Abstract

Prehistoric Maori fortifications are a prevalent piece in many of New Zealand's landscapes. Built usually in elevated areas, the sites maximise the natural defences of the topography. The function of *pā* has been predominately seen as defensive sites however their function is not truly understood (Davidson, 1984). Using GIS analyses, an investigation will be launched to contribute to the growing body of literature surrounding Maori *pā* and propose an alternative function. Results indicate that defence was of greater concern than needing to be seen within the landscape but some areas do indicate that visibility was of greater concern.

1. Introduction

New Zealand holds an important key in understanding settlement and cultural development in the Pacific. As one of the last landmasses to be colonised in the world, initial populations started small. As time went on, populations grew, tribal divisions became more prominent which was marked by an increase in warfare. Social reactions to an increase in warfare gave rise to the development of fortifications known as *pā* (Buck, 1987:139). These sites were morphologically distinct within the landscape consisting of major earthworks designed to keep raiding parties outside the defences. *Pā* tend to be built within landscapes that have naturally defensive features such as isolated hills, and ridges (Cumberland, 1949: 415; Best, 1927:15-16), which are further enhanced through human agency.

The *pā* has been interpreted to be one of two settlement strategies that Maori have used in prehistory (Best, 1924:305). Primary residence would have taken place at the *kainga*, an undefended settlement but would retreat to the *pā* in times of conflict (Best, 1924:305; Best 1927:4,18-19). The presence of the *pā* within the landscape did not mean that conflict was constant, but would have possibly been frequent enough that prehistoric groups deemed it necessary that the construction of major defences were needed (Buck, 1987).

Despite the research that has been undertaken within the study of Maori *pā*, the exact function of the *pā* is still debated (Davidson, 1984). As suggested above, *pā* were places of refuge where a group can retreat to in times of conflict (Best, 1924:305; Best 1927:4,18-19). Other interpretations suggest *pā* were used as permanent settlements in prehistory as well (Best, 1924:310; Buck, 1987:137; Firth, 1927; Orchiston, 1979). Mihaljevic (1973:145) even considers that *pā* could be interpreted as temples within the landscape. This interpretation is based on the absence of marae complexes in New Zealand despite being able to see them elsewhere in the Pacific. Therefore, suggesting that the *pā* can be substituted as the temple complex which provides religious authority to the region. Using these examples is to show that interpretations can change as they are trying to get at different events in time. At one point a *pā* settlement could be used as a citadel or it can be used as a permanent settlement. How the site was used through time is not the concern of this investigation but is key to understanding behavioural changes through time. For this research, concern is placed on the behaviours that gave rise to construction of *pā* to understand the primary function of *pā* within the landscape.

In this paper, a combination of viewshed analyses and slope analyses are used to test the visibility and defensibility of *pā* within the landscape. Visibility is often used to discuss issues regarding defensibility (Doyle et al., 2012) but in this model, visibility is used to explore symbolism within the landscape suggesting that *pā* were constructed to be seen. This hypothesis suggests *pā* are constructed initially within the landscape to be used as a symbol in the landscape. The null hypothesis of this investigation is that *pā* were being constructed in the landscape to be used as defensive structures by enhancing areas of the landscape that had natural defensibility. Slope calculation of the landscape around the *pā* will be used to investigate this view.

An important goal of this research is developing a model in which can explore initial function of *pā* to interpret the initial behaviours that *pā* may have represented. There is no doubt that *pā* were areas of activity but there lies debate to the behaviours that led to its construction.

By approaching the study of *pā* from a landscape approach, this research aims to contribute to discussion around the function of *pā* in the landscape by using spatial technologies to investigate whether *pā* are being placed in the landscape to serve a defensive function or are they being placed in the landscape to serve a symbolic function. The symbolic function in this investigation is determined by having the largest visual prominence within the landscape.

1.2 South Kaipara Head

The South Kaipara Head is located in the Northland region of New Zealand, 80 km north of Auckland (Kanwar et al., 2015:1126). It is a landscape that is rich in archaeological features with the most prominent being Maori *pā* (Bellwood, 1972:259). Many of the sites that are located within this region are concentrated within a band that runs parallel to the South Head 2km inland (Irwin, 1985). The sites themselves are dispersed throughout different elevations within the landscape but on average most of the sites are located between 1-100 m above sea level (Irwin, 1985:3). The sites according to Irwin (1985), are maximising the water resources that have been made available by constructing sites near rivers and streams making access to fresh water not an issue. The resources available to prehistoric populations would have made use of cockles and oysters within the Kaipara Harbour (Bellwood, 1972: fig.1) and possible near shore or offshore fishing on the coast.

