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

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In this communication we report the findings of extensive inland settlement in Palauli District, Savai'i, made possible with the use of LiDAR-guided¹ 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.

However, there have been few surveys of inland areas on the large islands of 'Upolu or Savai'i, 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 Vaito'omuli and Fa'aala, Palauli District, on the island of Savai'i. 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, Savai'i (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 Savai'i, 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 Sātupa'itea East are located on the island of Savai'i 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 (*fetuma'a*), earthen ovens (*umu ele'ele*), walls (*pā*) and walkways (*āualasavali*) to compare with previous surveys in

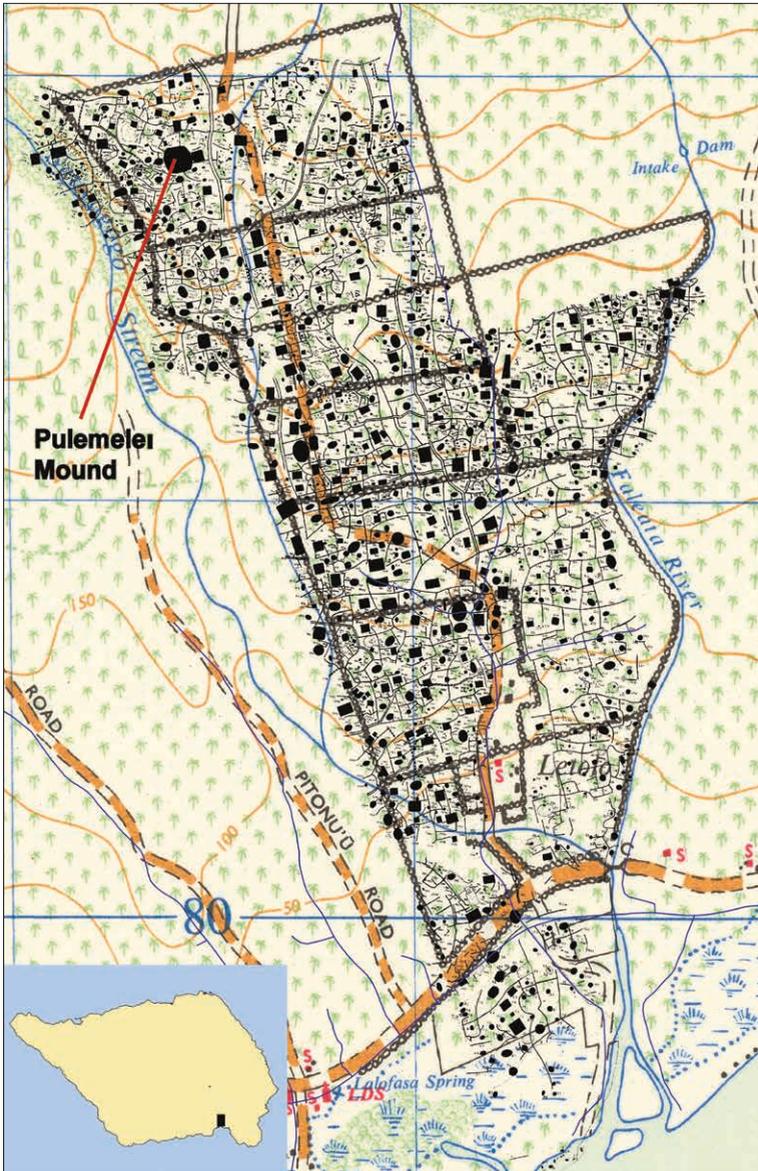


Figure 1. Letolo Plantation Survey, 1978.

both Savai'i and 'Upolu. A longer-term objective is to assist the Government of Samoa in developing heritage protection policies 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 / 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° 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).

