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MONUMENTAL IDEOLOGY: A GIS SPATIAL ANALYSIS OF INTERIOR FEATURES OF MATAKAWAU PĀ, AHUAHU (STINGRAY POINT PĀ, GREAT MERCURY ISLAND), NEW ZEALAND

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Humans construct and ascribe meaning to their environments through action informed by spatial logics. As such, "space is both a medium for and the outcome of human activity" (Knapp and Ashmore 1999: 8). Materialisation of social difference is a powerful mechanism of hierarchical naturalisation, whereby individuals internalise their social positions based on embodiment in their physical surroundings. Therefore, spatial distributions of archaeological features hold important clues relating to socio-spatial organisations in past human communities and how these contributed to structuring daily life.

These ideas are explored here using *pā* 'defended or fortified places' created and used by New Zealand Māori from as early as the 16th century AD (Schmidt 1996). The presence of terraces, ditch-and-bank earthworks, scarps, fences and palisades indeed attest to the defensive function of *pā*. However, archaeologists in New Zealand often elevate their military importance, with economic explanations of why they occur, over understandings of their semiotic importance within past Māori society (for example, see Davidson 1984, 1987, Groube 1970, Irwin 1985, 2013, McIvor and Ladefoged in press, Pearce and Pearce 2010). In this article, I argue that interior divisions and connections of space within *pā* have potential to highlight aspects of past Māori spatial logics and how these complexes served to promote and maintain social hierarchies from within, and display communal solidarity to the outside.

The analysis of Matakawau Pā (Tl0/169) is based on a terrestrial laser scanner "point cloud", a three-dimensional digital map or image of the headland and its culturally modified components. The point cloud is used to isolate platforms and terraces where people lived; pathways, which enabled movement and interaction between different living spaces; and scarps, which acted as barriers to block and redirect movement and spatial experience (Fig. 1). My analysis tests hypotheses based on Sutton's (1990, 1991, Sutton (ed.) 1993) observations of peripheral *pā* at Pouerua (Northland, New Zealand) and ethnohistoric accounts from the 18th and 19th centuries, namely that the highest features on residential *pā* were associated with chiefs, and their morphologies were consistently different from surrounding

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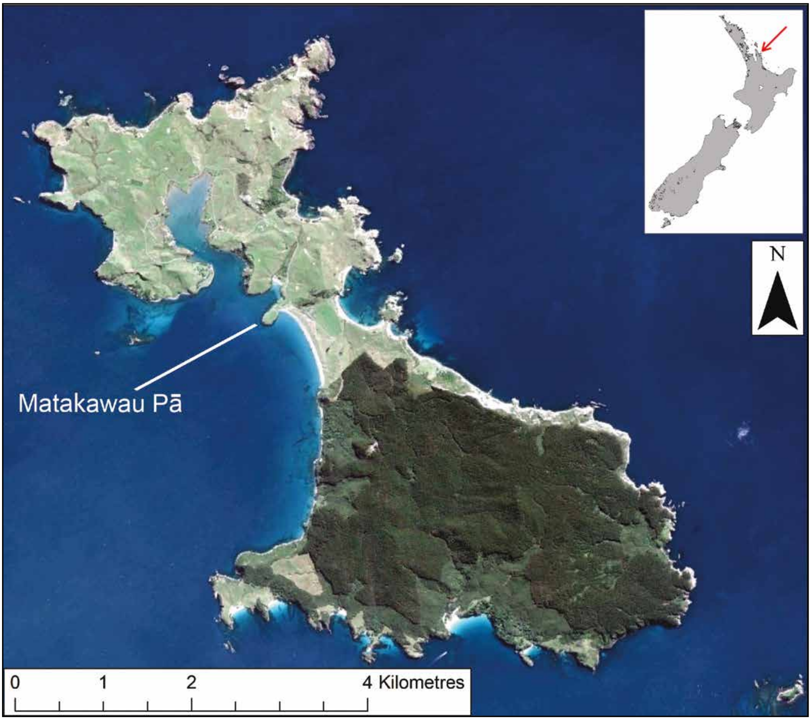

Figure 1. Map of Ahuahu (Great Mercury Island) with location of Matakawau Pā.

features (usually terraces) where lower status members of society lived. Using least cost path (LCP) network analysis, I also explore how open spaces and pathways connected, while scarps inhibited, movement between different areas of the *pā*. I test whether spatial logics were imprinted on the constructed layout of space within Matakawau against Best's (1927) and Groube's (1970) observations that *pā* form followed local topography.

SPACE IDEOLOGY AND CONSTRUCTED LANDSCAPES

Spatial perceptions are socio-historically contingent and guide how people conceive of their own existence in relation to their surrounding landscape, interact with other individuals and order their cultural materials and activities (Ashmore 2004, 2014, 2015, Bender 1993, Bradley 2000, Giddens 1984, Knapp and Ashmore 1999, Llobera 1996, Morton *et al.* 2012, Tilley 1994).

Through the intentional construction of barriers and pathways, and by repeatedly acting within spaces, people ascribe meaning to their physical environments in a way that creates order. In turn, meaning associated with different spaces is internalised through embodiment in relation to spatial order, while action further creates and associates meaning to those spaces (Kealhofer 1999: 61, Knapp and Ashmore 1999: 16).

DeMarrais, Castillo and Earle (1996) argue that ideologies can be promoted and maintained through the manipulation of spatial logics. Ideology warps or naturalises one's perception of the reality of one's social, political and economic condition (Cohen 1969). This is done through masking, rationalising, or accentuating social frictions, inequalities and frustrations (Leone *et al.* 1987: 284). By materialising ideologies in the form of monuments, ceremonies, physical objects and writing systems the intended message can be physically experienced, internalised and naturalised through action. Ideologies can be further strengthened through exposure to vast audiences on a daily basis and over long periods of time (DeMarrais *et al.* 1996, Earle 2001: 107).

In particular, monuments and constructed environments can be powerful mechanisms that manipulate spatial organisational structures to promote and maintain ideologies of social inequality. Trigger (1990: 119) defines monumental architecture as a structure with "scale and elaboration [that] exceed the requirements of any practical functions that a building is intended to perform". DeMarrais *et al.* (1996: 18-9) argue that these often highly visible constructions communicate an idea of centralised control over labour and materials by an influential party, whereby the structure makes power visible and therefore is power (Wilson 1988: 148). The building, reformation and maintenance of monumental architecture upholds that power and convinces people of the reality of that power (p. 179).

At the same time, the presence, size and elaboration of monumental architecture does not necessarily reflect dominance and social stratification (Burley 1994, Gibson 2004: 258, Kolb 1994, Rosenswig and Burger (eds) 2012). This is because monument construction occurs within societies of low social stratification as well as within highly stratified societies, while serving non-hierarchical purposes (Rosenswig and Burger 2012: 6). Sassaman and Randall (2012) propose that monumental architecture should not be viewed so much as a consequence of increasing socio-political complexity, but as an instrument in structuring culture change. Therefore, making the initial assumption that monuments relate directly to socio-political centralisation and stratification homogenises meaning and de-contextualises monuments from "local cultural understandings as sites or places that connect the seen and the unseen, the tangible and the intangible" (Ballard and Wilson 2014: 84).

Trigger's definition of monumental architecture is specific to "buildings"; however, the same effect is true for other constructed environments. Clark and Martinsson-Wallin (2007: 30) extend the conception of the monumental to include the surrounding landscape within which structures are situated. These constructed environments are created through cultural practice and in turn constrain the possibilities of practice (Smith 2003: 72). Entire settlement layouts reflect and maintain spatial logics that may be implicit within a community, such as by way of pathway and building orientations (e.g., Landau 2015, Richards-Rissetto and Landau 2014), boundary formation between different spaces (e.g., Kosiba and Bauer 2013), the location of status and ritual architecture (e.g., Kahn and Kirch 2011, McCoy, Ladefoged *et al.* 2011, Quintus and Clarke 2012) and spatial relationships between houses (e.g., Kahn 2007, 2014, Sutton 1994). At the cost of extra labour in constructing and elaborating these environments, variable ideologies, such as social inequality and communal solidarity, are internalised by human actors. Addressing these themes, however, must be situated within local contexts of cultural understanding and practice, rather than assuming that monuments have the same symbolic functions worldwide (Ballard and Wilson 2014, Rosenswig and Burger 2012).

