Savaii to pull 56 oars."

Furthermore, the boats were not just built by those of European descent. For instance, a letter on the subject of local tax inequities from E. Schmidt, President of the Municipal Government in Apia, to the Consular Representatives of the United States, Germany and Great Britain, dated 11 October 1895, supports the assertion of local Sāmoan boat-building during this time:

> The fact that these natives carry on a considerable business by the construction of the fashionable enormous village-boats increasing continually in number and by freeing themselves from the burden of the tax-payers, compete in an illegal way with the foreign boat-builders living in the islands, has caused considerable dissatisfaction among the latter … (Schmidt 1895)

THE DOMINANT SĀMOAN BOAT

By at least the end of the last decade of the 19th century then, the form and construction of the wooden *fautasi* had fully emerged. The lashings and the upraised stem and sternposts of the *taumualua* had vanished. Whether clinker-built (overlapping hull planks) or carvel-built (edge-joined hull planks), these lightweight fast wooden craft, usually between 18 to 30 meters (60 to 100 feet) in length, were constructed in the Western fashion with internal framing and an enlarged keelson to prevent longitudinal hogging or sagging along the vessel's extreme length. There are reports of oared boats of 36.5 metres (120 feet) and 47.5 metres (156 feet) in length (*Press* 1897: 5; *Sydney Morning Herald* 1899: 5). These boats with numerous thwarts for seating could feature 36 oars or more, had attached stern rudders with tillers, and to Western eyes, appeared distinctly related to elongated whaleboats.

One observer timed a *fautasi* race over a one-and-a-half-mile course, confirming the boats' and crews' ability to easily sustain 10 knots or 11.5 miles per hour (Emerson 1934: 1550). All these factors made them well suited for Sāmoa's marine environment, which boasted few protected harbours or wharves but multiple surf landings and long distances between islands (Emerson 1934: 1550–51).

The first specific mention of the term "*fautasi*" known to date is from 1898 in the context of racing, and more specifically observations on boat names:

> The natives certainly have a sense of humour as a glance at any of the names of their "fautasi's" … will shew—one I saw the other day was called the "Misela" (Measels) another the "Fiva" (Fever) while a third belonging to the other party was called the "Fua laau" (medicine) the owners of the latter informed me that she was built to cure the other two … (*Samoa Weekly Herald* 1898: 2)

Observers, at least as early as 1887, describe the popularity of numerous sports and competitive games of strength among the Sāmoan Islands, such as boxing matches, foot races, wrestling, spear practice, club fights, pulling or tug-of-war matches, pig hunting, pigeon-catching and canoe races[1] (Churchward 1887: 139; Stair 1897: 136). What began as competitive events between individuals was often mirrored or transferred to the inter-village level, taking on a more formal and institutionalised aspect (Mageo 1991: 20). In this case, it seems that the newest version of the Sāmoan canoe, the *fautasi*, fitted easily into the existing intense and enthusiastic inter-village competition.

From at least their first appearance in numerous correspondence and newspapers, *fautasi* were immediately very popular, clearly associated with both racing and wartime uses, speed being a primary concern in both. Their great popularity and expense recall elements of a naval arms race combined with the pursuit of speed in professional boating competitions.

> A curious craze for boat-building recently spread through Samoa. Village vied with village as to which could build the largest boat, and this extravagant public works policy threatened to ruin the competitors ... They were often 120 feet in length, and would carry the whole village on a journey. At least one village built a boat which cost 2000 dollars, and its name, "The End of All Things," burst the building boom. (*Poverty Bay Herald* 1897: 4)

In fact, *fautasi* were so popular that some outside observers compared the significance of boat construction in Sāmoa to the importance of building a church.