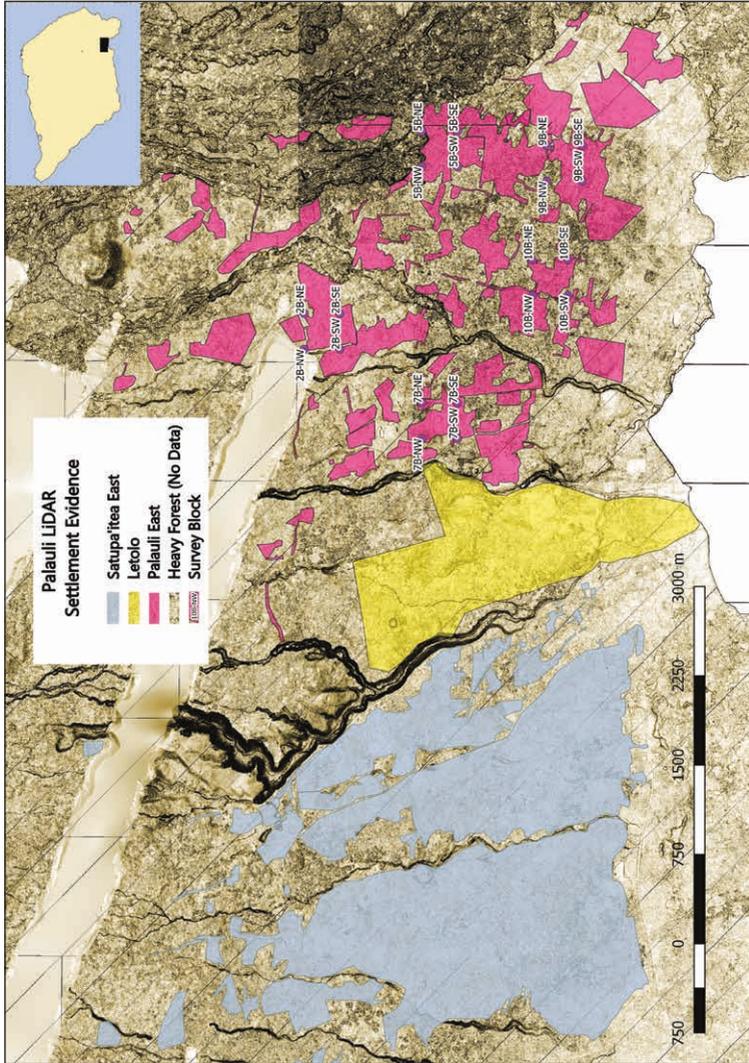


Figure 2. Area surveyed in 2017 showing prehistoric habitation with LiDAR or ground survey (3,500 hectares).

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

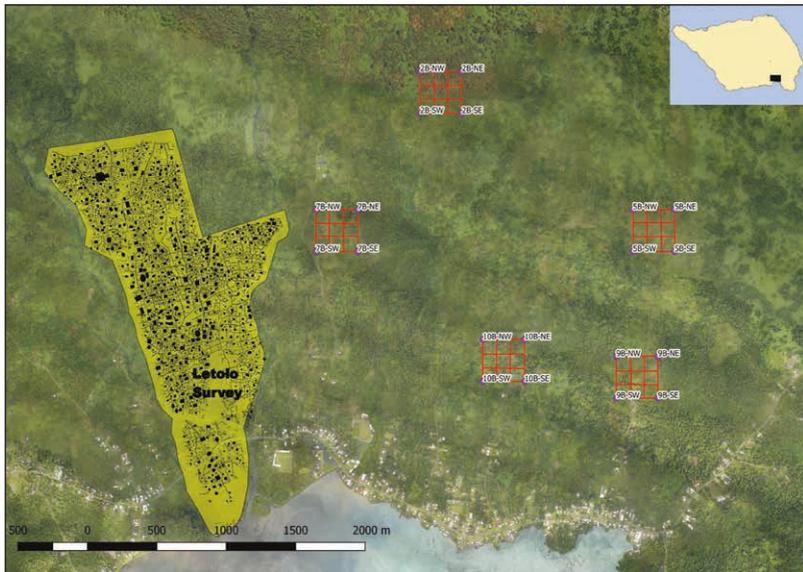


Figure 3. Survey areas in 2017 showing 300 × 300 m survey blocks and location of modern villages. The 1978 Letolo Survey is highlighted in yellow for reference.

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.

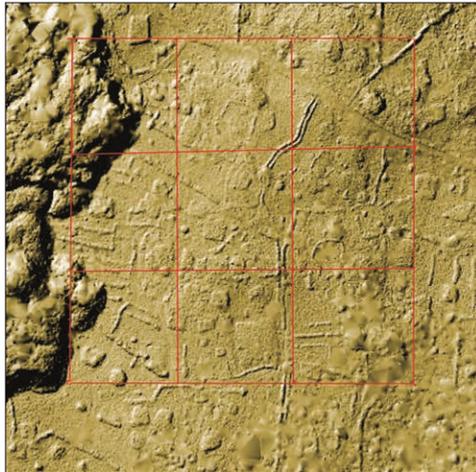


Figure 4a. Hillshade LiDAR (Block 5B).