PĀ AS SPATIALLY CONSTRUCTED LANDSCAPES

Polynesians built monumental architecture for residential, ritual and fortified purposes, structures that are often associated with the rise of social hierarchies, socio-political centralisation and economic control (e.g., Clark and Reepmeyer 2014, Kahn and Kirch 2011, Kirch 1990, Kolb 1994, Martinsson-Wallin and Thomas 2014, Quintus and Clarke 2012). In New Zealand, Māori built *pā,* which are perhaps the most visible and widely studied form of archaeological remains in the New Zealand archaeological landscape. *Pā* were constructed from as early as 1500 AD and continued to be used after European contact and into the 19th century (Schmidt 1996). They were defended by constructing wooden palisades, along with terraces, ditches and banks, as well as by taking advantage of natural topography, such as cliff faces. Over 6,700 individual *pā* have been located throughout New Zealand, although they are most concentrated around areas with marine access and in the warmer areas of the North Island where horticulture was most viable (Anderson 2014, Barber 1996, Irwin 2013, Pearce and Pearce 2010).

Pā form and function varied considerably between individual complexes and over time (Sutton *et al.* 2003). This is partly because they were created in many short term events over long time periods (Holdaway 2004). *Pā* have been variably argued to serve as symbols of communal *mana* 'authority, prestige, power' (Fox 1976: 44-9, Groube 1964: 210-11, Sutton (ed.) 1993, Sutton *et al.* 2003), food stores (e.g., Law and Green 1972), citadels (Davidson

1987: 168, Orchiston 1979) and defended settlements (Sutton (ed.) 1993). Their common marker, however, is their defences. Nonetheless this does not limit their symbolic importance; by intensively restructuring local landscapes and then acting within them—regardless of whether or not the intention was there—people negotiate and materialise their social logics and ideologies.

Spatial proxemics in the New Zealand archaeological record have been explored, to some extent, by Sutton (1990, 1991, Sutton (ed.) 1993, 1994) who compared the orientations, dimensions and spatial relationships between houses in *kainga* 'undefended settlements' with terraces (flat surfaces with culturally modified scarps on one to three sides) and platforms (flat surfaces with scarps on all four sides) on peripheral volcanic cone *pā* at Pouerua. Sutton argued that *tihi* (the most elevated flat surface) in *pā* were the structural equivalent of the chief's dwelling in *kainga. Tihi* are commonly rectangular with scarps on all sides (morphologically a platform in archaeological terminology), and were often associated with the chief, sometimes with a dwelling on top (Fox 1976: 45-6). Sutton compared the *tihi* of four *pā* with eight excavated "Type 1 dwellings", the largest, most elevated and uniformly built houses in the Pouerua *kainga*. Both Type 1 dwellings and *tihi* were situated in the most elevated areas of the settlement and had length:width ratios of approximately 1.3:1. *Tihi* were oriented within 40˚ of north, while Type 1 dwellings consistently had 27˚ orientations. Other terraces in *pā* and dwellings in *kainga* had variable dimensions. Sutton (1993) also observed they radiate out "circumferentially ... around *tihi*" (p. 101) and Type I houses, and are "oriented to all points of the compass" (p. 103). In other words, terrace width axes were qualitatively observed to be in line with the position of the *tihi*. Sutton argued that both the Type 1 dwellings and *tihi* were representations of the chief's elite social status, but that internal spatial divisions were accentuated in the development from *kainga* to *pā* over time. Ditches, scarps, palisades and differential elevations between spaces symbolised the *mana* of the inhabitants and the *pā* itself (Marshall 1987, Sutton 1990, 1991: 546, 1993: 101-03).

However, Sutton's conclusions about terrace and platform morphologies in relation to spatial logics are problematic. Specifically, on headlands or volcanic cones *tihi* platforms are almost always going to be the most elevated feature on *pā*. Similarly, in elevated *pā*, terraces are predominantly cut into the hillslope with width axes necessarily running parallel to aspect. Thus terraces built on conical hillsides will surround and appear to circumferentially radiate out from any feature at the top of the hill (in this case the platform). Related to this, Best (1927: 34) and Groube (1970: 142) commented that *pā* morphology often conformed to local topography. To evaluate how spatial differences may reflect past social differences, we must first understand the relationship between slope and aspect on modified or constructed landscapes.

Ethnohistoric accounts also describe spatial organisation within *pā* that reflect materialised spatial logics and influenced the actions of inhabitants. Best (1927: 147-51) described the ritual of lifting *tapu* 'sacred or ritual restriction' from *pā* by Māori in the 19th century—an inauguration process to clear the sacredness of the complex so that it could be lived in. He described that *pā* were initially built with only one prominent house (the largest). After the lifting of the *tapu*, others asked the chief's permission as to where they could build their houses in relation to the first. Furthermore, Best (1927: 127; see also Skinner 1911: 74) described examples where the "principal chiefs of a hill fort [*pā*] would reside in the uppermost area, the *tihi*", while other accounts by Europeans in the 18th and 19th centuries described how separate family units occupied individual terraces that were spatially bounded by scarps, fences and/or palisades and connected by pathways in neat arrangements (Beaglehole 1962 [I]: 432-33, 1968: 198-200, Best 1927: 32, 286, Fox 1976: 45, Nicholas 1817 [I]: 174-75, Skinner 1911: 74, Yate 1835: 123). Open areas (*marae*) were documented at the centre of *pā* and used for formal meetings and general communal interaction (e.g., Angus 1847: Plate 15, Best 1927: 129, Crozet 1891: 32, Firth 1959: 91-104). Such observations of open spaces have been documented archaeologically at Mangakaware Pā (Bellwood 1978) and in *pā* along the Waihou River (Phillips 2000: 154-55), while Sutton (1990) and Fox (1976: 44-9) linked the *tihi* themselves to *marae*. Although these accounts indicate certain organisations of space within *pā*, they are 18th and 19th-century observations and do not necessarily apply to the use, meaning and construction of space as far back as the 16th century AD—when *pā* were first constructed. Nor should one generalise spatial logics across all of New Zealand as meaning and the organisation of space is likely to be regionally variable as individuals negotiate their own local contexts.

The above archaeological research and ethnohistoric information highlight the potential for more archaeological investigation into *pā* as constructed landscapes that both reflected and maintained spatial logics and ideologies. Using GIS and undertaking a spatial analysis of terrestrial laser scanning data from Matakawau Pā, I explore the hypothesis that differences between the *tihi* and other terraces show a materialised social hierarchy of different living areas. I test whether or not terraces "radiate out" in arcs around the *tihi* and if terrace morphologies are consistently different from that of the *tihi*. Through the use of least cost path (LCP) networks, I also explore where earthworks constrain, and open spaces encourage, movement and social interaction within Matakawau to address where potential communal areas may be located and how different living areas are connected to one another through pathways. I evaluate these ideas against the null hypothesis that feature morphology and layout conform to local topography.

CASE STUDY: MATAKAWAU PĀ, AHUAHU

Ahuahu (Great Mercury Island) is the largest (1740 ha) of the Mercury Islands, 13 km from the east coast of the Coromandel Peninsula (Fig. 1). The island, along with the adjacent mainland, was first settled by descendants of the Te Arawa canoe in the 13th century AD. The local area was preferable for early settlement due to the wealth of marine resources, the local climate for horticultural activity, the proximity to high quality stone resources for tool manufacture (Tahanga basalt and Tuhua/Mayor Island obsidian), the presence of large fauna and its location as a stopping-off point for travellers along the east coast of the North Island (Furey 2000, 2009: 13). The size of human populations on Ahuahu fluctuated both seasonally and inter-annually according to changes in local ecological and social environments through time (McIvor and Ladefoged in press). In the 18th and 19th centuries—before and after the visit of Captain James Cook and the *Endeavour* to Mercury Bay in 1769—Marutuahu (Hauraki) and Ngāpuhi (Northland) groups repeatedly raided and settled along the Coromandel's eastern coast. These incursions led to loss of land, population decline and the temporary abandonment of territories by local communities (Beaglehole 1962 [I]: 417, Buchanan 1937, Davidson 1987: 168, Johnston 2000: 6-11, Parkinson 1972: 98, Salmond 1991: 210-11, Smith 1910: 426-29, White 1888: 212-13). McIvor and Ladefoged (in press) suggested that during this time, social stress promoted localised communal solidarity in the form of *pā* construction (such as Matakawau, Tamewhera and Motutaupiri on Ahuahu, as well as Wharetaewa and Whitianga in Mercury Bay) over intermittent episodes of occupation according to competition and external incursions by other groups.

