

DID SĀMOA HAVE INTENSIVE AGRICULTURE IN THE PAST? NEW FINDINGS FROM LiDAR

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ABSTRACT: During recent field survey work in Aleipata on the southeast coast of the Independent State of Samoa several new archaeological features have been discovered by a LiDAR-guided ground survey. The survey confirmed evidence from LiDAR images of a dense habitation zone from the coast to several kilometres inland with an extensive drainage system. We suggest that prior to the nineteenth century, when Sāmoan political organisation was first described, the extent and interconnectivity of the channels suggest that a larger population, a more intensive organisation of labour and resources for agricultural production, and a more extensive system of political authority existed.

Keywords: Sāmoan archaeology, agricultural intensification, cultural heritage, political organisation, LiDAR survey, remote sensing

Archaeological evidence of past agricultural practices and food production systems has long been important when considering the prehistoric evolution of political organisation in Sāmoa and other Polynesian societies (Earle 1978; Kirch 1984; Ladefoged *et al.* 1996; Lepofsky and Kahn 2011). Intensification of agriculture, defined as increased labour, capital and skill input against constant land (Brookfield 1972), is thought to lead to increased production, and in the prehistory of Polynesia, is associated with more stratified and extensive political organisation (Kirch 2006; Leach 1999; Morrison 1996; Quintus and Cochrane 2018). Earlier archaeological research on Sāmoa suggested that agricultural systems were not intensive (Carson 2006; Green 2002). For example, comparing cultivation in Sāmoa with other Polynesian societies, Carson argued that agriculture was practised on a comparatively small scale in Sāmoa, consistent with autonomous family production, rather than large-scale cultivation under the leadership of chiefs who controlled large territories, as in Hawai'i for example (Ladefoged and Graves 2006).

As Carson put it, food production involved “family-operated parcels rather than a single unified field system”, perhaps indicating “a small resident population” (2006: 19) so that “development of vast and complex agricultural fields apparently did not transpire in Sāmoa” and that “elaborate systems for production, storage, and distribution of food crops are not a material necessity for long-term or large-scale settlement [in Sāmoa], unless perhaps a certain population threshold is approached or breached” (p. 23). This view matches descriptions of land use and political organisation by anthropologists in the twentieth century (Gilson 1970; Holmes 1974; Mead 1969; Shore 1982) who saw Sāmoa’s political system as characterised by small, fragmented rival chiefdoms comprising groups of allied villages and kin groups.

These conclusions have recently been questioned by Quintus and Cochrane (2018), and the data presented here provides grounds to further question Green’s and Carson’s conclusions. Our paper discusses evidence of what appears to be extensive terrestrial modifications that are evidently drainage systems for inland agriculture and for the protection of structures such as house platforms. These suggest a much greater degree of organised land use and drainage, to allow extensive planting of food crops and protect inland settlements from the effects of heavy rainfall, than has been evident in Sāmoa in historical times.

As we have argued elsewhere (Jackmond *et al.* 2018), although there were few inland villages in Sāmoa in the nineteenth and twentieth centuries, there is now archaeological evidence, revealed by LiDAR (Light Detection and Ranging) imagery, of extensive inland settlements throughout Sāmoa, suggesting there was a much higher population in the past compared to that recorded in the nineteenth century. Our analysis of LiDAR images,¹ in addition to identifying extensive inland settlements, has found what appear to be tens of square kilometres of channels (Fig. 1) on arable lands of the north and south coasts of ‘Upolu. These are so extensive that they suggest that in the past there were larger populations, more intensive agriculture and larger-scale organisation of labour and resources than previously supposed to be the case in Sāmoa. If this was so, then there was probably more extensive chiefly control over land in the past than has previously been recognised in the ethnographic and archaeological literature.

This paper discusses the findings from a LiDAR-guided ground survey of the systems of channels and their archaeological contexts on the land of Sāmusu-uta in Aleipata district of ‘Upolu (Fig. 1). Specifications of LiDAR images² of Sāmoa are described in Jackmond *et al.* (2018). The Sāmusu survey and findings described below are part of a long-term project, planning for which started in 2011, to build a Sāmoan Archaeology and Cultural Heritage Database³ at the Centre for Samoan Studies (CSS), National University of Samoa, with the aim of recording, analysing and where possible preserving

ancient and historical heritage areas (Jackmond *et al.* 2018). The database will support archaeological research in Sāmoa, build a knowledge base on Sāmoan prehistory and heritage, and assist the Government of Samoa to develop heritage protection policies and legislation that are lacking at present (see Sciusco and Martinsson-Wallin 2015).