1.3 Previous research on the South Kaipara Head

Previous excavations that have been carried out on the South Kaipara Head have been done by Bellwood (1972) which was primarily undertaken to provide information about how defensive structures have changed through time. Irwin (1985) is the first to investigate the spatial relationship between *pā* sites and relate them within a social context. His work at the Pouto, on the North Kaipara head allowed him to integrate a greater number of *pā* sites and relate them through social organisation to produce an interpretation of dynamic social change over time.

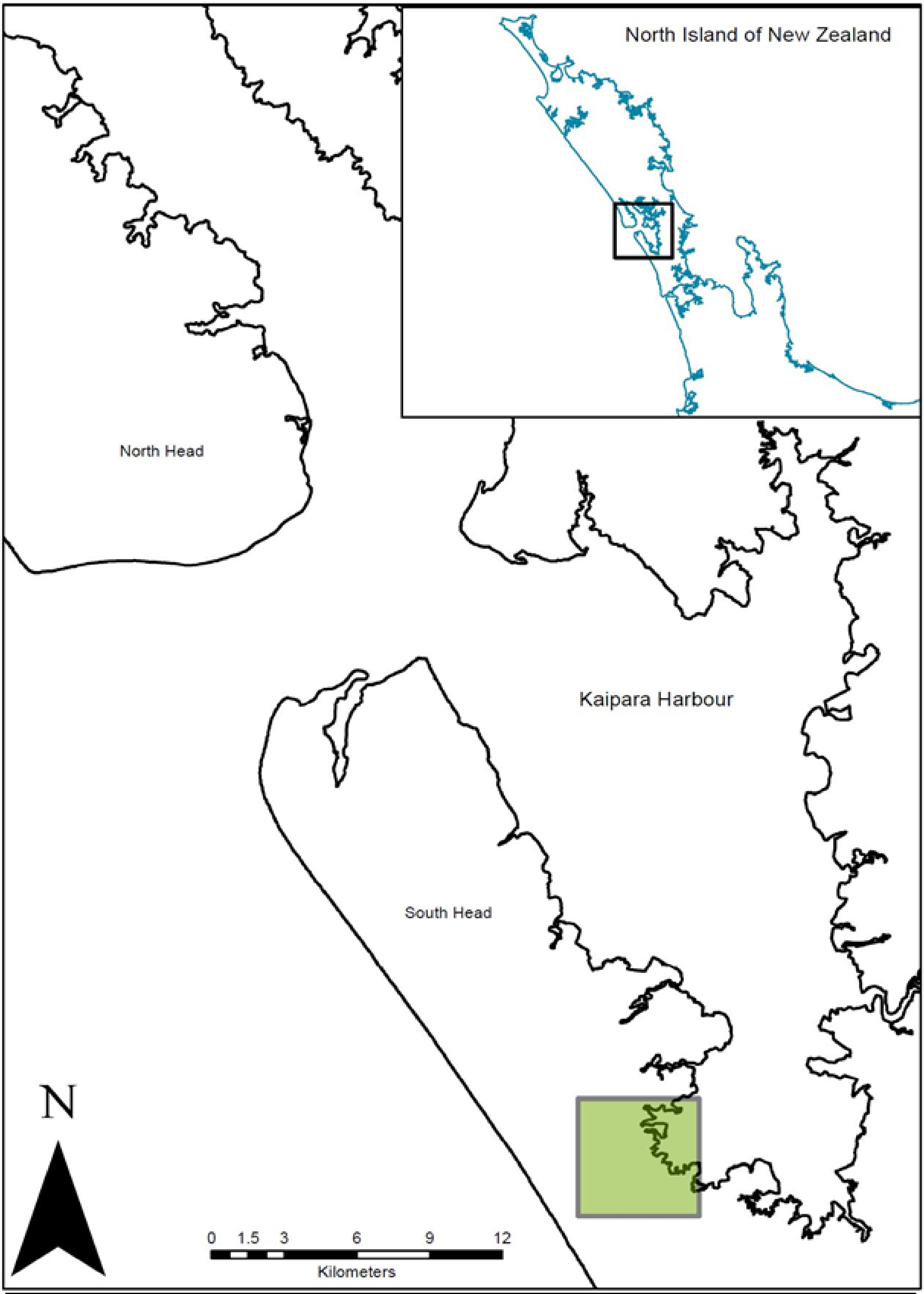

Figure 1. Map of the North Island of New Zealand showing the study area in green

2. Theory of viewshed analysis

A viewshed analysis is a geographical method used to calculate locations that can be seen from other locations and not be obstructed by the topography of the landscape (Llobera, 2003:29). For a viewshed to work, analysis must be done on data within a raster format (Llobera, 2003:29). The raster data is a collection of cells which are coded to have a value. In this case the raster value is coded to be representative of elevation therefore each cell contains a value that relates to the elevation of a specific cell within the landscape. The data that is being used for this investigation has a resolution of 1 m. Therefore, a 1 cell is representative of a 1x1 m^2 area. Viewsheds are often displayed visually as patches of data that symbolise areas that can be seen from a certain point (Supernant, 2014).

