Prehistoric human impacts on Rapa, French Polynesia

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New excavations and survey on the island of Rapa have shown that a rockshelter was occupied by early settlers around AD 1200 and the first hill forts were erected about 300 years later. Refortification occurred up to the contact period and proliferated around AD 1700. Taro cultivation in terraced pond-fields kept pace with the construction of forts. The authors make a connection between fort-building and making pond-fields, demonstrating that the pressure on resources provoked both the intensification of agriculture and hostility between the communities of the small island.

Keywords: French Polynesia, Rapa, colonisation, demography, fortification, warfare, anthropogenic environmental change

Introduction

With the world's population exceeding six billion, human-induced environmental change is an acute problem confronting our increasingly inter-dependent global community. Agricultural expansion, deforestation, soil depletion, and decreasing crop yields contribute to food scarcity and world hunger (Brown 1996). In coastal and island settings, where a large percentage of the world's population resides, fisheries are being decimated at an alarming rate (Pews Ocean Commission 2003). The local effects of food scarcity, which include social fragmentation, migration, conflict, and the overall destabilisation of political systems, have far-reaching consequences and archaeologists are well positioned to provide a historical perspective on social and political responses to anthropogenic environmental change (Crumley 1994; Lentz 2000; Jackson *et al.* 2001; Redman *et al.* 2004).

Remote islands provide well-bounded microcosms for studying the ecosystem effects of human colonisation, demographic expansion, and resource intensification, along with inter-related behavioural responses promoting sociopolitical integration or fragmentation (Kirch & Hunt 1997; Kirch 2004). In this paper we report work on the remote French Polynesian island of Rapa, located in East Polynesia equidistant between New Zealand and Easter Island, and 513km from its nearest neighbour (Raivavae) on the south-eastern extremity of the Austral Group (Guillin 2001). The island is small (35km^2) and

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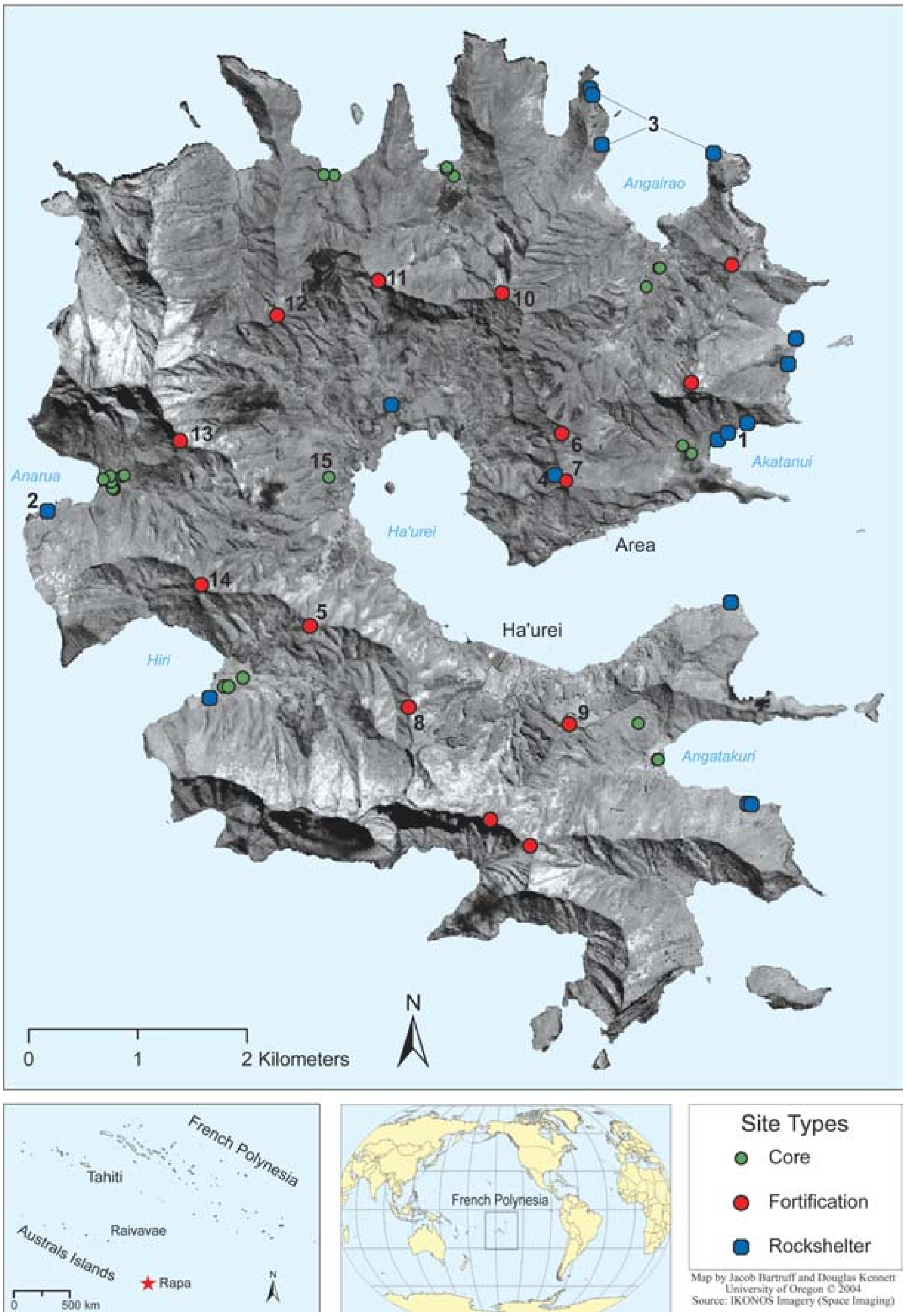
horseshoe-shaped; a breeched caldera that forms a natural amphitheatre surrounding Ha'urei Bay (Chubb 1927; Figure 1). At historic contact (AD 1791), an estimated 1500 people were living on the island in a series of heavily fortified hilltop communities distributed along the ridgeline surrounding Ha'urei Bay (Vancouver 1801 I: 214-5). Here we report on the earliest colonisation phase of the island and establish a chronology for demographic expansion, fortification, and human induced environmental change.