LiDAR-GUIDED GROUND SURVEY AT SĀMUSU

The population of the district (Aleipata Itūpā i Lalo) was recorded as 3,887 in 2010 (Government of Samoa 2011), and its two electoral sub-districts (*faipule*) comprise over a dozen villages. The district consists of a gently sloping broad coastal plateau with a small elevated hilly area along the north coast, several volcanic craters to the southwest and an eastern lower coastal floodplain, which was recently inundated by a tsunami in 2009. Since the tsunami many households of the affected villages have established inland sub-villages on land previously only used for agriculture. Numerous intermittent streams (only a few of which are named) run from west to east across the plateau and coastal plain. Behind the coastal villages, gently sloping plantation land mixed with forest rises up through the coastal plateau.

The survey was part of a field school with a team composed of five lecturers, five research assistants and 30 students from the programme in Archaeology and Heritage Management at the National University of Samoa (16 September–21 October 2018). Before the survey area described here was selected for intensive ground survey, a preliminary reconnaissance had been conducted of possible survey areas on ‘Upolu using LiDAR, aerial photos and quick on-the-ground GPS point survey to gauge the feasibility of a further study.

The ground survey area measured from 100 to 300 m in width and was almost 1.5 km in length (see coloured squares in Fig. 2). It was chosen because it comprises a relatively open area for grazing cattle and consists of a large swath of plantation covered in low grass, brush and coconut trees. This location made it easier to examine more closely the systems of ditches revealed by LiDAR. The land belongs to one of the authors of this article (Tautunu), a leading *matai* ‘head of household’ and orator (*tulāfale*) of Sāmusu-uta, and the survey was approved and supported by the other *matai* of Sāmusu-uta.

The survey area was marked off digitally using 100 x 100 m blocks (Fig. 2) to give the survey teams a frame of reference, though these were greatly modified by the boundaries of the intermittent streams to the north and south of the Sāmusu survey area. Priority was given to areas of low vegetation, which ensured the best possible positive outcome from the survey.⁴ The area bears evidence of extensive settlement extending several kilometres inland from the modern village of Sāmusu-uta. The archaeological features

included terraces, a *malae* ‘village green’, star mounds, earthen ovens and forts. The general features discovered during the ground survey match those previously described (Buist 1969; Green and Davidson 1969, 1974; Jennings and Holmer 1980; Jennings, Holmer and Jackmond 1982; Jennings, Holmer, Janetski *et al.* 1976; Scott 1969). A significant difference is the relative scarcity of stone building material for constructing platforms and walls in Aleipata compared to elsewhere.