3. Method

Before analysis of *pā* are to be investigated, some assumptions must first be made. The goal of this study is to look at the function of *pā* and suggest through empirical studies that they were constructed to serve as a symbol within the landscape. Using viewshed to generate a spatial representation of the extent *pā* can see within the landscape we assume that areas that the *pā* can see, can also be seen by individuals. Therefore, the greater visual representation that *pā* have within the landscape indicates that sites were made to be seen and by extension to be symbolised as a place to be revered.

The Digital Elevation Model (DEM) was made available through the Auckland Council with a resolution of 1 m. Because the DEM has such a high resolution, further manipulation of the data to reduce error within the DEM was not necessary.

Data of archaeological sites from New Zealand were gathered from ArcSite, a New Zealand based archaeological database. The data that was contained in the file possessed data from a range of different archaeological sites therefore data manipulation had to occur to extract just the *pā* sites. Using the select by attributes in arcmap, only *pā* sites were selected and extracted for analysis. Due to the number of *pā* that were still present, a decision was made to sample an area within the South Kaipara Head. The sample was based on size of the area rather than number of *pā* leading to a study area of 5000x5000 m being chosen as the study extent. A polygon of the study dimensions was created and positioned in an area that looked to have the greatest variation of *pā* sites within the landscape which occupied coastal as well as hilltop *pā*. Another issue that arose with the data was the problem with the presence of no data within some parts of the study area. These areas of no data were the coastal waters which were the void of information. This will cause errors in the viewshed analysis of *pā* close to the coast. To correct for this, no data had to be converted into zero so it had a value therefore will not cause errors when calculating the viewshed. Once the data had been prepared, viewshed and slope analysis could now take place.

Within the study area, the investigation examines the spatial distribution of fifteen *pā* in the landscape. Visual impact of the structures on the landscape are calculated using the viewshed tool to understand how a structures ability to be seen, affects perspectives of the viewer (Phillips et al., 2015)

The radius of the *pā* were calculated using Phillips (2001) size classification (Table 1). In Phillips classification the *pā* sizes varied in size ranges. To simplify the data, an average size was calculated from the size range. Using the average size of *pā*, the average size was multiplied against the total giving a total area of the *pā* that fall within the specific size range. The total area of *pā* were added together and then divided by the total number of *pā* within the sample giving an average size of 7,130 m^2. This was further simplified to 7,000 m^2. The radius of a 7,000 m^2 circle is 47.2 m, however, for this investigation, numbers have been rounded to the nearest significant figure to keep things clear resulting in a radius of 50 m instead of 47.2 m.

Number of Pā	**Size range**	**Average of each classes**	**Total area of *Pā* classes**
9	1,500-9,300 m^2	5,400 m^2	48,600 m^2
4	4,800-5,800 m^2	5,300 m^2	21,200 m^2
7	2,400-8,700 m^2	5,550 m^2	38,850 m^2
3	16,400-20,500 m^2	18,450 m^2	55,350m^2

Table 1. Summary of *pā* sizes extrapolated from Phillips (2001)

Individual *pā* were represented as a 50 m buffer around a central point of the *pā* to simulate the potential size the settlement could have been in prehistory. The buffer around the *pā* was calculated using the 'buffer' tool and then converted into a line using the 'buffer to line' tool. This was done to reduce error from the viewshed analysis by representing the *pā* as an enclosed area rather than a point in the landscape. This will enable a more accurate representation of visibility from different areas within the landscape. To correct for height, an offset of 3m was used to represent the potential wall heights of the *pā* and its ability to be seen from different locations within the landscape, but was also used to correct for micro-topographic errors that one might come across when conducting viewshed analyses (Phillips et al., 2015). To control the extent in which the *pā* can "see" within the landscape, a buffer of 1000 m was placed on the viewshed as interest in visibility is confined to the locality of the *pā* rather than the extent of the study area.