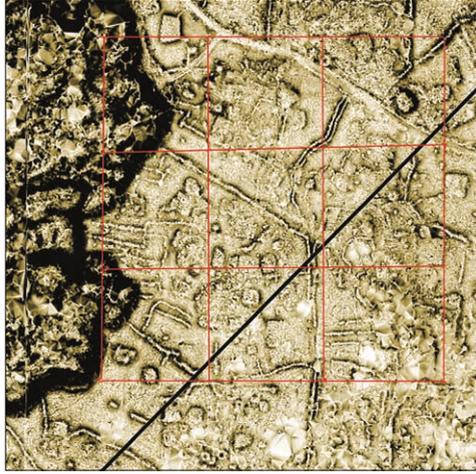


Figure 4b Sky-view LiDAR (Block 5B).

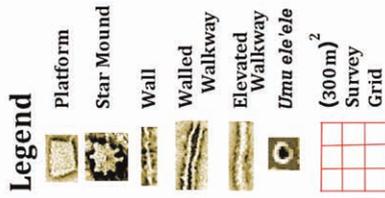


Table 2. Block 10B data.

Apr 4–6 Stats	Vaito'omuli (Block 10B)	Platforms:	Length	Width	Area
Platforms	56	Avg.	13	9	134
Walls	36	Max.	30	22	660
Walkways	5	Min.	3	2	6
<i>Umu ele'ele</i>	2	Median	12	9	102
Stone Piles	0	STDEV	6	4	117
Star Mounds	2	Legend			
Other	0	■ Platform	▶ Walled Walkway	 (300m) ² Survey Grid	
All Sites	101	★ Star Mound	▲ Elevated Walkway		
		○ Wall	* <i>Umu ele'ele</i>		

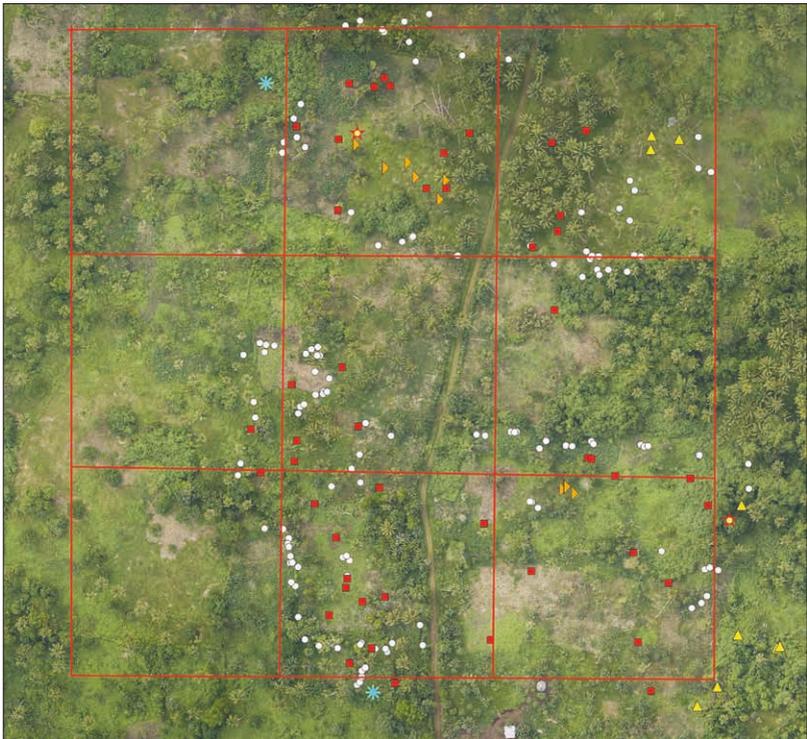


Figure 5. Archaeological features recorded during the April 2017 survey: QGIS Map – Block 10B.

Table 3. Block 9B data.

Apr 7–8 Stats	Fa'aala (Block 9B)
Platforms	50
Walls	46
Walkways	25
<i>Umu ele'ele</i>	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

Legend

- Platform
- ★ Star Mound
- Wall
- ▶ Walled Walkway
- ▲ Elevated Walkway
- ⋆ *Umu ele'ele*
-  (300m)² Survey Grid