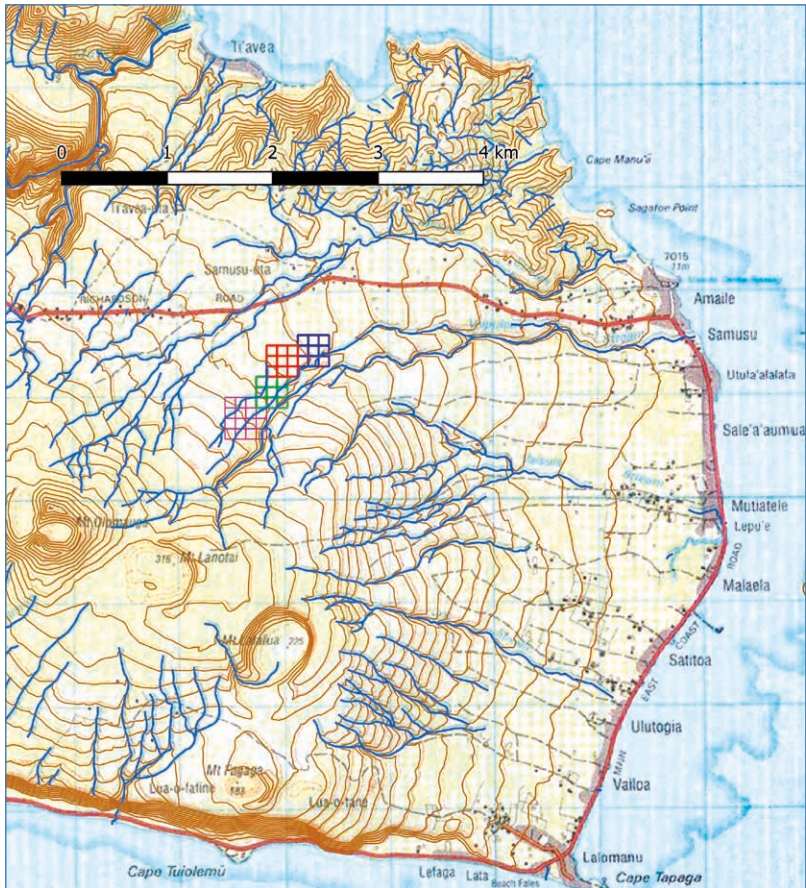


Figure 2. Topographic map of Aleipata. Coloured squares show the general location of the survey area.

ARCHAEOLOGICAL FEATURES IDENTIFIED

The main objective of the survey was to assess the function of the channels in Aleipata as seen on LiDAR (Figs 3 and 4), and to contextualise them with other archaeological remains of prehistoric settlements. An earlier archaeological survey in 1966 of a portion of Aleipata (Lalomanu, 6 km to the south of the survey area) was done by Davidson (1974a: 190–95), who recorded numerous star mounds, platforms, walls, ditches, scarps and terraces. Her survey did not extend to Sāmusu to the north and did not identify the extensive channel system described here, which is not easy to identify at ground level.

Channels

LiDAR images⁵ of Aleipata district reveal an extensive system of human land modification: a network of over 150 km of channels covering an area of 20 km² or more encompassing the entire eastern tip of ‘Upolu (Fig. 3). Although deep forest cover obscures the LiDAR readings in some areas, those portions of the forest that have been cleared for contemporary agricultural purposes show a network of drainage channels extending in all directions for several kilometres associated with an apparently dense and extensive habitation zone consisting of house platforms, terraces, walls, earthen ovens and numerous walled and elevated walkways. LiDAR images usually show only a small portion, approximately one-third or less, of archaeological features compared to what may subsequently be found by a ground survey. However, in the case of Aleipata, drainage channels were often more recognisable on LiDAR images than from the ground survey, due to their low profile and eroded condition (see Figs 5 and 6). In some places they appear to form boundaries around platforms, but more widely they appear to form a network of interconnected channels that occasionally connect to larger intermittent streams (Fig. 2). A high-resolution image of those located by LiDAR within the Sāmusu ground survey area can be seen in Figure 3. The ditches are not confined to gently sloping terrain; rather, they start several kilometres inland, in the uplands of Aleipata, and continue down toward the coast. In most areas their downhill orientation has been obscured by the 2009 tsunami (Fig. 3).

Some of the channels may have originally been natural watercourses or intermittent streams but are obviously modified by human actions. Most channels have what appear to be purposefully low raised edges on one or both sides, capped in some places with small rounded river stones that may have formed a protective embankment to reduce erosion. They made a fine walkway when the ground turned muddy during our survey after the numerous rains, suggesting that they functioned similarly in the past (Figs 5 and 6a). Many channels also intersect at right angles. Some run perpendicular to existing

streams and parallel to contour lines across the ridges between streams (see Figs 3 and 4). They range in width from less than half a metre to several metres, and in depth from a few tens of centimetres to a metre or more. Their raised banks or berms were formed with the excavated earth or with earth dug from their sides. The sides are often gently sloping, not vertical, and are now completely covered in vegetation (Figs 5 and 6). According to the people of Sāmusu-uta, the channels have not been worked on in recent memory (for the past 70 years or more); however, they still appear to function today, without maintenance, by draining the excess rainwater from the land.