Matakawau is situated on a partly welded ignimbrite headland attached to the isthmus between the northern and southern ends of the island (Hayward 1976: 10) (Figs 1 and 2). The promontory lies between two bays and overlooks the entrance to the large Hurihi Harbour 500 m to the northwest. The *pā* is approximately 200 by 100 m and has an area of c. 19,000 m^2 behind the outer transverse ditch earthworks. The outer defences display at least two different fortification events in the past. These consist of an outer ditch, which has an elevation of up to 2 m lower than the top of the adjacent bank behind it, and an inner triple ditch (double bank) arrangement, where the deepest ditch is up to 5 m lower than the top of the adjacent bank. Based on the premise that older earthworks have been subject to more erosional and depositional processes over time, the shallower and smoother outer ditch may be older. Different orientations between the two sets of defences support the idea of at least two different construction events.

Golson (1955) excavated two storage pits on the southeastern side of Matakawau, which he interpreted to have had at least four different phases of construction, expansion and/or infilling. Because there is no absolute chronology for the site, it is yet unclear whether a sequence was created over multiple phases of occupation for specific events when defence was required, or if the terrace was used over a longer period with changing spatial organisation through time. Nevertheless, Matakawau provides a good example for analysis of the spatial logics and materialised ideologies within *pā* due to the neat layout of the terraces, the considerable energy put into building the defensive earthworks and the size of the headland.

DATA AND METHODS

The surface archaeological record on Matakawau has been and continues to be subject to a range of erosional and depositional processes. These include wind, rain, waves, livestock movement, soil creep, archaeological excavations and the construction of fences and pathways as part of farm management. Ahuahu has been intermittently grazed by sheep and cattle since transferral from Māori to European ownership between 1858 and 1863 (Mizen 1998, Turton 1877). The length of time that sheep and cattle were farmed on the *pā* itself is unclear. Erosion from stock movement has caused the smoothing of scarp and bank edges; the infilling of terraces, pits and ditches; and the creation of sheep paths cutting through various earthwork areas. These erosional and depositional processes contributed to a large section of the cliff falling into the sea. Two other slumps have occurred on the western and southern ends of the *pā*. These mass movements have caused nearby terraces to reduce in size, while some archaeological features may have been lost altogether.

A 90 m pathway was bulldozed through the northwestern end of the ditch-and-bank defences in the 20th century. A fence line has also been built across the southeastern end of the ditch-and-bank features furthest from the mainland, as well as through the centre of the ditch towards the mainland. Additionally, the 19.5 by 1.8 m trench excavated by Golson (1955) has permanently disturbed terrace morphology on the southeastern side of the *pā*. It is difficult to infer the shape and size of terraces prior to these alterations. However, despite the range of processes that have acted and continue to act on archaeological record at Matakawau, the vast majority of the *pā* has not been dramatically altered by recent land use. While the contemporary landscape surface is by no means the same as it was when the headland was last occupied, the clear slope contrasts between flattened areas and scarps still isolate terrace and platform features, making this spatial analysis possible.

Raster Creation and Feature Identification

The landscape surface was surveyed by Tim Mackrell during a University of Auckland field school directed by Simon Holdaway in February, 2013, using a Leica C-10 terrestrial laser scanner with ±1 mm accuracy. The scanner sends out millions of laser beams which rebound off of and thereby record point locations on physical surfaces (e.g., the ground surface, grass, trees and rocks). Each point of rebound in the landscape is recorded with an x, y and z value in relation to the position of the scanner (Pflipsen 2006: 14). The resulting collection of points provides a three-dimensional model of the landscape surface which is referred to as a "point cloud". From this 3D digital map or model it is possible to measure distances, elevations, angles and volumes. The raw point cloud of Matakawau consisted of 85 million points, which was reduced to just over 3 million points with a 10 cm average point spacing in Cyclone 8.1.[1] This made the dataset more manageable in ESRI ArcGIS 10.1, where I carried out the subsequent analyses.

The point cloud was converted into a DEM (Digital Elevation Model) raster, which is a pixellated landscape surface representation, where each cell contains a value of elevation in metres. The point cloud was interpolated to a 10 cm cell size using the Kriging method (see O'Sullivan and Unwin 2010: 293-310). This method estimates elevation values for the spaces not directly recorded in the point cloud, based on the elevation values of measured points. After interpolation, every location in the DEM has an estimated elevation value (a continuously pixelated surface), while in the point cloud only the points contain information. From this DEM, I created a slope raster, which displays the maximum rate of elevation change between each cell in the DEM and its surrounding eight cells. Slope is calculated in degrees, flat surfaces have values near to 0º, while steep slopes have values approaching 90º. The slope raster enables the isolation of terraces and platforms based on change in slope values through space.

The terraces and platform on Matakawau had slopes ranging from 0 to 12º, while scarps that defined the boundaries of these surface features were as small as 10º (Fig. 3). This slope overlap meant that different slope values had to be used to define terrace and platform boundaries throughout the *pā*. Figure 3 shows two examples of flat areas defined by slopes from 0-6º and 0-16º. Both examples define some terrace boundaries accurately, while others do not. Terraces on the flatter contours of the headland centre generally had lower sloped scarps (better defined by a low slope contrast), while terraces in steeper areas (e.g., northwest and southwest) had much steeper scarps (better defined by high slope contrasts). As such, terrace and platform features could not be isolated by an automated algorithm based on uniform slope contrasts, as has been applied elsewhere in the Pacific (e.g., McCoy, Asner *et al.* 2011, Quintus *et al.* 2015).

To circumvent this issue, I manually digitised features based on a series of slope contrast rasters, where flat surfaces were defined by slopes from 0-4º, up to 0-16º with 2º slope intervals. To account for the variability in terrace and platform surface morphology, I created two sets of feature boundaries. The first defines 24 large flat areas that were identified at high slope contrasts (>12º, Fig. 4). The second defines 42 smaller features at low slope contrasts (<12º, Fig. 4), within the above larger features. I analysed morphological feature characteristics of the second feature set, as these smaller divisions of space enabled a more detailed analysis of past spatial

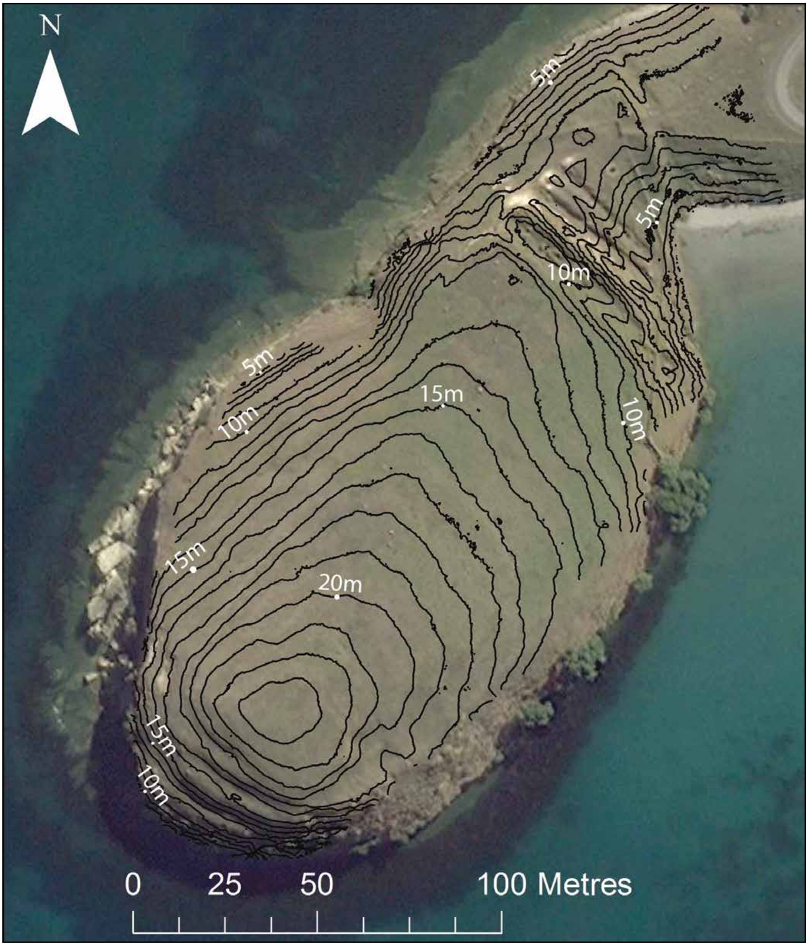

Figure 2. Satellite image of Matakawau Pā with 1 m contours, labelled at 5 m intervals.