> Probably the two strongest inducements to the Samoan to work in order to obtain money are the desire to obtain a large racing-boat or faitassi [*sic*], or to build a new church in which to worship. The faitassis [*sic*] are long, narrow boats of the whaleboat type, built in European fashion, and have often as many as thirty-six oars. When one of these is required, the Samoan will work by cutting copra or gathering cocoa in a manner that would put to shame many a European worker. (*Evening Post* 1923: 7)

While the writer may have found something humorous in comparing a racing boat to a church, there is more involved. The importance of the *fautasi* to Sāmoans is related to its history rooted in warfare and its importance as a means of village transportation for traditional village *malaga* (traveling parties) to neighbouring villages, as well as the village identity and rivalries associated with racing.[2] Because of these factors it was infused with and embodied a significance beyond a mere sporting vessel. One can say this with some certainty because the polite Sāmoan term for a *fautasi* is *sā* or sacred (*Samoa News* 2017). Watercraft in many cultures are often decorated for traditional or ceremonial roles (Fig. 4).

From their beginnings and into the first decades of the 20th century *fautasi* became the basic transportation platform for village-to-village and island-to-island travel. Like many places in the world, and particularly for island settings, the ocean provided a natural highway connecting people and communities, prior to the laborious effort of road and highway construction. As marine steam propulsion slowly made inroads into the Pacific, to be followed by gasoline and diesel propulsion, man-powered small craft retreated from their familiar commercial and military roles. There is surely

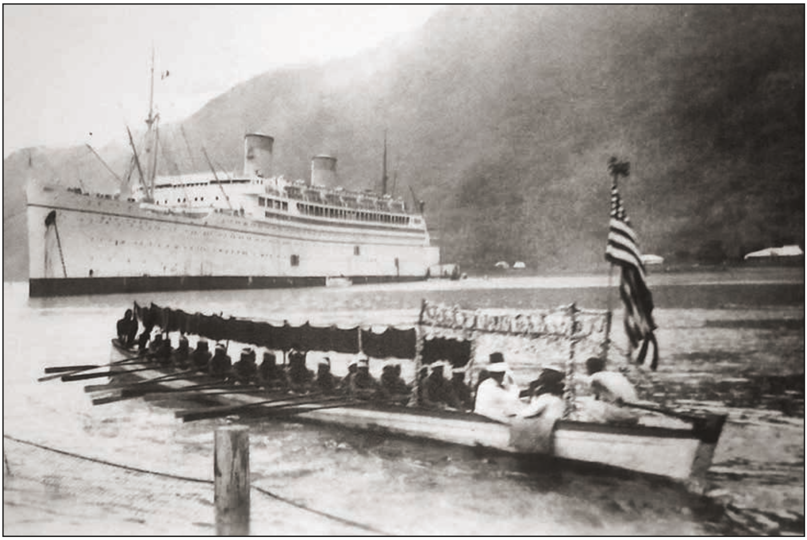

Figure 4. Pago Pago Harbour: Governor O.C. Dowling (Captain, U.S. Navy) departs American Samoa 15 January 1936 in a ceremonially decorated *fautasi* manned by 24 Sāmoan rowers. U.S. National Archives.

some truth to Peter Buck's 1930s assertion that the old *fautasi* seemed to be all rotting away (pp. 371–72).

At least some *fautasi* and *tulula* remained in limited commercial service in specific locations well into the 20th century. The shorter, more manoeuverable *tulula* were often used to ferry cargo through narrow reef channels to and from larger vessels anchored offshore, a critical role for islands where there were no port facilities available, such as the Manu'a Islands. Longer *fautasi* were better suited for inter-island open ocean crossings. For instance, in the 1950s, "All trade is carried on by the five *fautasis* (long-boats) which ply to and from Manono or Upolu" (Holmes 1954: 237).

TERRITORIAL PROHIBITIONS AND THE ROLE OF RACING

In 1899, the Tripartite Convention partitioned the Sāmoan Islands between Germany and the United States, and in 1900 the U.S. Navy took possession of the eastern islands, establishing a coaling station and administrative centre on Tutuila. During this time many aspects of life in American Samoa came under increased regulation, including inter-island travel.