When the viewshed was calculated, an error arose. The issue that needed to be addressed is the bias caused by edge effects. Because some *pā* sites are close to the edge of the study area, calculating viewsheds from these sites do not calculate the total visible area of the viewshed. To correct this issue, the study area was increased from 5000x5000 m^2 to 7000x7000 m^2 to remove the edge effects caused by the viewshed analysis. A 'raster calculator' was then used to calculate and define the difference between "visible" and "non-visible" cells within the 1000m *pā* radius. This calculation allows for the visibility and non-visibility of cells to presented in a clearer manner which would contribute to the design of a visibility index.
The other measure that will be calculated is based on the natural defences of the landscape in which the individual *pā* are situated. The natural defences have been defined as the mean natural slope of the topography. Some *pā* sites reside in areas that have high slopes while others are located in areas that are quite flat. To calculate slope some data management first had to be carried out.

The individual 50m *pā* extents had to be merged together into on shape file using the merge tool. The output of this is the representation of the *pā* being in one shapefile, while still retaining their individual attributes. Using the "slope tool" in ArcGIS the slope was calculated for the internal areas of those 50m buffers and exported into a different shapefile.

The data from the visibility index and data from the defensibility index were exported into excel for the calculation of the visibility percentage and mean slope of the local *pā* topography. Further analysis was done by crating further metrics of the data by calculating the ratio of “visibility to defence” and also “defence to visibility”. This data was then exported back into ArcMap and joined with the merged data.

Once all the data had been collected, the data could then be transferred back into a point shapefile to look at spatial correlations between data.

4. Results

4.1 Site visibility

Within the study area, three of the fifteen *pā* had the highest visibility and were spatially located near the coast (see Q10/448 in fig.3), or located within the estuarine environment (Q10/268 and Q10/703 in fig.2). Two *pā* that fit in the next visibility group are located in two different geographical locations in relation to local topography. Q10/225 is located adjacent to Q10/448 near the coast while Q10/250 is located inland, away from the coast. *Pā* that have a visibility between 20-29% and 30-35% are inland away from the coast with exception to Q10/233 which is positioned in an intermediate zone between the two distinct spatial areas. P*ā* a settlements Q10/246 and Q10/231 show the least amount of visibility in the landscape despite being located in areas that could have had potential for *pā* construction thereby utilizing natural landforms and visual-scapes.

The results of a visibility analysis indicate that there are areas that have distinct advantages of constructing *pā* within the landscape. In the coastal areas, visibility seems to have a more prominent role where settlements were established to maximise visibility. An emphasis on vision within the landscape suggests *pā* on the coast were meant to be seen based off the notion if ‘I can see you, you can see me’ therefore it is suggested that visibility is more important for coastal *pā.*