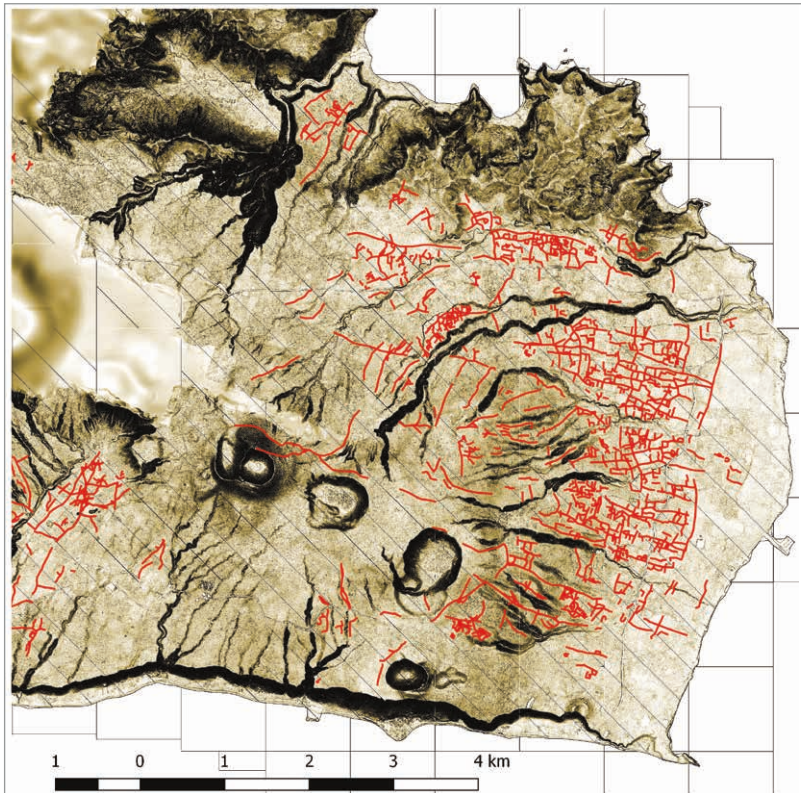


Figure 3. Some of the probable Aleipata channels (red lines) extrapolated from LiDAR.

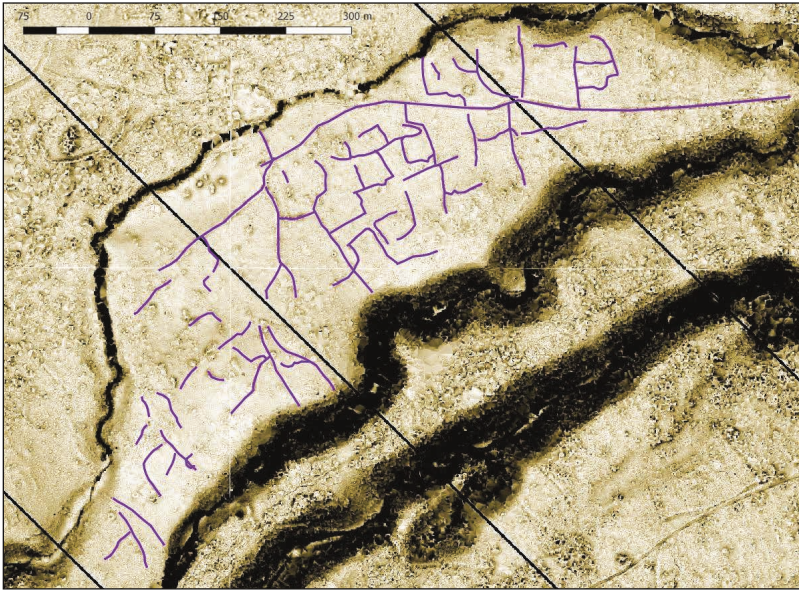


Figure 4. Channels as extrapolated from LiDAR in the Sāmusu ground survey area (vectored in purple).

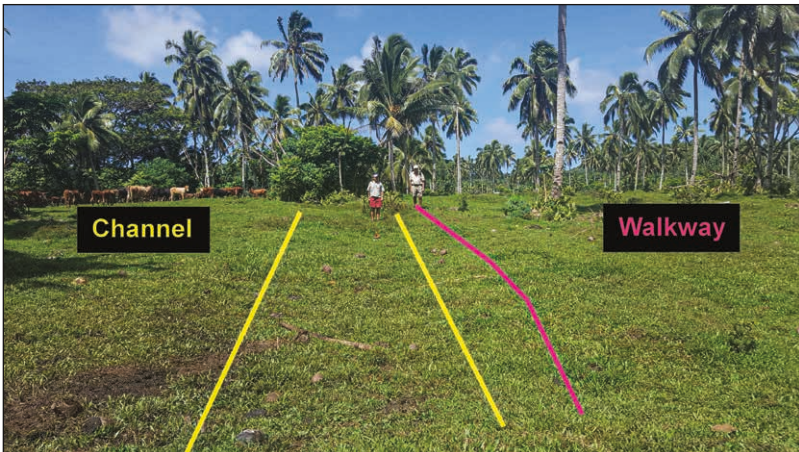


Figure 5. An example of a wide channel (the sides of which are marked in yellow) with its associated elevated stone alignment, a possible “walkway”, marked in red.