On 30 March 1903, the Naval Government in American Samoa promulgated a regulation concerning travel on *malaga* or traditional large-scale group travel by Sāmoans to visit other villages on other islands. Any trip that involved eight or more people using any type of vessel had to submit an application to the Secretary of Samoa Affairs, who would then make recommendations to the Governor, who would then decide whether to approve or deny the travel. This regulation was a *de facto* restriction on *fautasi* travel since the crew alone was upwards of 32 rowers. This regulation was likely a factor in reducing the demand for and maintenance of *fautasi*. Many of the older boats began to rot in their boatsheds (Buck 1930: 371).

Over the next 60 years, inter-village boat races increasingly became the sole and default use of *fautasi.* The U.S. Naval Station's regular newsletter, *O Le Fa'atonu*, provides a reference for many (not all) of the flag-raising or Flag Day (17 April) ceremonies and sporting events between 1900 and 1950. The *American Samoa News Bulletin* helps to fill in some of the years from 1965 to 1985. Flag Day *fautasi* races first appear in the naval newsletter in 1909. Prior to that, *tulula* races and local canoe and whaleboat races are listed without *fautasi* being specifically named, though they are certainly prevalent in historical photographs prior to this period. Also, there is a hint that they may have been used on the first Flag Day on 17 April 1900, as a programme kept in the U.S. National Archives has a handwritten note about "large boat races". Later, the general size of *fautasi* becomes synonymous with the number of oarsmen or oars carried on board. This was often juxtaposed with the minimum number of boats needed in each size category for the race, as in "For boats of at least 36 oars, three boats must enter; for boats of 24 to 34 oars, three boats must enter" (*O Le Fa'atonu* 1913: 4). Flag Day events included parades, formal speeches, benedictions and a large variety of competitive sports.

CONTINUING ADAPTATION: THE EVOLVING *FAUTASI* EVENT

The *fautasi* race course itself changed over time, in course length, boat size and prize money. In the early decades, the course was usually one and a half to two miles long, with various landmarks for start and finish lines. Today the *fautasi* race is between three and seven miles long, depending on the weather and ocean conditions. On Tutuila, races usually started offshore and outside Pago Pago Harbour, coming into the inner harbour and towards the spectators at the finish line. Elsewhere race routes both started and finished in the calm inner waters, rounding a sea buoy and doubling back.

> The fautasi race was the most exciting race ever held in Tutuila, the course being straight and all boats having an equal chance to win the race. The course

> … was a mile and three quarters in length extending from Aua to Blacklock's wharf. (*O Le Fa'atonu* 1911: 4)

Boat length also steadily increased. Whereas early racing *fautasi* in the first decade of the 20th century often fell into the range of 20 to 36 oars (10 to 18 thwarts), by the 1960s *fautasi* had surpassed that size. Eventually, 40 to 50 oarsmen became the norm. The additional length and added oars most likely increased the speed of the boat. By this time, the course was two miles long and the average time for completion was 10 minutes with a speed of 12 knots (13.8 miles per hour) (*American Samoa Daily Bulletin* 1967: 1).

Prize purses grew significantly by substantial leaps over the years. In 1924, the purse size more than doubled for a showdown between American and Western Samoan *fautasi*. In 1975, the first six winning boats received awards, with $5,000 for first place and $500 for sixth place, a purse ten times larger for the winner compared to 1950. The steady increase in prize packages up to the 1970s finally stalled with the new millennium. Though the winner was awarded $15,000 in 2017 (a 98% increase from 1905), the 21st-century prize value actually declined compared to earlier purses when adjusted for inflation. In addition to monetary prizes, a perpetual trophy was annually transferred between winners.