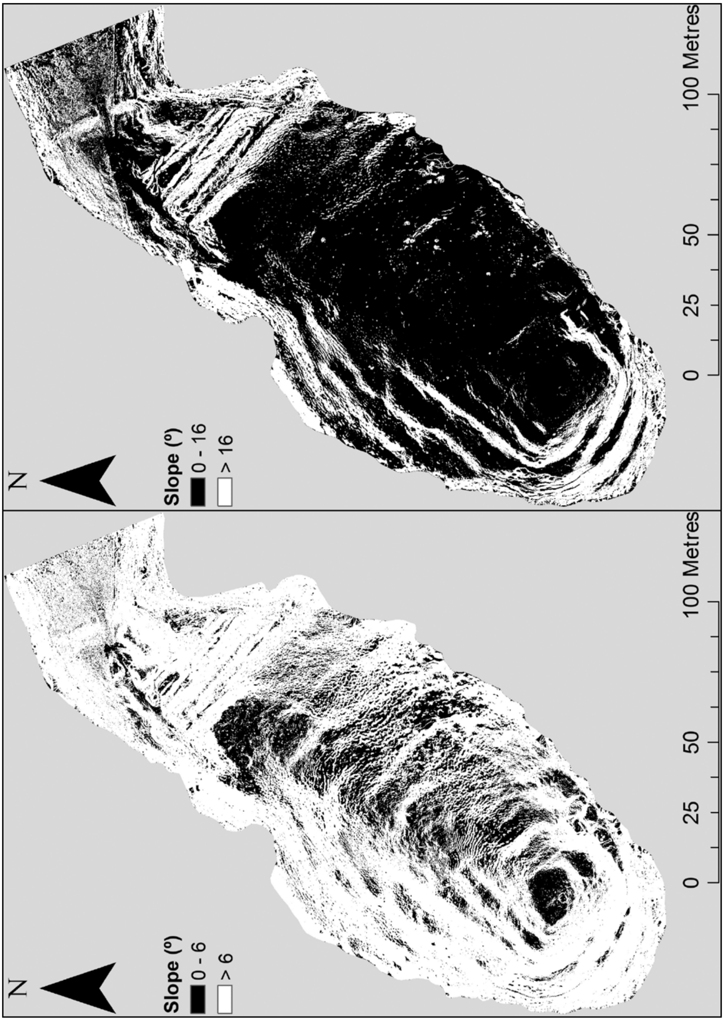

Figure 3. Matakawau Pā slope contrast maps. On the left is a low slope contrast example, where flat areas are defined between 0 and 6° of slope (black), while scarps, defensive banks and natural slopes are greater than 6° (white). On the right is a high slope contrast example, flat areas are defined between 0 and 16°. Low slope contrasts isolate features bound by small scarps, while high slope contrasts define features bound by steeper scarps.

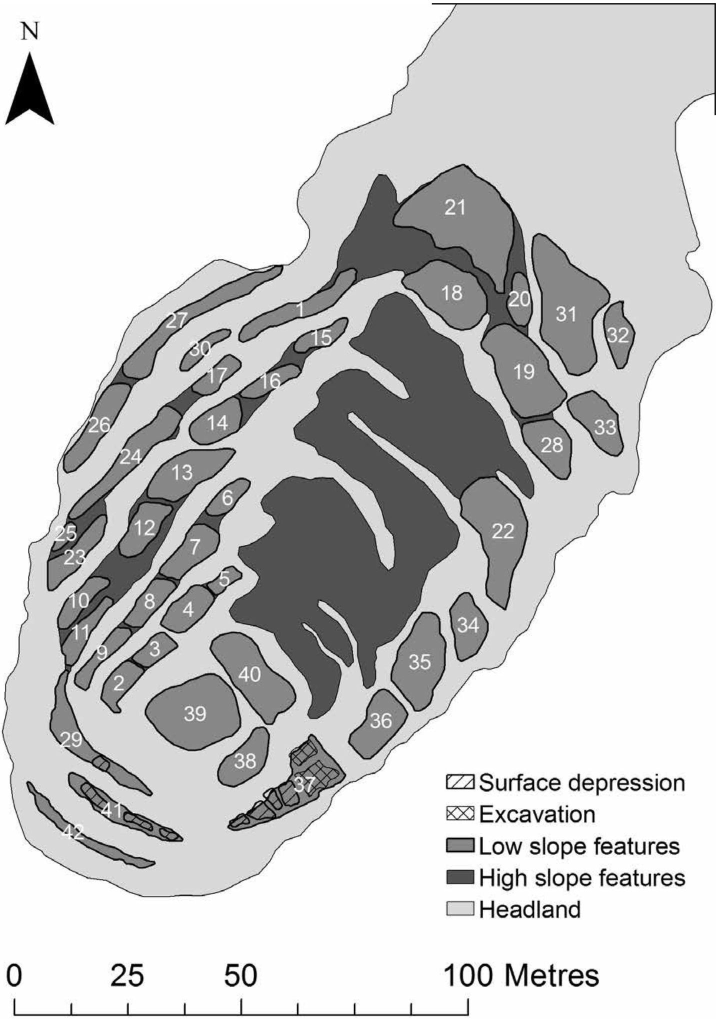

Figure 4. Two sets of feature boundaries based on high and low slope contrasts. Features defined by low slope contrasts were either equal to or smaller than those defined by high slope contrasts. Surface depressions were also located through slope contrast analysis.

logics. The second dataset highlights both how erosional processes have smoothed scarps over time and how shallow-sloped pathways may have connected different areas of the *pā*.

In addition to the terraces and platform, I located rectangular surface depressions in the slope raster (Fig. 4). These all occur on terraces at the southern end of the *pā*. The two largest, on terrace 37, are remnants of storage pits that Golson (1955) excavated, which were identified by their rectangular form and the presence of post moulds and drains lining their floors. The other surface depressions on terraces 37, 29 and 41 may also have been storage pits or, alternatively, sunken house floors built to insulate against the wind (e.g., Marshall 1994). The depressions on terraces 29 and 41 are particularly amorphous in shape, which may indicate they have complex histories, similar to those that Golson excavated.

Morphological Feature Characteristics

In his study at Pouerua, Sutton (1991: 546) compared the shapes of volcanic cone *tihi* and Type 1 houses, which had mean length-to-width ratios of 1.3:1. Other terraces and living areas had irregular shapes and construction patterns compared to the *tihi*. Length-to-width measures of spatial dimensions are helpful in describing rectangular shapes; however, they do not account for irregularity in other feature shapes nor how axes should be defined. To account for this, I developed a shape index based on characteristics of minimum bounding rectangles (MBR) (Fig. 5). A rectangle was created around each feature with the smallest possible width, and from this length and width dimensions were calculated. The equation below creates a shape index based on the difference of a feature's actual shape from that of its MBR:

$$\frac{MBR\ Width}{MBR\ Length} \times \frac{Feature\ Area}{MBR\ Width \times MBR\ Length}$$

The MBR width-to-length ratio indicates how well a feature fits to the dimensions of a square. The measured width and length may not be represented in any section of a particular feature, because none of the surveyed features are true rectangles. To account for this, the MBR width-to-length ratio was multiplied by the ratio of the actual feature area to MBR area. The final calculated shape index ranges from 0.01 (a feature that is elongated or of an irregular shape) to 1 (a square feature with parallel sides).

Lastly, I calculated feature orientations to test Sutton's (1993: 102-3) hypothesis that *tihi* orientations on peripheral *pā* at Pouerua were ± 40º of magnetic north, while surrounding terraces radiate out circumferentially from the *tihi*, i.e., they have width orientations in line with the position of the *tihi*.