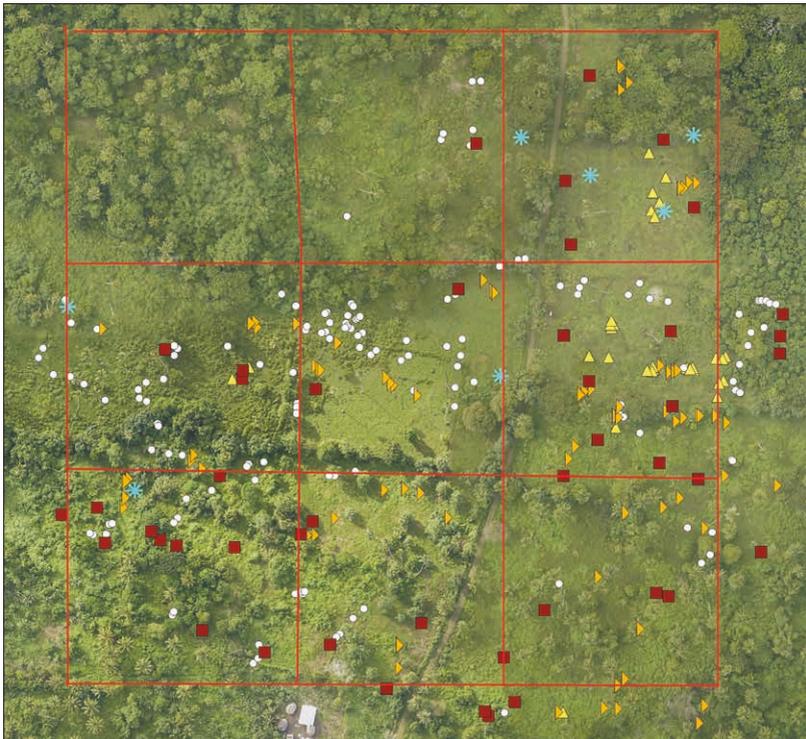


Figure 6. Archaeological features recorded during the April 2017 survey: QGIS Map – Block 9B.

Table 4. Block 7B data.

Jun 19–20 Stats	Vailoa (Block 7B)
Platforms	33
Walls	20
Walkways	15
<i>Umu ele'ele</i>	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

Legend

- Platform
- ★ Star Mound
- Wall
- ▶ Walled Walkway
- ▲ Elevated Walkway
- * *Umu ele'ele*
-  (300m)² Survey Grid

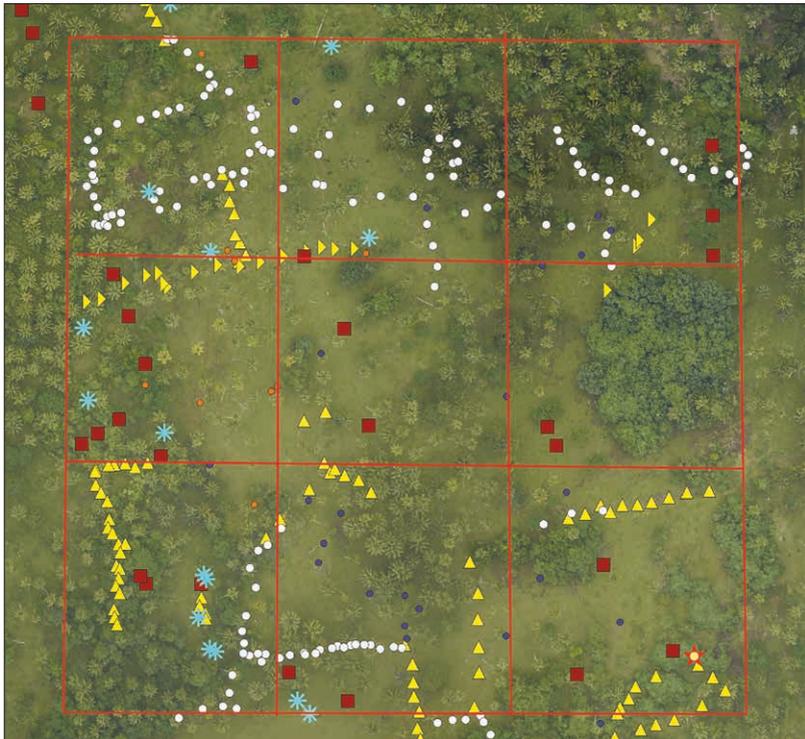


Figure 7. Archaeological features recorded during the June 2017 survey: QGIS Map – Block 7B.

Table 5. Block 5B data.

Jun 22–26 Stats	Fa'aala (Block 5B)
Platforms	40
Walls	27
Walkways	27
<i>Umu ele'ele</i>	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

Legend

- Platform
- ★ Star Mound
- Wall
- ▶ Walled Walkway
- ▲ Elevated Walkway
- ⊛ *Umu ele'ele*
-  (300m)² Survey Grid