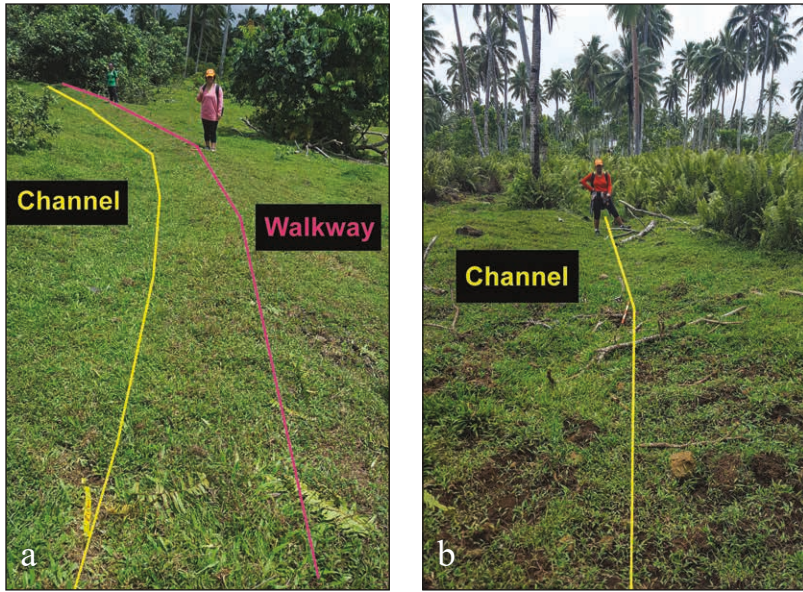


Figure 6a. A narrow channel (marked in yellow) with associated elevated stone alignments that may have functioned as “walkways” or paths (marked in red).
Figure 6b. A channel (marked in yellow) with no associated “walkway”.

Terraces

Hundreds of terraces (level ground formed by removing earth from the uphill side of a slope and depositing it on the lower part) can be seen on the LiDAR throughout Aleipata, on almost every visible ridge or area of uneven ground. Over 30 were examined in the ground survey to get a better understanding of how they appear on LiDAR. Terraces are one of the most prevalent anthropogenic features of the landscape, but they have not yet been counted. Their function, for habitation or agriculture, could not be discerned from the LiDAR images, but many of those inspected showed evidence of past habitation. Presently most of those examined are or have been planted with crops, but more detailed work needs to be done to investigate their original function.

Malae

As Davidson noted over 50 years ago (1969), it is difficult, even impossible, to identify former malae sites archaeologically. Malae were, and still are in many villages, an open space in a central position, without any artificial features that could be expected to survive archaeologically. The sites were usually

associated with one or more *faletele*, which were the houses of the highest-ranking chiefs and were of ceremonial importance. We found an open space likely to have been a malae, measuring 150 to 190 m long by 60 to 70 m wide (Fig. 7), bordered on the north by an intermittent stream and on the south by a small shallow channel and its associated low rock embankment about 10 m upslope (the light-coloured diagonal line in Fig. 7b). Its possible historical significance is suggested by the fact that the landowner's grandfather left the space unplanted with coconuts over 70 years ago. The space contains seven large piles of small-to-medium-sized river stones, ranging in size from 7 to 13 m long and 5 to 9 m wide with a height of 0.1 to 1.3 m (Table 1).

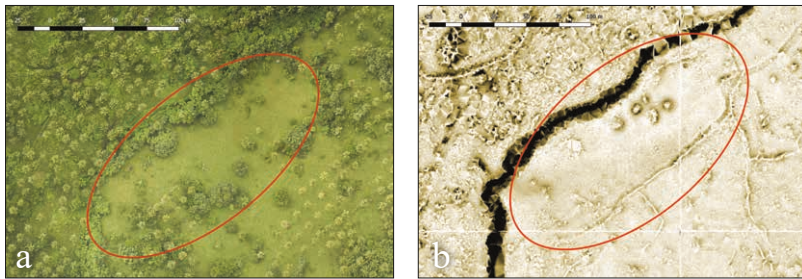


Figure 7a. Sāmusu survey malae (aerial). A clear malae area (marked by a red oval) is evident in the photo, but platforms are obscured by vegetation.
 Figure 7b. Sāmusu survey malae (LiDAR). Platforms appear as “raised” light areas surrounded by darker shapes.