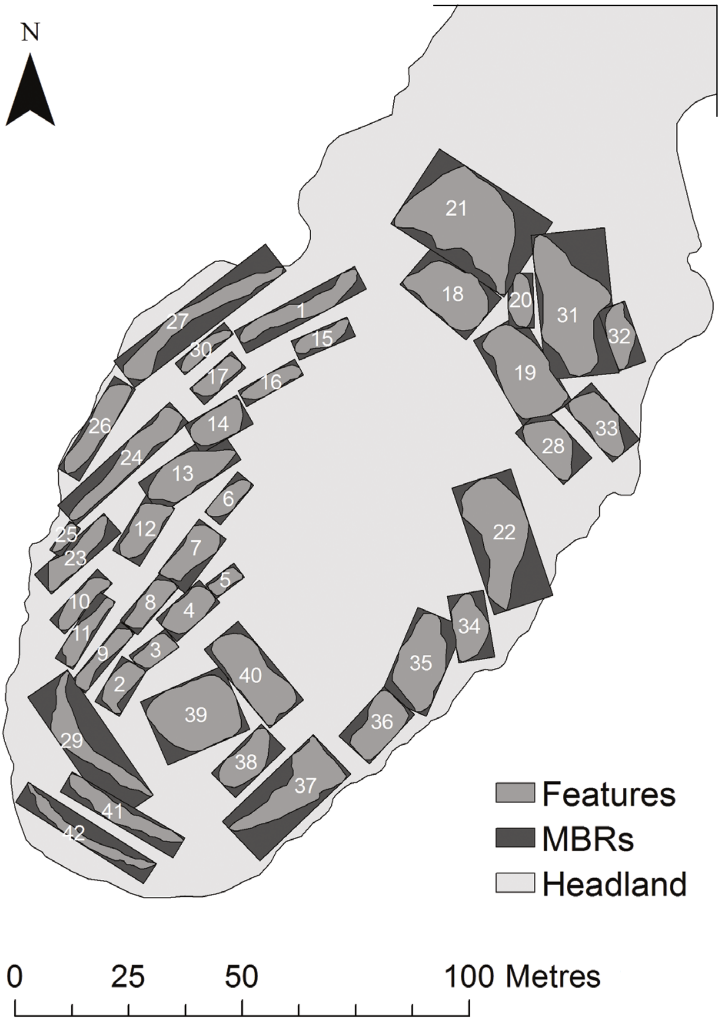

Figure 5. Minimum bounding rectangles (MBRs) around all 42 features identified by low slope contrast analysis. MBRs were used to calculate feature shapes, dimensions and orientations.

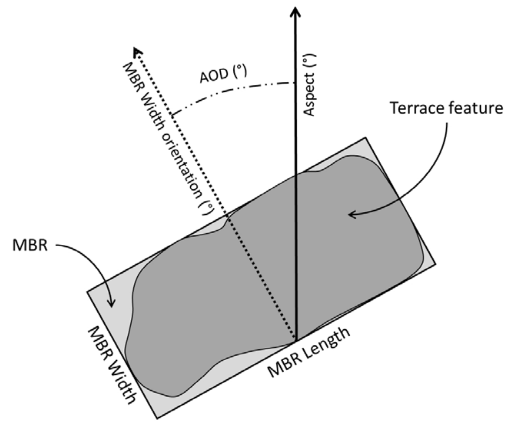

Figure 6. Illustration of how MBR (minimum bounding rectangle) width, length and orientations are calculated, which enabled calculation of the AOD (aspect-orientation difference).

Sutton interpreted this as the structural representation of the chief's eminent social status within the local community. I calculated feature orientations according to length and width axes of their MBRs (Fig. 6); this ensures orientation axes are calculated consistently and not subject to observer error.

Least Cost Path Networks

Ethnohistoric accounts of *pā* interiors often describe central open areas or *marae,* where the community gathered to interact and partake in ritual and communal ceremonies (e.g., Angus 1847: Plate 15, Best 1927: 129, Crozet 1891: 32, Firth 1959: 91-104). Additionally, individual terraces are often described as having been occupied by individual or collections of family units that were cut off from one another via steps, scarps, fences and palisades, but connected via pathways. Physical divisions in constructed environments both symbolise and reproduce social differences, while connections and open spaces promote community interaction and the continued association of meaning to the landscape through action.

Least cost path (LCP) analysis is a method of defining optimal routes between two or more locations based on distance and the cost of moving over the landscape surface (Surface-Evans and White 2012: 2). In the case of this research, pathways were modelled between platform and terrace centre points, while slope defined the cost of moving from A to B.[2] As such, the LCP algorithm created pathways along the shortest possible route, while targeting the flattest areas to move through. The aim was not to quantify the economic or labour costs of walking around the headland, but to isolate pathways that would have linked adjacent terraces and, therefore, directed movement of individuals and in turn social interaction. I hypothesised that pathways would converge in centralised open spaces, where communal interaction likely took place. Further, my expectation was that the highest residential feature would be isolated from other terraces and not associated with the convergence of pathways, given the *tapu* nature of chiefly activities and those of associated individuals.

The first step was to increase the cell size of the slope raster from 10 cm to 50 cm to limit the effects that micro-topographical variation in the original point cloud had on calculated LCPs (e.g., from surface vegetation and livestock tracks). One pathway was created between each of the 42 features, which made for 861 individual pathways. Each 50 cm cell that a pathway passed through was given a value of one (other cells had no value). These 861 individual pathway rasters were then overlaid onto one another to create a single raster layer containing each individual pathway. Cell values in the final LCP raster layer described the number of pathways that passed through that cell. It was therefore possible to see which areas of Matakawau would have had the most foot-traffic and social interaction, assuming that all features were contemporaneously occupied.

Headland Topography

To assess topographic relations, I worked with the null hypothesis that feature morphology was dependent on local headland topography. In this way, one would expect local slope to determine terrace shape, whereby areas of high slope would restrict terraces to long and thin morphologies. Similarly, areas of high slope would encourage feature MBR width orientations to be consistent with the local hill aspect. The difference between a feature's MBR width orientation and aspect is denoted as AOD (aspect-orientation difference) (Fig. 6). If the null hypothesis were true, one would expect feature shape indices and AOD to be smallest in high slope areas. To calculate local slope and aspect, I reduced the resolution of the DEM from 10 cm to 5 m cells, so that values were less affected by the terraces and scarps. Although the result is still a product of the current ground surface, including the earthworks, the averaging function across different raster cells smoothes micro-topographical variation in surface elevations so that general trends of slope and aspect can be derived. I then calculated the mean slope and aspect of the 5 m cell centre points within each feature.

ANALYSIS AND RESULTS

Feature 39 (see Fig. 5), the sole platform, had the highest elevation above sea level (23.2 m) of all 42 features because it was at the summit of the hill. It had a plan area of 247.5 m^2 and a length-to-width ratio of 1.3:1. This platform also had a shape index of 0.6—the highest of all the features on Matakawau. As this feature is at the headland's summit, its orientation was not constrained by aspect. Therefore, unlike other features in the *pā,* its orientation (MBR length orientation: 66.3˚) is the best indicator of past spatial logics. These morphological characteristics of the platform are different from all other features, which are terraces.

Terraces range in size from 16.3 to 383.1 m^2 with length-to-width ratios of 1.5 to 6.4. Shape indices range from 0.1 to 0.5, while MBR width orientations appear to face outward with aspect—they give the impression of radiating out from the platform because the slopes face away from the headland summit. The high variability of terrace morphology follows Sutton's observations that terraces are irregular in form and orientation in relation to the more structured form of the *tihi*. However, these observations do not highlight spatial distributions of feature morphologies in terraces.

To calculate where statistically significant ($p < 0.05$) clusters of shape and AOD values occurred between the different terrace and platform features on Matakawau, I used Moran's I cluster analysis. This statistic calculates the spatial clustering or dispersion of values "based on the difference between a feature's value and the mean value of its neighbourhood"[3] (O'Sullivan and Unwin 2010: 222-23; Fig. 7). Output values range from -1 (indicating perfect dispersion of values) to 1 (perfect spatial correlation or clustering of values), which are then displayed as z-scores,[4] where values greater than 1.96 or smaller than -1.96 describe statistically significant clusters or dispersions of values at the 95% confidence level. There was a statistically significant cluster of high shape values centred at the platform (feature 39, $p < 0.001$), while there was also a cluster (p-values between 0.039 and < 0.001) of low shape values in terraces 29, 41 and 42, which are long and thin (shape indices: 0.1) and have locally high slope (17.4 to 29.3˚). This supports the notion that slope heavily influences feature shape and that the platform and immediately adjacent terraces are built in the most rectangular form of all terraces in the entire *pā*.