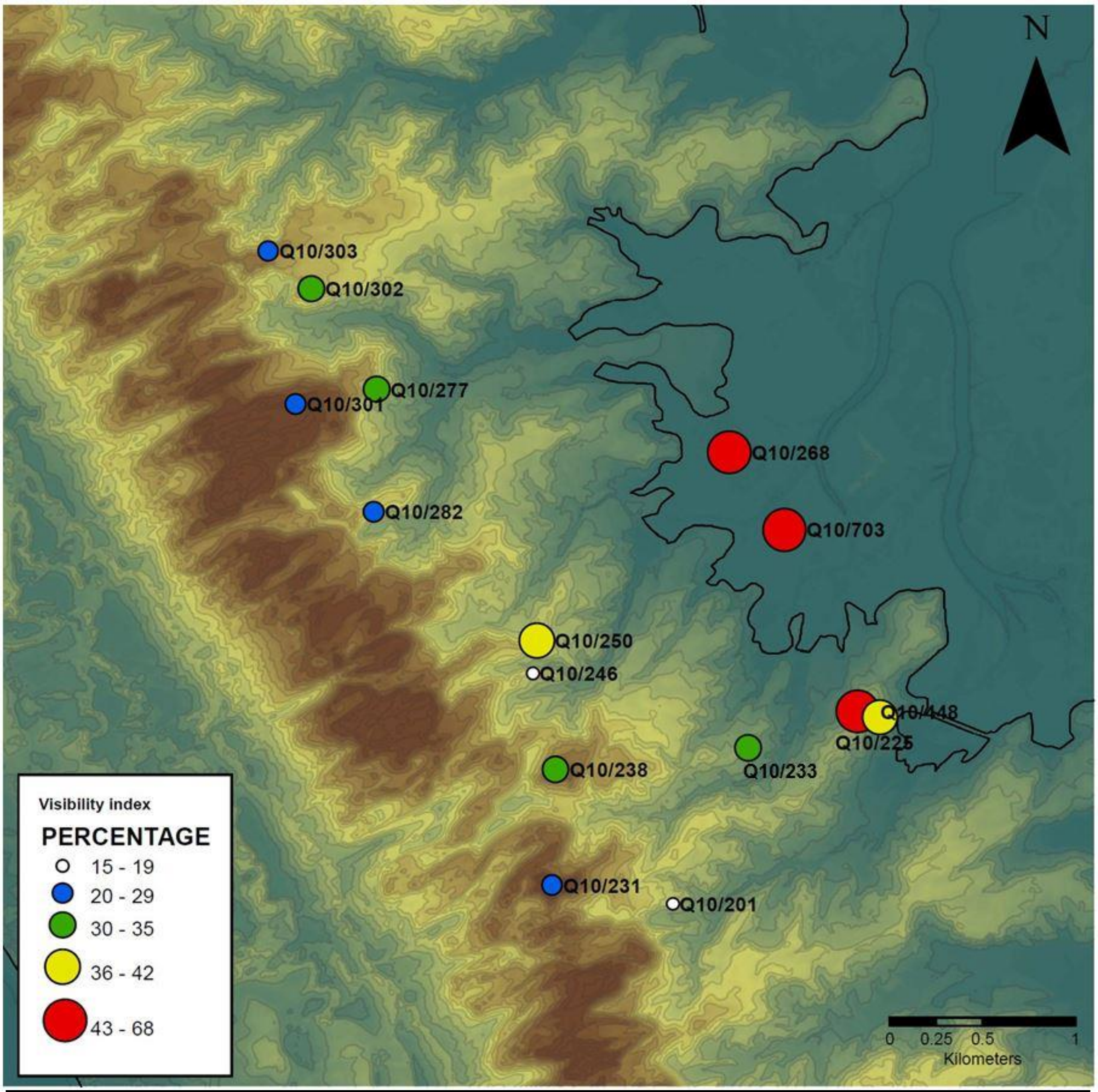

Figure 2: Site locations and their visibility within the landscape

4.2 Site defence

In this analysis there is a reversal of spatial patterning of *pā* within the landscape. Q10/282 having a low visibility index in visibility analysis, is seen to hold the highest defensibility index in the area based on degrees in slope (Fig. 3). Two outliers, Q10/238 and Q10/231, are positioned in areas where sites do not follow the assumed trend presented by the other *pā* in the landscape. The trend being *pā* located inland away from the coast are utilizing the natural defences of the landscape which increases the defensibility of the site itself. The reason for this result can be seen as a result of topography. Both sites show that the location of the site, is positioned in a plateau-like region where slope is minimal (Fig. 3)

The results of a defensive analysis based on the natural topography of the area suggest more *pā* are positioned in terms of defensive strategies by utilizing the natural topographic environment. In terms of understanding settlement patterns and the construction of *pā* within certain areas, the behaviour of the prehistoric peoples can be inferred to be orientated toward a more defensive route rather than placing importance on needing to be seen. The spatial pattern related to slope in this area support Irwin's (1985:3) settlement pattern of *pā* being concentrated around a similar elevation and distance away from the ocean.