Fautasi construction today is experiencing an accelerated transition, perhaps changing the nature of the race itself. *Fautasi* with wooden-plank construction existed up until the mid-1980s, when boats constructed with marine plywood coated with fibreglass and resin appeared on the scene. Then, starting in 2000 these plywood/fibreglass boats began to be replaced by more advanced models—referred to as "high-tech" boats. There was also an accompanying transition from heavy wooden oars to advanced lightweight carbon-fibre hybrid sweeps.

AN ANTHROPOLOGICAL BLIND SPOT?

With few exceptions, anthropologists working in Sāmoa seem to have ignored hybrid vessels such as *fautasi* and their use and significance in contemporary sports, despite the increasing popularity and size of the race events (Fig. 5). For instance, Albert Francis Judd's extensive field notes from a Bishop Museum expedition in American Samoa and the Pacific barely mention *fautasi* boats and make no reference to any races at all, notwithstanding the existing *fautasi* record of regular events occurring throughout that period (Judd 1926–27). Field notes record the *paopao* as being the common kind of canoe; "the big canoes have completely disappeared from American Samoa" (Judd 1926: 58).

Could this oversight be due to a matter of unfortunate timing, possible effects of the hurricane in January 1926 that may have destroyed the boats?

Figure 5. *Fautasi* (longboat) regatta, Apia, c. early 1900s. Photo from Museum of New Zealand, Te Papa Tongarewa (available at: https://collections.tepapa.govt.nz/object/1452587).

Or perhaps to an unconscious bias common among outside observers, valuing only the material record of an ethnographically "pure" past, unaffected by Western influence? A historical photograph documents the presence of a sizable *fautasi* in the village of Fitiuta in 1938 (Fig. 6). Despite their unique size and their important function in Sāmoan culture, *fautasi* may simply have been mistaken for Western objects and overlooked. One observer briefly describes *fautasi* in Ta‘ū Village and has a map indicating two boathouses for them, but merely identifies them as "European long boats" (Holmes 1957: 307).

Since the blossoming popularity of the *fautasi* in the late 19th century, devastating events have cancelled some of the regular race events (hurricanes, tsunami, world wars), and the written record kept by the naval administration is partial and incomplete at best. Yet, despite these obstacles and the apparent lack of interest on the part of Europeans, the consistency and significance of the *fautasi* race for Sāmoans remains clear. The Naval Station newspaper *O Le Fa‘atonu* often noted that the *fautasi* race was "an important event", the "main event" and the "apex" of all the sports of Flag Day in American Samoa.

Figure 6. Beach launching of a wooden *fautasi* at Fitiuta Village c. 1938. Adolf and Marjorie Borsum Collection, American Samoa Historic Preservation Office.

Across the Sāmoan Archipelago, *fautasi* races amongst the villages' *sā* (sacred boats) remain serious inter-village competitive events. In American Samoa, up to 150 men compete for one of the 45 seats in the village boat. Participation in the race is recognised as a sign of leadership, village pride and camaraderie, and may have additional health benefits (such as weight loss and cardiovascular health). Teams begin training in early February for the April race. Training consists of a steadily intensifying mixture of aerobic and anaerobic exercises that frequently reflect the military training of the captains. Closer to the race it is not unusual for men to run as a group up mountainsides in the morning, and go for another run together along the road before a late afternoon row. This acts to build endurance and camaraderie while simultaneously signalling commitment to other village members.

There is a strong emphasis on building unity amongst the *fautasi* crew that extends to the entire village community. In the weeks leading up to the race the men are expected to refrain from all sexual activity and begin living and sleeping together at the boathouse or a large Sāmoan guest house (*maota* or *faletele*). Families and village members support the crew directly by providing meals at their temporary home, and indirectly by reallocating their chores and responsibilities and providing money towards boat maintenance and team uniforms. These matching uniforms prominently display village colours, which indicate village pride and are mirrored by the matching tee-shirts and colours of cheering village members during evening practice heats in the harbour, as well as the during race itself. This synchronicity is further evidenced during practices and races when crew member calls for *foetasi*! 'row as one!' or 'pull the oar in sync as one!' are commonly heard.