There is also statistically significant clustering (p-values between 0.019 and < 0.001) of terrace AOD values directly north from the platform, in terraces 4, 5, 7 and 8, with AOD values from 16.1 to 25.1˚ (Fig. 7). These terraces have MBR width orientations towards NW (307.0 to 322.8˚) with local aspects of NNW (330.6 to 342.5˚). Furthermore, the terraces directly adjacent to the platform, on its northeastern and southeastern sides, are perpendicular

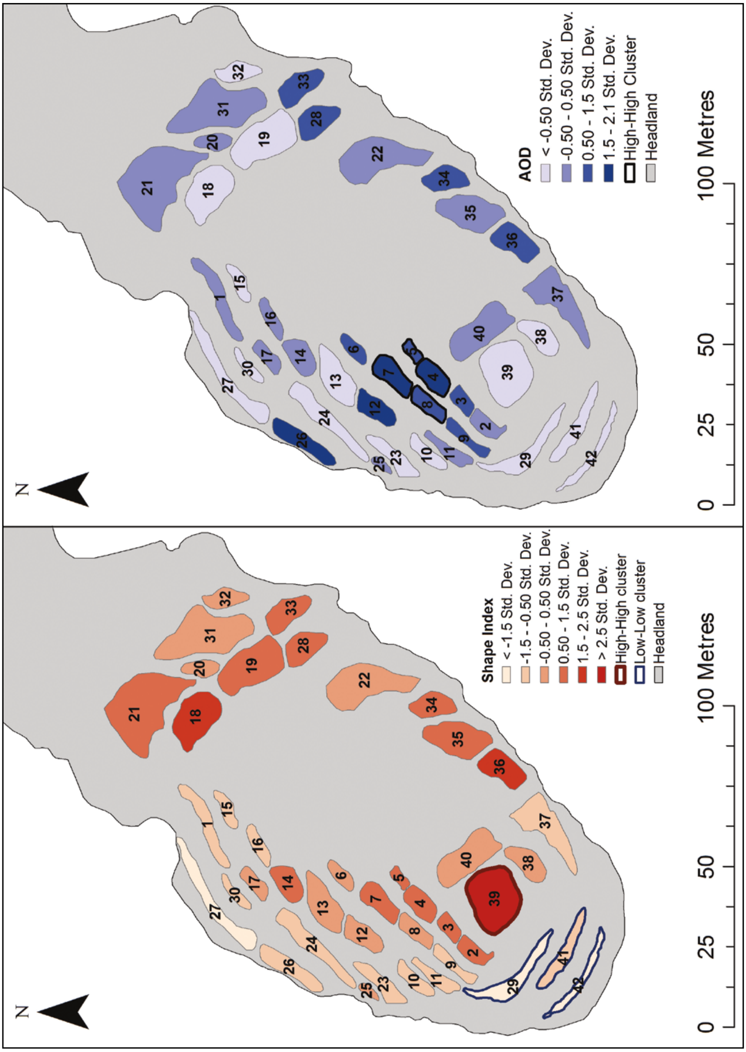

Figure 7. Maps showing the results of Moran's I cluster analysis for shape index and AOD (aspect-orientation difference) values between features. Bold outlines describe significant value clustering, while fill colours describe standard deviations away from the mean.

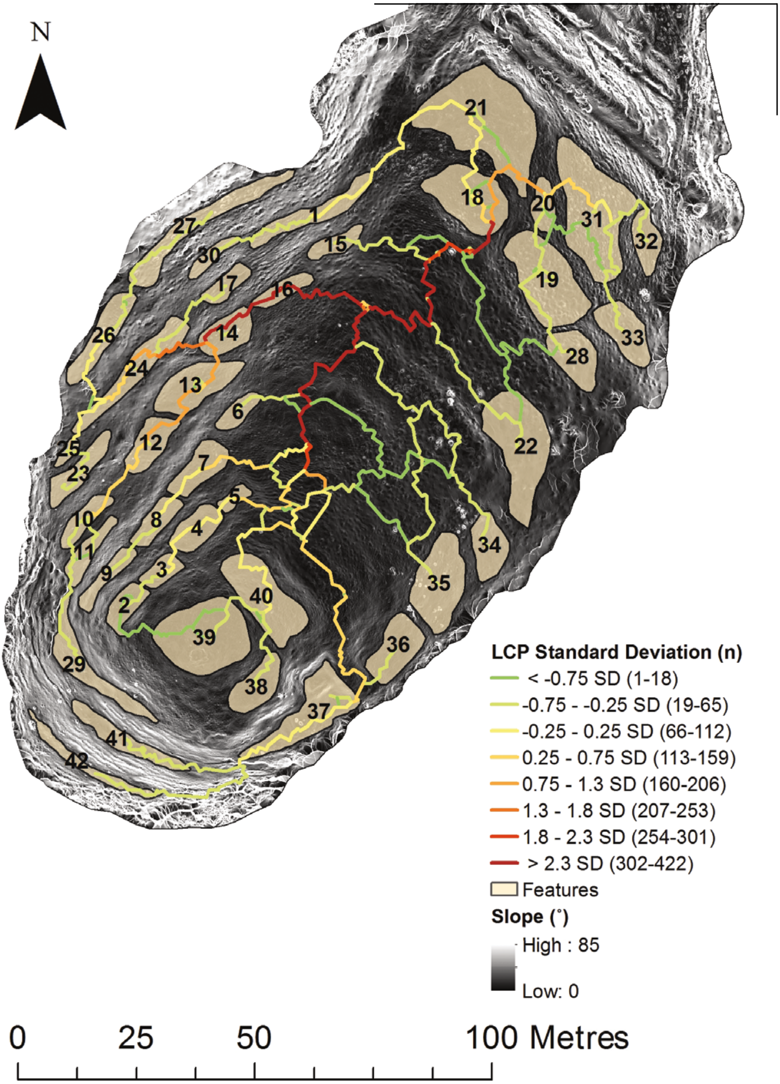

Figure 8. Least cost path (LCP) network analysis between all features defined by low slope contrasts on Matakawau Pā. LCP colour groups were defined by 1/2 standard deviations away from the mean.

and parallel to its adjacent northwestern terraces, respectively. High AOD values in these terraces indicate that they were oriented in relation to one another, rather than aspect. However, despite their proximity to the platform, the platform has a consistently different MBR length orientation of 66.3˚.

The LCP (least cost path) network highlights clear pathway arterials through the centre of the *pā*, where at one stage 422 of the total 861 LCPs overlap (Fig. 8, shown in red). The patterning of these pathways follow low slope connections between adjacent features and, therefore, explain why a single arbitrary slope contrast raster could not define terrace and platform boundaries—especially through the centre of the *pā*. Terrace features 18, 20, 21, 31 and 32, at the northeastern end of the *pā*, are connected to the rest of the complex by a small causeway at the southern end of feature 18 and onto a series of large open areas in the centre of the headland. A major pathway (with 381 overlapping paths) diverts to the northwest, through features 14 and 16, from the central arterial. Pathways follow these five to six northwestern facing terrace levels horizontally to meet the central arterials in the large open areas at the centre and connect with other areas of the *pā.* In contrast, terrace features 22, 34 and 35 on the southeastern slopes were less constrained by scarps and therefore connect up to the main arterial pathway individually. The most isolated areas of the *pā* (those that have the least connected pathways) are at the peripheries, such as features 37, 41 and 42, some with surface depressions, and the platform itself (feature 39).

Micro-topographical variation had limited effects on the LCPs because terraces on Matakawau are large with clear flat pathways between the majority of them. However, in the southern area of the *pā,* terraces 41 and 42 have scarps on all sides. As a result, their associated pathways follow livestock tracks east towards terrace 37, while LCPs connecting to terrace 37 follow the slope of what appears to be the soil heap from Golson's excavation in 1954–1955. Although the associated LCPs do not reflect pathways from when these areas were last used by Māori, they are relatively isolated from other terraces and therefore have limited effects on the LCP patterning in the rest of the *pā*.