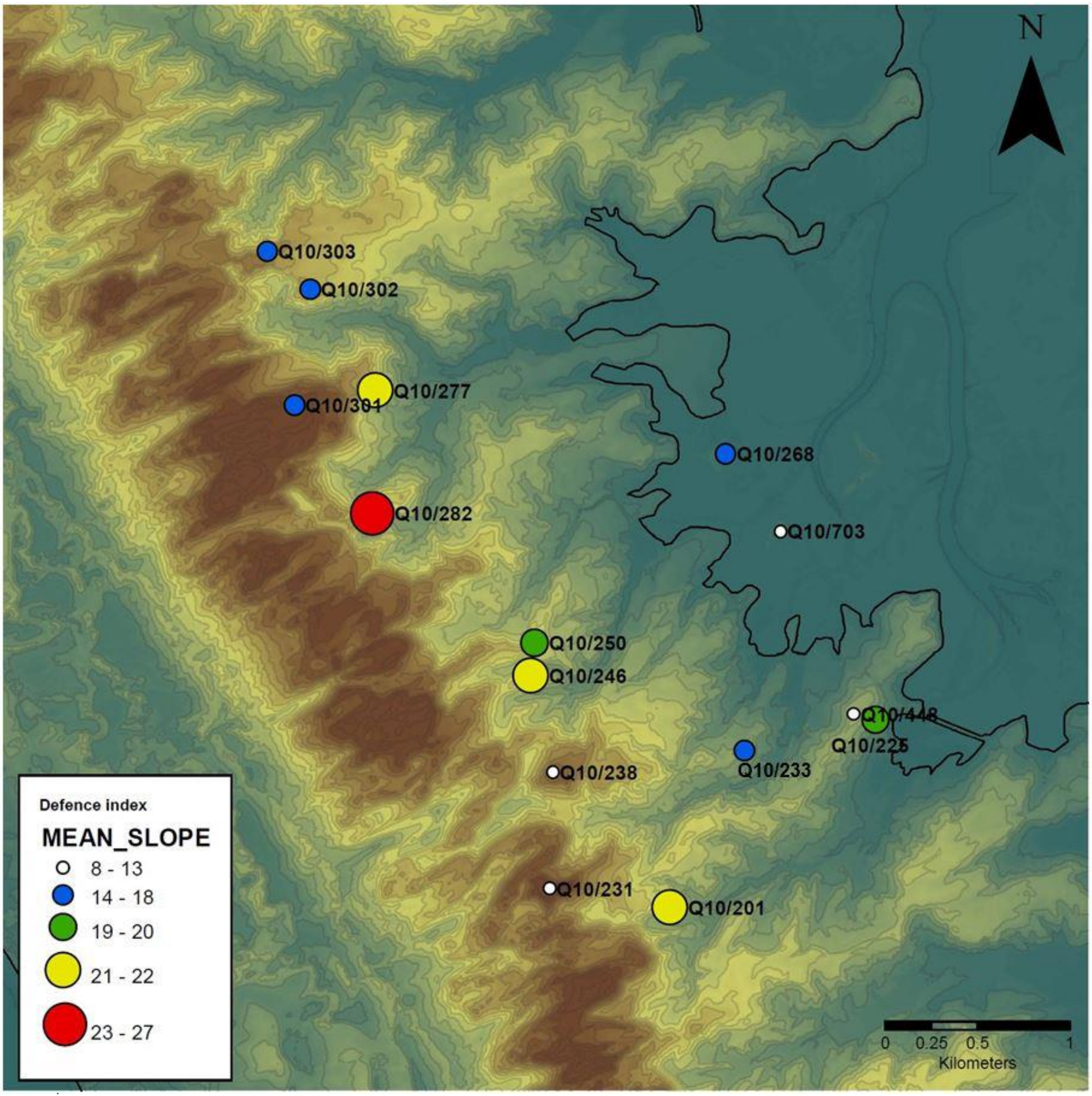

Figure 3: Site locations and their defensibility within the landscape

4.3 Ratio of visibility to defence

This analysis was for the sole purpose of seeing the relationship between visibility and defence. The ratio between visibility and defence in this assessment is in favour of visibility over defensibility, showing sites that are orientated towards a need to see or be seen in the landscape compared to sites that need to be defended in the landscape.

Evidence suggested by this ratio proposes that coastal sites (with exception to Q10/238) are areas that have been selected for *pā* construction based on visibility of the land rather than defence.