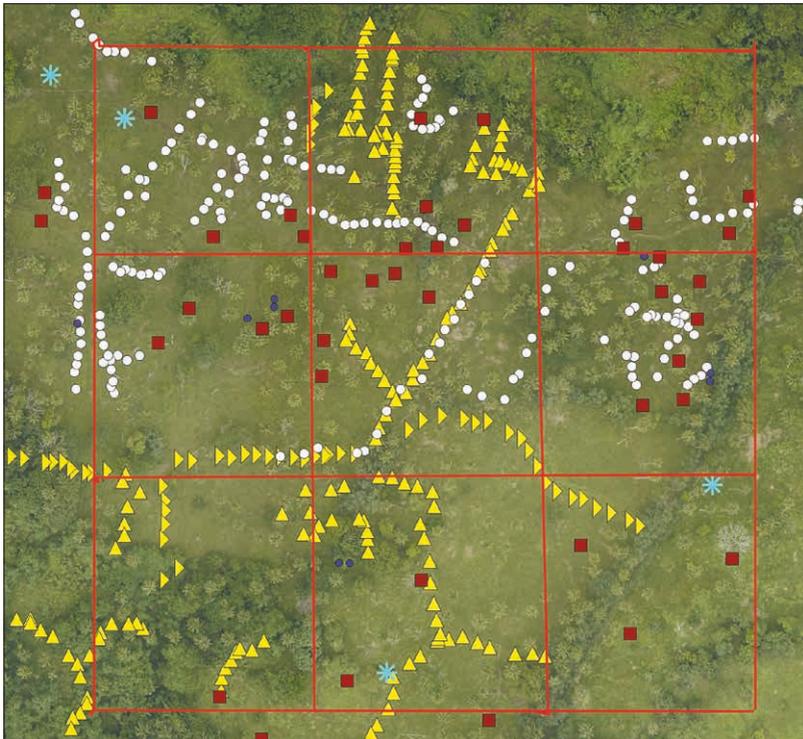


Figure 8. Archaeological features recorded during the June 2017 survey: QGIS Map – Block 5B.

Table 6. Block 2B data.

Jun 27–29 Stats	Vaito'omuli (Block 2B)	Platforms:	Length	Width	Area
Platforms	31	Avg.	12	8	121
Walls	10	Max.	25	20	500
Walkways	13	Min.	4	3	12
<i>Umu ele'ele</i>	2	Median	12	8	82
Stone Piles	9	STDEV	5	4	111
Star Mounds	0	Legend			
Other	0	■ Platform	▶ Walled Walkway	 (300m) ² Survey Grid	
All Sites	65	★ Star Mound	▲ Elevated Walkway		
		○ Wall	✳ <i>Umu ele'ele</i>		

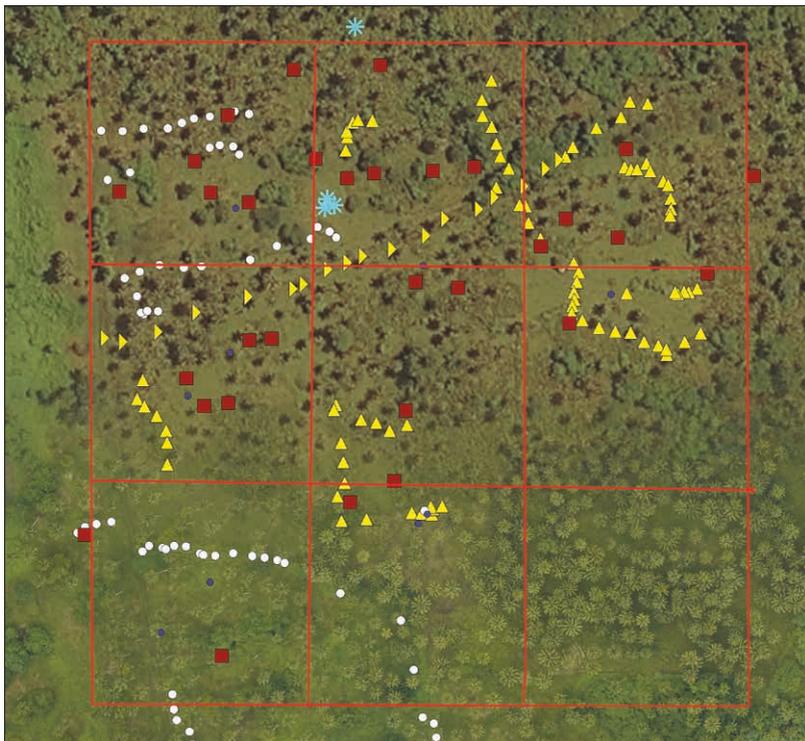


Figure 9. Archaeological features recorded during the June 2017 survey: QGIS Map – Block 2B.

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 descriptions⁴ (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 Savai'i and 'Upolu now being analysed, confirm the evidence from the earlier 'Upolu and Savai'i 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 60³ 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 ($6 \times 5 = 30$) 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; $200 \times 30 = 6000$), 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 per 10 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 Fonoti² 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>

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