I used Pearson's correlation coefficient, a measure of the strength of a linear relationship between two variables, to assess correlations between slope and both feature shape and AOD. There was a strong negative linear relationship between local slope and terrace shape indices ($r = -0.792$, $p\text{-value} < 0.001$, Fig. 9). More rectangular terraces with low length-to-width ratios were located in areas of lower slope, while higher slopes influenced the construction of longer and narrower terraces. This is likely the result of more effort required in cutting into greater slopes to make wider terraces. There was a weak negative relationship between slope and terrace AOD ($r = -0.318$, $p\text{-value} = 0.043$, Fig. 10). Higher slopes vastly confined terrace orientations; however, there is

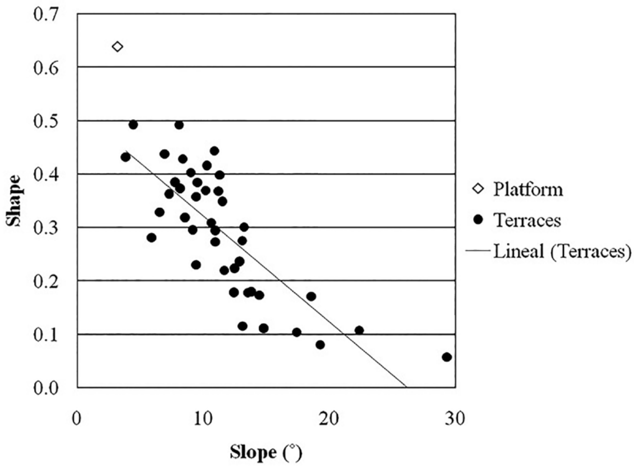

Figure 9. Scatterplot showing the relationship between feature slope (°) and shape index values ($r = -0.792$, $r^2 = 0.628$, p-value < 0.001).

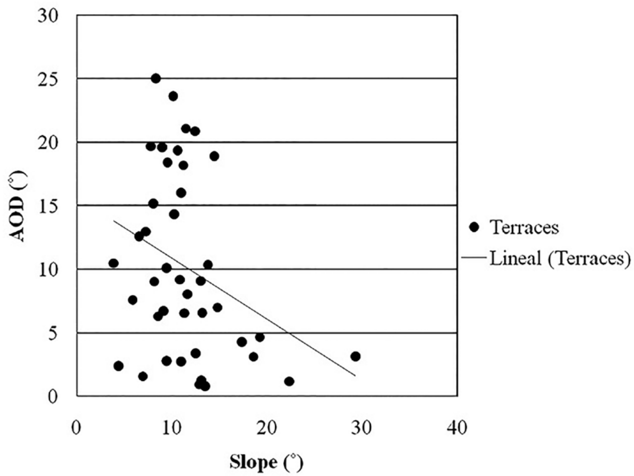

Figure 10. Scatterplot showing the relationship between terrace slope (°) and AOD (aspect-orientation difference) (°) ($r = -0.318$, $r^2 = 0.101$, p-value $= 0.043$).

a slope threshold around 15°, below which slope has no observable effect on terrace orientation. In these locations, terraces were built according to certain orientations at the expense of more effort in working against slope aspect.

In summary, the platform of Matakawau (feature 39) is morphologically different from all other features. It has the highest shape index, with a width-to-length ratio the same as platform features on peripheral *pā* at Pouerua, and is directly adjacent to terraces that also have high shape indices. Clusters of AOD values highlight how terraces adjacent to the platform are oriented parallel and perpendicular to one another, in a grid-like layout around the platform. At the same time, the platform is consistently oriented differently from all of them. The LCP network highlights areas on Matakawau with the most potential communal interaction, which also intersect with large open spaces. Similarly, confined pathways indicate where scarps limited movement vertically and less connected features indicate isolation from the rest of the *pā*. There is a strong negative correlation between slope and terrace shape indices, which indicates that terrace morphology was greatly influenced by local topography. There is also a weak negative relationship between slope and AOD. Below slopes of 15°, however, AOD values were highly variable (minimum: 0.8°, maximum: 25.1°, mean: 11.1°, SD: 7.1°).

DISCUSSION

The surface archaeological record on Matakawau has been created by multiple constructive, erosional and depositional processes—not all directly related to human behaviour in the past. Livestock erosion, fence line construction, bulldozing, slumping, fluvial erosion and soil creep are processes that have changed and continue to change the headland topography, as well as the morphology of surface archaeological features. The 10 cm resolution slope raster, for example, captures mass erosional events on the southern end of the headland and smaller areas of soil creep and minor erosion in and around terrace boundaries. The recorded feature morphologies are not pristine versions of terraces and platforms as they were last occupied or created. However, this analysis has clearly defined locations of more recent landscape changes and also indicates that features are still preserved well enough to define their boundaries based on changes in slope.

There is yet uncertainty regarding the contemporaneity of feature construction and use. This may appear to be a limitation for understanding past human behaviours; however, it may also be considered useful, as it allows archaeologists to view patterns that accumulated over the long-term (Bailey 2008, Binford 1981: 197). The time-averaged nature of archaeological phenomena does not necessarily provide an ethnographic snapshot of human behaviour in the past, but is instead a palimpsest of variable land use practices through time. The archaeologist, therefore, has the ability to assess long-term averages of spatial logics as they are materialised in spatial distributions of archaeological records. In this way, the spatial patterning and morphological characteristics of the terraces and platform on Matakawau Pā may be the result of and therefore reflect spatial organisational semiotics in development from the first occupation of the headland.

Indeed, archaeologists have documented complex occupational histories for *pā* involving short-term events of undefended occupation, terrace remodelling, fortification, abandonment and rebuilding (Holdaway 2004, Sutton *et al.* 2003: 231-32). Irwin (2013: 313-14) argued that defences—natural or culturally modified—usually completely protected internal areas of *pā*. Therefore, horizontally adjacent defences were often contemporary. Similarly, a terrace was unlikely to be built next to another terrace if the first terrace was not being used in some way. Yet terrace and platform morphology may not be the same today as when first constructed, due to remodelling through time. As such, at some point in Matakawau's occupational history, at least the majority of terraces would have been used contemporaneously, while their current morphologies are indications of spatial organisational semiotics during most recent occupations. The situation may be different for the sprawling terraced landscapes on the central volcanic cone at Pouerua (Sutton *et al.* 2003) and those in Auckland (Davidson 1993, 2011, Fox 1980, Fox and Green 1982, Green 1983, Shawcross 1962), where terraces and evidence of occupation are not necessarily bounded by defensive earthworks. However, terraces within headland *pā* and others with greater occupational evidence behind and in association with defensive earthworks, were likely to have been occupied contemporaneously at some point in their use-histories if not at the time of last use. The spatial organisation of terraces, platform, pathways and scarps on Matakawau, as demonstrated in this study, further attest to a large portion of the site being occupied contemporaneously at some point in its history.

Sutton (1990, 1993) argued that *tihi* platforms on peripheral volcanic cone *pā* at Pouerua were the structural equivalent of the Type 1 house found in *kainga*—the dwellings of chiefs and associated family members. *Tihi* platforms were rectangular with length-to-width ratios of 1.3:1, they were the most elevated areas within *pā* and they were consistently oriented within 40º of north. Other terraces had less rectangular shapes and were distributed in arcs radiating out from the *tihi*. On Matakawau, the single platform (feature 39) fits with Sutton's description of platforms at Pouerua. It is also rectangular in form with a length-to-width ratio of 1.3:1 and has the highest shape index of all features behind the defences. The platform has a MBR orientation of 66.3˚, which diverges from those at Pouerua; however, the orientation is consistently different from the surrounding, directly adjacent terraces. As the platform is at the summit of the hill, its orientation is not confined to aspect. Therefore, the builders consciously oriented the platform away from its surrounding features or vice versa—in either case argued here to be a material expression of social difference. Furthermore, the terraces surrounding the platform had high AOD, suggesting that they were oriented to some extent against the natural aspect at greater effort and costs to maintain this spatial logic.

High shape indices of the terraces directly adjacent to the platform also suggest that these living areas were occupied by families of high status or close association to the chief. Individual and community identity in Māori society is strongly linked to *whakapapa* 'genealogy', whereby the *tuākana* 'eldest male' lineage tracing back to iconic ancestors inherits elements of ancestral *mana* (Kawharu 1977). Family members that have close *whakapapa* ties to the chiefly or *tuākana* line hold heightened *mana*. At Matakawau this appears to be materialised in terraces most proximate to the platform, with additional effort put into their orientations and rectangular forms, compared to terraces in other areas of the *pā*.