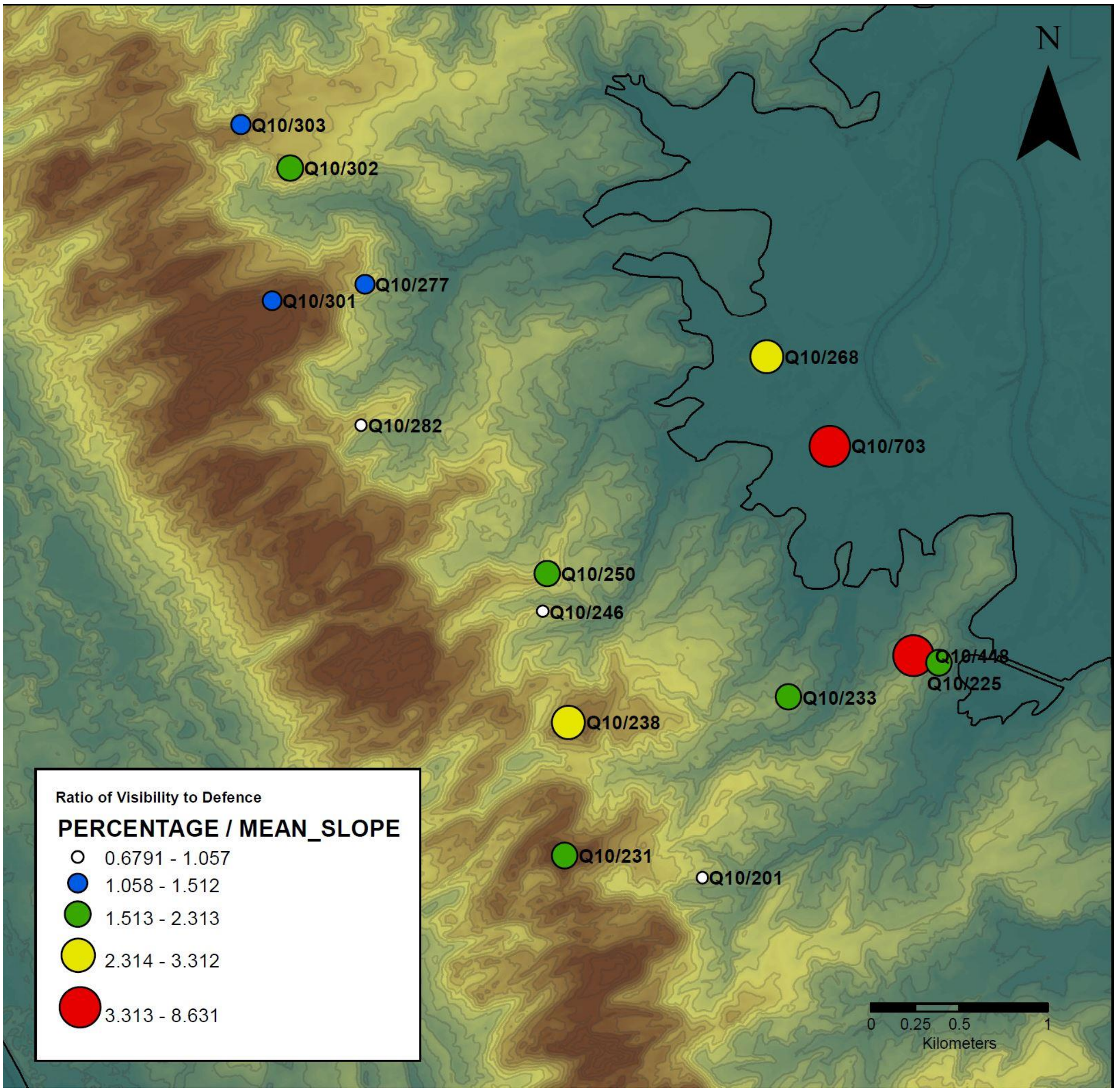

Figure 4: Site locations and ratio between visibility and defensibility within the landscape

4.4 Ratio of defence to visibility

Investigation into the ratio between defensibility and visibility was the subject of this analysis. From this assessment, the data shows that more *pā* are in favour of defence rather than visibility, with exception to Q10/238. The largest *pā* sites that have utilized the natural defensibility of the landscape seem to be Q10/246 and Q10/201 which in Fig. 5 is shown to have one of the lowest visibilities within the study area.