Table 1. Dimensions of platforms in malae area shown in Figure 7.

Designation	Length (m)	Width (m)	Height (m)	Sides
P1001	9	8	0.2	sloping
P1002	11	9	0.8	sloping
P1003	7	5	0.5	sloping
P1004	7	9	1.4	sloping
P1005	9	8	1.1	sloping
P1006	13	8	1.3	sloping
P1015	11	9	0.1	sloping

Star Mounds

Overall for Aleipata, 85 star mounds or possible star mounds were observed on the LiDAR (Fig. 8), and the team recorded nine of them. Davidson (1974a: 191, Fig. 77) recorded 16 star mounds in her Lalomanu survey, but only a little more than half were visible on LiDAR because of the deep forest cover.

Umu Ele'ele (Earthen Ovens)

For Aleipata, 136 *umu ele'ele* 'earthen ovens' were found on LiDAR (Fig. 8). Eight of them were recorded within the survey area, and an additional nine were found that are not visible on LiDAR.

Forts

Four probable ditch-and-bank type forts were observed on LiDAR, one of which was previously recorded (Cochrane, pers. comm., March 2017). Of those previously unknown the team recorded one in the ground survey. This

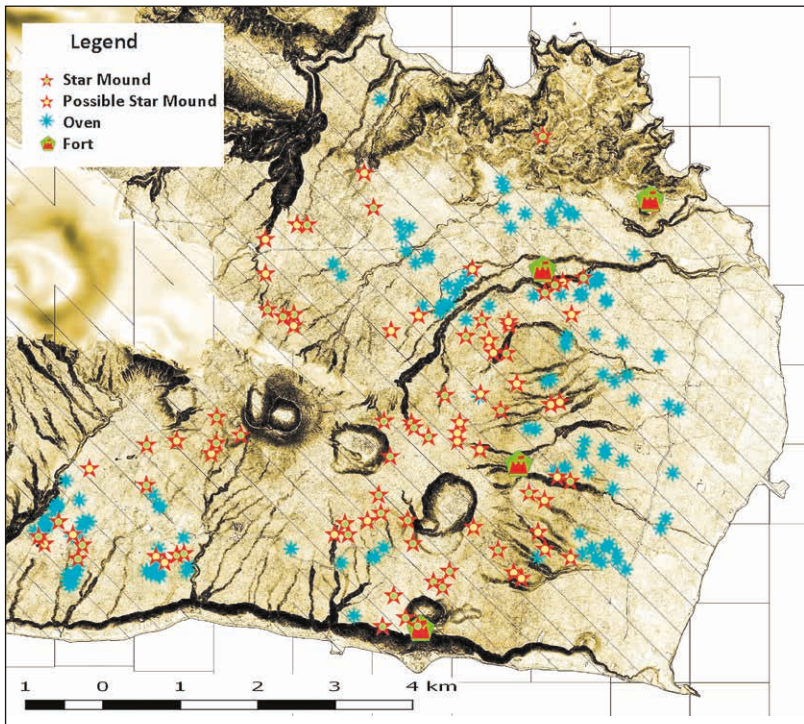


Figure 8. Other LiDAR features of special interest in Aleipata district.

conformed to the type of ditch-and-bank fort that extends across a ridge from gully to gully described by Davidson (1974b: 240–42). It differed only by the deepest portion of the ditch being on the inland side of the fort with the bank on the seaward side, suggesting that this fort may have been built to defend from an inland attack as opposed to a seaward attack, as assumed for forts examined by Davidson (1974a: 181).

Table 2. Summary of features recorded in the 2018 Sāmusu ground survey.

Features	Total ID in survey (24 ha)	No. ID in 17 ha parcel*
Drainage channels	34	25
Pits	23	16
Platforms	95	80
Stone piles	82	58
Walls	19	15
Elevated walkways	39	29
Walled walkways	21	16
<i>Umu ele'ele</i>	17	14
Star mounds	1	1
Other	2	2

* During the first four days 17 hectares were surveyed almost completely, while the remaining seven hectares were only partially surveyed on the last day.