Today considerable community funding goes into the design and construction of faster and more lightweight *fautasi*. They are computer-designed boats that are made of sleek moulded fibreglass with foam cores, sliding seats and in some cases built-in GPS navigation units. Currently, the fibreglass-coated marine-plywood *fautasi* and the high-tech boats still race against each other because the different technologies have different advantages and disadvantages. The lighter high-tech *fautasi* are superior

Figure 7. *Fealofani Samoa III*, a modern "high-tech" *fautasi* from the village of Fagasa. Photo by David J. Herdrich.

in the calm waters of the harbour, but the older, heavier *fautasi* have more stability in the swells of the open ocean and are less prone to swamping. Still, there is some discussion and debate as to whether the high-tech boats have too much of an advantage and, if so, what can be done about the situation. Though the modern boats may only bear a passing resemblance to the original wooden-plank *fautasi*, they provide a clear symbol of this seafaring culture's interaction with the global community (Fig. 7).

In the last few decades, prize awards have grown considerably, boat technology and construction costs have skyrocketed and commercial sponsors now support the racing events. These changes may have financial ramifications for villages that wish to continue this tradition. *Fautasi* racing has seen dramatic change, with some in the sport now questioning whether the tradition itself is threatened (Likou 2017). Regardless of technology, each *fautasi* in the race is still dependent on the support of its village, on the strength, teamwork and spirit of its crew, on the strategy and decisions of its captain, and on the luck of the weather and sea state. These represent unchanging elements of the *fautasi* traditional cultural practice. Although the technology has transitioned over time, the cultural tradition of the *fautasi* and its connection to the Sāmoan past continues.

* * *

The story of the *fautasi* in the South Pacific represents a series of connected traditions and events that weave their way through Sāmoan history, and now find their most current expression in the annual races. This story begins with the evolution of the outriggerless form of the Sāmoan-built *taumualua* at a time when Western longboats played some minor roles in Sāmoan warfare. Adoption of specific Western construction methods, as well as the purchase of extremely modified longboats from abroad, led to a market for these fast and desirable vessels. The first of those came to be named *tulula* in 1894, followed soon thereafter by boats of a length and design that appeared to be *fautasi* in 1895. The resulting *fautasi* building boom drew attention and comment from many other parts of the Pacific, the new watercraft and its improved speed having proved its worthiness in multiple roles like inter-island passenger service, military operations and recreational events. The rise of powered vessels and government regulations reduced these roles, but never succeeded in eliminating the *fautasi.* The tradition of competitive racing held on and thrived, continuing into the 21st century to the point where modern advancements in materials science and computer design raise the question of sustainability of the *fautasi* traditional cultural practice in modern culture. But for now, even with the changes in technology, the importance of the *fautasi,* or the *sā* of the village, remains strong.

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NOTES

1 By 1906 several references to pulling/rowing vessels had even worked their way into the translations of some contemporary proverbial Sāmoan expressions regarding travel at sea:

- *'Ua fa'afetaia'iga a taulā* —'the meeting of sailboats': when two boats sail past each other in a favourable breeze, only short greetings can be exchanged. If the boat is being pulled by oars, the rowers can stop and there is time for a longer conversation.
- *E tutupu matagi i liu* [*o va'a*]—'a wind can rise even in the hold': when the wind dies down the crew have to take to the oars. Should anyone then hoist the sail the others will mock him. He, however, will answer with droll exaggeration…
- *'Ia fa'atutu mai foe 'ina ia faia'ina le savili*—'pull hard so that we may overcome the wind': when a boat has to fight against a strong headwind, the helmsman calls out …
- *O le mao a le ala*—'the warning "pull, there is a lull"': the boat entrance to Taga, Savai'i, is dangerous as there is no reef and the waves are unusually high. It is necessary that the boat crew await the lull that sets in after the seventh wave and then pull with all their might. It is easier to judge from the shore when the right moment comes. That is why whenever a travelling party approaches, the villagers assemble on the strand to watch the spectacle and to advise the travellers with the cry … (from Schultz 1906: 74–80).