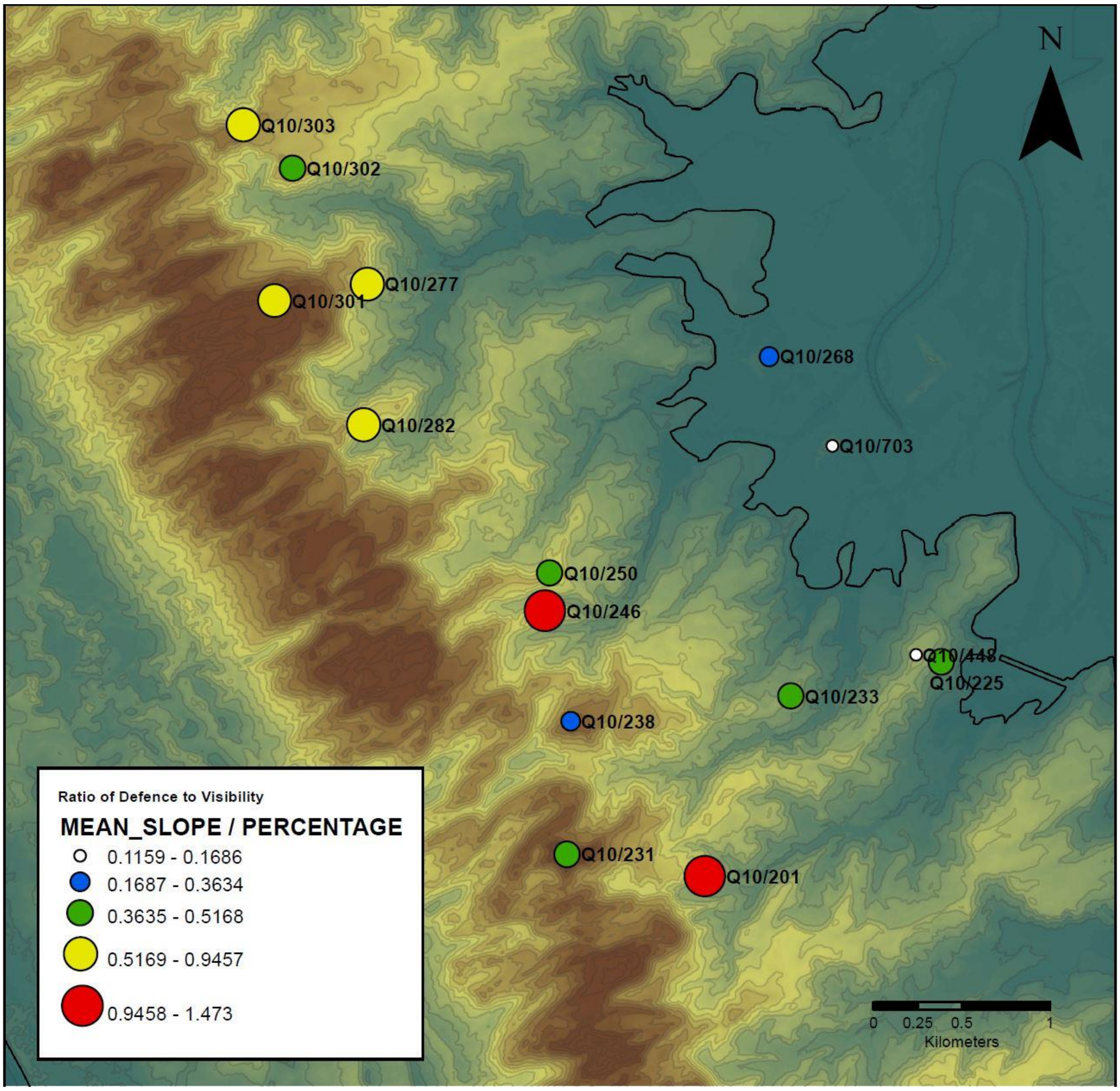

Figure 5: Site locations and ratio between defensibility and visibility within the landscape

5. Discussion

Much of the variation of *pā* function comes from how it was used through time or trying to establish function at a specific point in time. This is difficult to do based on temporal changes in environmental conditions and changes in social patterns through time.

Trying to unravel the palimpsest in an attempt to see how a site has functioned in the past is wrong as seen in attempts from previous authors to assign function to a site (Best and Others). Attempting to gain cognitive information from this processes can be better used if approached from understanding initial function of a site in relation to the cognitive reason for its creation. Using a visibility tool from GIS enabled this study to look at the cognitive choice of initial construction with regards to what variables were important in *pā* construction, whether it was more important to be seen or was it more important to defend.

The results from the analysis suggests that at initial construction, favourable conditions were geared towards the best defensive areas compared to the need to be seen from greater areas in the landscape. However, there are exceptions to this rule which is more prominent in sites Q10/448, Q10/238, Q10/703 and Q10/268. These sites suggest initial construction was made to visibility and how they can be seen within the landscape but can be explained through topographic prominence.

A limitation of this study has been found to be the development of using slope as an indicator of defence. When analysing the data fig. 3 shows that Q10/268 and Q10/703 have one of the lowest defendable areas within the landscape. However, this is not entirely true. The location of these *pā* within the landscape are positioned on islands within the mangrove forests of the site area (Bellwood, 1972). This intertidal area would have been protected by the mangroves as well as over saturated soils that will impede movement. Therefore, it can be suggested that island areas such as Q10/268 and Q10/703 have a high defence rather than what is suggested through the slope analysis. To correct for this further studies can combine least-cost paths as well as the analyses that have been discussed within this investigation to gain a better grasp on the role landscapes play in the placement of *pā* within the landscape.

6. Conclusion

The aim of this investigation was to challenge previous research of Maori *pā* by suggesting an alternative interpretation of the function of *pā* through the use of landscape archaeology applications. This was not an attempt to solve the debate around the function of *pā* (Davidson, 1984) but to revitalise discussion around the importance of Maori *pā* within the context of New Zealand's prehistory. What was found in this investigation were *pā* localities seem to be making the most out of the natural defensibility of the landscapes rather than being concerned with visibility within the landscape. Based on this investigation, it is probable that prehistoric behaviours to the construction of *pā* within the landscape were directed to respond to increasing conflict between prehistoric groups rather than being a symbol of status within the landscape.

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