DISCUSSION

Survey Findings

The LiDAR and ground survey findings indicate the existence of an extensive ancient indigenous population zone stretching from the coast to three or more kilometres inland throughout most of the area of Aleipata and characterised by an extensive system of channels (Fig. 9, Table 2). These may once have had many functions: to drain cultivated land, to mark field boundaries or to protect malae and house platforms, as Quintus *et al.* (2015) noted in their analysis of similar features on the island of Ofu in the Manu'a Islands of American Samoa. For example, if the feature we think is an old malae and the channel south of and above it were both constructed at the same time, they show how a channel could divert the heavy runoff of rainwater and protect the site. At different times each channel could have functioned as

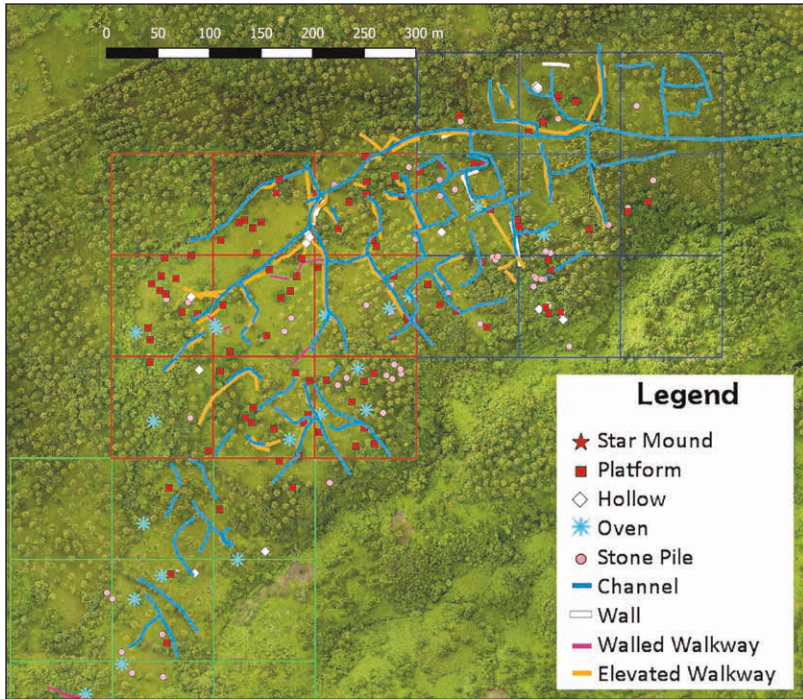


Figure 9. Distribution of features found in the Sāmusu ground survey, with traversed areas indicated by 100 m² coloured grids.

an embankment and walkway as well as a drain. There is no evidence that they were once used for irrigation as they did not connect to the intermittent natural streams at a level that would allow water to flow into the channels and onto the surrounding terrain.

Our findings show a system of channels extending in a honeycomb pattern, from Sāmusu at the north end of Aleipata to Lalomanu on the south coast, 6 km away (Fig. 3). Further investigation is needed in this and other areas of ‘Upolu where LiDAR images reveal similar features. We interpret the Aleipata channels as an extensive system of dryland drainage channels that appear to be a more extensive and complex variation of those described by Barber (1989, 2001) in northern Aotearoa New Zealand. Barber described what he termed “Category B ditches” as “gentle slope ditch systems”, used to demarcate land units, reticulate water and counteract water erosion, unlike the systems for dryland irrigation or wetland drainage systems commonly found in Polynesia, as described by Kirch and Lepofsky (1993).

The findings suggest a much larger population for Aleipata in the past than at present (Fig. 9, Table 2). Within the 17 ha most completely surveyed, 80 platforms were located, numbering about 4.7 platforms per hectare. If we assume that only one-tenth of those platforms were occupied at any one time, with five occupants per house platform ($4.7 \times 5 = 23.5$) in a habitable area of 3,000 ha (6×5 km), it allows us to estimate a population of at least 7,050 compared to the present population of 3,887 for the entire northern district of Aleipata Itūpā i Lalo.

Chronology

Although no excavations were carried out and no dates have been directly obtained, other research in Sāmoa suggests a general chronology for Aleipata. Cochrane's 2013–14 corings and excavations, covering a little more than 10 percent of the Aleipata coast, gives us evidence of an AD 1400 date for habitation of coastal areas of Aleipata (Cochrane 2015). The numerous archaeological features apparent on LiDAR indicate extensive human activity, likely between AD 1400 and 1800, the dates previously associated with these features by Holmer (Jennings and Holmer 1980), Herdrich and Clark (1993) and Wallin *et al.* (2007). And, although we have no dates for the channel system in Aleipata, similar, smaller examples have been dated in American Samoa to between AD 1400 and 1600 (Quintus 2015).