2 Memories are long regarding victories in *fautasi* racing. For example, the village of Fagasa won the *fautasi* race held for American Samoa's jubilee celebration in 1950. The village was so proud of this accomplishment that 50 years later there were concerted efforts to train and support a strong crew, and much expense was undertaken to build the first "high-tech" *fautasi* to ensure another victory for Fagasa during American Samoa's centennial celebrations in the year 2000 (pers. comm. Atuatasi Lelei Peau pers. comm., 2017).

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ABSTRACT

The racing of *fautasi* (30-metre, 45-seater, oared Sāmoan longboats) remains a central cultural competition that unifies contemporary American Samoa and the two Sāmoan states more generally. However, the *fautasi*'s emergence and transition into this role has been dismissed as a vestige of colonialism and has been understudied by scholars. This paper examines the origin, development and use of the Sāmoan *fautasi* with special reference to the *taumualua* (double-ended paddling canoes) and *tulula* (9-to -12-metre, 20-seater, oared boats) that preceded them. We describe these traditional Sāmoan boats and the popular racing events that have grown around them in the context of hybrid nautical design, Western colonialism and modern commercialisation. Previous descriptions of the development of *fautasi* in the anthropological literature are, in many cases, oversimplified. Rather than simply replacing the *taumualua* when Sāmoan warfare ended, we argue that, pinpointing their origin to 1895, *fautasi* were developed because of their superior speed, a clear benefit in numerous functions including use as war boats, cargo and passenger vessels and racing craft. Over a period of 127 years all of these functions, except the popular sport of *fautasi* racing, fell away due to government regulations and the adoption of motorised vessels. Despite these transitions, *fautasi* retain a strong cultural connection to Sāmoa's maritime past with the annual *fautasi* races and represent the single largest cultural event in American Samoa.

Keywords: Sāmoa, history, maritime vessels, *fautasi* ‘longboats’, *taumualua* ‘double-ended paddling canoes’, *tulula* ‘oared boats’, boat-racing

CITATION AND AUTHOR CONTACT DETAILS

Van Tilburg,[1] Hans K., David J. Herdrich,[2] Michaela E. Howells,[3] Va‘amua Henry Sesepasara,[4] Telei‘ai Christian Ausage,[5] Michael D. Coszalter,[6] 2018. Row as one! A history of the development and use of the Sāmoan *fautasi*. *Journal of the Polynesian Society* 127 (1): 111-136. DOI: http://dx.doi.org/10.15286/jps.127.1.111-136

[1] Corresponding author: Office of National Marine Sanctuaries, National Oceanic and Atmospheric Administration, NOAA/DKIRC/Hans Van Tilburg, 1845 Wasp Blvd, Building 176, Honolulu, Hawai‘i 96818, USA. Email: hans.vantilburg@noaa.gov

[2] American Samoa Historic Preservation Office, Executive Offices of the Governor, American Samoa Government, Pago Pago, American Samoa 96799, USA. Email: david.herdrich@go.as.gov

[3] Department of Anthropology, University of North Carolina Wilmington, Osprey Hall 1018 Suite, 601 S. College Rd, Wilmington, North Carolina 28403-5907, USA. Email: howellsm@uncw.edu

[4] Department of Marine and Wildlife Resources, American Samoa Government, Pago Pago, American Samoa 96799. Email: hsesepasara@gmail.com

[5] American Samoa Historic Preservation Office, Executive Offices of the Governor, American Samoa Government, Pago Pago, American Samoa 96799, USA. Email: chris.ausage@gmail.com

[6] Department of Anthropology, University of North Carolina Wilmington, Osprey Hall 1018 Suite, 601 S. College Rd, Wilmington, North Carolina 28403-5907, USA. Email: mdcoszalter@live.com