Ethnohistorical accounts of settlement layout in the 18th and 19th centuries support the notion that the different living areas were materialisations of social hierarchies. Best's (1927: 147-51) depiction of the prominent house being built first in *pā,* followed by others being built in relation to it, attests to the importance of spatial semiotics within *pā* as heavily constructed environments. Best (1927: 127) also described examples of chiefs living on the *tihi.* Other accounts by Europeans in the 18th and 19th centuries described family units occupying individual terraces within *pā,* which supports the analysis of terraces as materialisations of social units, which were in turn spatially organised with the use of scarps, fences, palisades and pathways (Beaglehole 1962 [I]: 432-33, 1968: 198-200, Best 1927: 32, 286, Fox 1976: 45, Nicholas 1817 [I]: 174-75, Skinner 1911: 74, Yate 1835: 123).

The LCP network based on the 50 cm^2 resolution slope raster of Matakawau highlights areas of potential high social interaction between individuals and groups of people living in different areas of the *pā*. Barriers in space inhibited movement and confined experiences, while pathways and open spaces promoted movement and interaction between individuals. Defensive earthworks, such as palisades, ditches and banks, created stark boundaries between inside and outside, defenders and aggressors, the local community and others in the surrounding landscape (Mihaljevic 1973). At the same time, internal divisions, by way of scarps and accompanying fences and palisades, are cognitive maps made physical in the constructed environment. At Matakawau these areas of high interaction occurred in open spaces in the centre of the *pā*, which mirror ethnographic accounts of open areas (*marae*) being the central location of communal interaction and formal ceremonies (e.g., Angus 1847: Plate 15, Best 1927: 129, Crozet 1891: 32, Firth 1959: 91-104). In contrast, more isolated areas, such as peripheral terraces, storage areas and the platform (feature 39), may be locations of private housing, high *tapu* or specialised activities. Scarps that create the different levels of terracing—especially on the northwestern hill face—also inhibited vertical movement through the *pā*. Scarps were potentially lined with palisades and fences, which would have further restrained people from walking directly up them. Pathways redirected movement horizontally to the open communal areas at the *pā*'s centre, from where other areas of the *pā* could be accessed. These areas of more communal interaction would have facilitated identification with the *pā* and solidification of the community (Morton *et al.* 2012: 390, Peponis and Wineman 2002: 271).

Best (1927) and Groube (1970) suggested that *pā* morphology predominantly followed the topography of the landscape. To some extent this is true for Matakawau—the strong positive linear relationship between slope and feature shape indicates this. High slopes require more effort in making wider terraces. As a result, terraces become long and narrow, and follow aspect. On the other hand, where local slope is between 0 and 15°, terraces were built in relation to one another in parallel layouts. This is especially true for terraces near the platform and on the northwestern hill face. Although local topography influences feature morphology, past inhabitants reformed their environment to reflect their spatial logics and reproduce ideologies of social difference.

This analysis of the spatial patterning of archaeological spaces represents the first step in understanding past spatial semiotics. Although constructed environments may materialise ideological structures, they do not have inherent meaning. Instead, it is the relationships between humans, things and spaces, which have meaning (Hodder 2012: 9-14). As such, the next step to investigating the spatial semiotics of past Māori constructed environments would be to analyse the spatial contexts of material culture. Future excavations may test the discussed models of human behavioural patterning on Matakawau by documenting the spatial distribution of prestige goods and housing forms in relation to the terraces and platform upon which they are found. Spatial semiotics may also be explored in other archaeological contexts through terrestrial laser scanning, LiDAR, legacy surveys, aerial photography and satellite imagery (see McCoy and Ladefoged 2009 for a review of spatial technologies and archaeology).

This investigation into the materialisation of a monumental ideology at Matakawau also should not be considered in isolation. Matakawau is one of

15 *pā* on Ahuahu, which vary in size and number of visible surface features. It is one of the three largest *pā* on the island, along with Tamewhera and Motutaupiri, both of which are heavily terraced headlands with surface evidence of large storage pits. Analyses of the spatial organisation of surface features, similar to those of this case study, could usefully be applied to these *pā* in conjunction with laser scanning. In addition, a chronology of both earthwork defences (using methods outlined by Irwin 2013) and internal features will tell us how early these headland *pā* were occupied and how their form may have changed during different occupations through time.

* * *

The case study of Matakawau Pā is an example of how spatial principles of organisation influence the spatial distribution of archaeological features. *Pā* form and function are often explained in environmental and defensive terms (e.g., Davidson 1984, Groube 1970, Irwin 1985, 2013, McIvor and Ladefoged in press*,* Pearce and Pearce 2010). Local environments and the purpose of *pā* as defensive structures are important; however, the semiotics behind spatial distributions of features requires more attention (Barber 1996, Crosby 2004, Marshall 1987, Mihaljevic 1973, Sutton 1990, 1991, Sutton (ed.) 1993). Following Crosby (2004: 122), "the importance of the interlaced concepts of *tapu, noa* (mundane, non-sacred, opposition to *tapu*) and *mana* for Maori life cannot be overestimated, as they provided the ideological framework by which Maori viewed the world." In this sense, *pā* are intensively constructed environments within which Māori lived in the past; their spatial layouts hold important clues as to the importance of these complexes within Māori society and what role they played in affirming and maintaining social organisational structures and ontologies.

Consistent with Sutton's findings for peripheral volcanic cone *pā* at Pouerua, the platform on Matakawau had a rectangular shape and an orientation dissimilar from other terraces. Terraces directly adjacent also had rectangular shapes and were oriented in relation to one another, around the central position of the platform, instead of aspect. Boundaries and pathways within the *pā* confined and redirected movement laterally to open communal areas and away from the platform at the summit of the hill. These heavily constructed environments, as they exist today, are time-averaged imprints or last use reflections of past spatial logics, which in turn structured how individuals interacted with others and conceived their own existence within society. Material manifestations of social status were reproductions of an individual's or family's *whakapapa*, their *mana* within their community through inheritance or prowess, and their associations with leading individuals.

Figure 11. The southeastern side of Matakawau Pā, as seen from Oneroa Beach, with visitors assembled on the *tihi* (image courtesy of Tim Mackrell).

The large earthworks, together with fences and palisades, would have been an impressive symbol to outsiders of the *mana* of the local community (Marshall 1987, Sutton (ed.) 1993, Sutton *et al.* 2003, Fig. 11). However, internal spatial divisions and connections made this external impression possible. The constant physical experience of one's social status helped to solidify the chief's position and encourage communal engagement in fortification construction and centralised storing of resources. At the same time, spaces of community integration promoted social identification with place and reaffirmed community membership. This would have been particularly important during times of resource competition on Ahuahu and the adjacent mainland, as well as during incursions from groups from outside the Coromandel as late as the 19th century.

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NOTES

1. The entire point cloud was created from 22 scans which were unified in Cyclone 8.1. Excess points, such as those from vegetation, surfaces outside the study area and fence lines were manually deleted.
2. The slope cost surface was given an exponential function $b = a^a$, where a is the original slope cell value and b is the exponential slope value cell output. For example, slope values of 3 and 45 become 9 and 2025, respectively. As a result, LCPs follow flatter surfaces for longer distances rather than going over scarps. The default ArcGIS 10.1 least cost path algorithm was used for this analysis.
3. Spatial neighbourhoods were defined by inverse distance, so that closer feature values had more weight in calculating local spatial autocorrelation than more distant feature values.
4. Z-scores were calculated using the equation: $z = \frac{(score - mean)}{standard\ deviation}$

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ABSTRACT

The physical and symbolic organisation of space in constructed environments both reflects and influences human action. With the case study of Matakawau Pā (Tl0/169), Ahuahu (Stingray Point Pā, Great Mercury Island), New Zealand, I analyse a terrestrial laser scan point cloud to address how archaeological feature morphologies and spatial relationships reflect spatial logics of the last inhabitants of this Māori headland *pā* (fortified or defended place). Feature shape and location in relation to other features, slope and aspect are considered, along with a least cost path analysis of likely routes of movement between features. Materialised ideologies relating to social hierarchy are argued to be apparent in the orientation and shape of the constructed features, a platform and adjacent terraces. Boundaries and pathways within the *pā* confined and redirected movement laterally to open communal areas.

Keywords: terrestrial laser scanner, New Zealand archaeology, *pā* 'fortified or defended places', least cost path analysis, Māori spatial proxemics, monumental ideology

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