* * *

The significance of our findings from field surveys and LiDAR images for the Aleipata district of 'Upolu call for a reanalysis of Sāmoa's ancient agricultural, and possibly its political, systems. The evidence we describe here strongly suggests that in the past a much more centralised system of political authority and leadership existed to manage drainage systems on land for the production of food. These findings question conclusions that Sāmoa did not have an intensive agricultural system (Carson 2006) and that the pre-contact population of Sāmoa was less than 50,000 (McArthur 1967). As Quintus and Cochrane have argued, more research is needed:

Large stretches of land in the interiors of many islands remain to be surveyed, especially on the island of Savai'i. Even those landscapes for which information is present have been the subject of only limited archaeology relative to agricultural landscapes in places such as Hawai'i and New Zealand. (2018: 495)

The extent of the channels we describe logically suggests they had a function in food production. In the rainy season of November to March, Aleipata may receive over 300 mm of rain per month (Government of Samoa 2018), so it can be assumed their functions were to minimise the

excessive saturation of the soil and mitigate soil erosion by channelling water away from inundated areas. Past assumptions (previously cited) that Sāmoan food production was small-scale under dispersed local authorities are challenged by the extensive network of drainage channels we describe. These, unlike walls and other stone structures and earthworks, are unlikely to have developed piecemeal, as each unit of channel construction must receive and expel water in conjunction with each adjoining unit, if the system was to drain land efficiently. If there had been an unregulated system of small family plots, neglect by one family would undermine the function of the whole system. It is assumed that to support extensive agricultural production and a large population, the construction and maintenance of the channels would have required a considerable investment of time and cooperative labour. It is likely that channels were also once used as boundary markers in locations where stone is not sufficiently abundant to build walls as boundary markers.

In contemporary Sāmoa households rarely cooperate in their farming practices. As things are done today, it would be difficult to maintain a widely shared system of drainage channels without a system of authority that required cooperation. For example, in Aleipata today there are over 10 villages, many with sub-villages, comprising some 200 to 300 matai and their families. Although matai are still ranked according to the importance of their titles, today this speaks more of ceremonial precedence than of the extent of authority over land and land use that likely existed in the past.

Earlier archaeological research in Sāmoa that found no evidence to show that Sāmoa had, in the past, the kind of extensive food production systems that would indicate the exercise of chiefly authority on a large scale has been from islands in the Sāmoa Archipelago that are much smaller than ‘Upolu and Savai‘i (Athens and Desilets 2003; Ayres *et al.* 2001; Carson 2003, 2006; Clark 1988, 1990; Clark and Herdrich 1993; Cochrane *et al.* 2004; Moore and Kennedy 1996; Quintus 2011; Quintus and Clark 2012; Quintus *et al.* 2015, 2016; Valentin *et al.* 2011). However, more recently Quintus and Cochrane (2018), from their work in American Samoa, note that larger-scale political patterning is apparent even in the small islands of the Manu‘a Group. Recent ongoing research by Cochrane in the comparatively extensive land of the Falefā Valley on ‘Upolu is, like our work, questioning past conclusions about the absence of agricultural intensification in Sāmoa and the nature of prehistoric political organisation.

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NOTES

1. The LiDAR images rendered for this project, covering the entire archipelago of the Independent State of Samoa, are presently available online at: <http://samoanstudies.ws/AFCP/MapServer/>
2. A full account of the original LiDAR survey can be found in *Report of Survey: Airborne LiDAR Bathymetric and Topographic Survey of Samoa 2015, Survey Period 6 July to 9 August 2015*, Doc. No. TLCS00.047.008, prepared by Fugro (Australia) for the Ministry of Natural Resources and Environment, Government of Samoa. Available online at: http://samoanstudies.ws/AFCP/Books/Fugro2015_Airborne%20Lidar%20Bathymetric%20and%20Topographic%20Survey%20of%20Samoa%202015.pdf
3. A detailed description of the database is available online at: <http://samoanstudies.ws/AFCP/Books/UTUoverview.pdf>
4. Unsurveyed blocks are evident in Figure 9 by the lack of mapped sites (features).
5. The general criteria used for recognising archaeological features on LiDAR can be seen on the “LiDAR Information” (<http://samoanstudies.ws/AFCP/MapServer/Lidar.html>) and “Recognizing Archaeological Features on LiDAR” (<http://samoanstudies.ws/AFCP/MapServer/SAA/Tutorial/Recognize.html>) web pages of the Centre for Samoan Studies Map Server.

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