Age of colonisation

Opinions about the age of initial human entry to East Polynesia have varied considerably, but the recent trend has been toward younger estimates. Spriggs and Anderson (1993) suggested initial colonisation in the interval AD 300-600, but additional research on sites of the colonisation era (Anderson *et al.* 1999; Anderson & White 2001; Anderson & Sinoto 2002; Anderson *et al.* 2003; Rolett & Conte 1995; Rolett 1998; Steadman *et al.* 1994; Tuggle & Spriggs 2000; Weisler 1996) indicates a stronger probability of arrival later in the first millennium AD. This period is also consistent with recent evaluations of the initial age of anthropogenic affects upon vegetation change (Anderson 1995, 2002; Athens *et al.* 1999; Burney 2002; McGlone & Wilmshurst 1999). Weisler (1996) puts the beginning of occupation in the Pitcairn Island group at about AD 800, although the earliest date is not securely tied to cultural events, and the age of colonisation on Easter Island, best recorded by radiocarbon dates from Anakena associated with bones of extinct birds, is approximately AD 1000 (Steadman *et al.* 1994). In the south-eastern region of East Polynesia, settlement of the Gambier Islands began about AD 1100 (Anderson *et al.* 2003). It is worth noting, however, that Rapa is the southernmost island in East Polynesia and that all of South Polynesia, which lies to the south-west of it, was colonised later again, about AD 1200 (Anderson 1991, 2000).

Our excavations on Rapa were divided between fortifications and coastal rockshelters, the latter being expected to yield the better evidence of initial habitation on the island because they were readily accessible for habitation to the earliest colonists. Rockshelters are scarce on the island and most of them are less than 10m in maximum dimension (see Figure 1). However, the Tangarutu rockshelter in Anarua Bay (Figure 2A), on the more sheltered western coast, is so conspicuous from the sea, and so capacious (80 × 40m) that it is likely to have been used from the earliest period of settlement. It is filled with dune sand which holds abundant archaeological remains. Small test excavations by Walczak (2001: 32) produced calibrated radiocarbon dates between AD 1400 and 1650 (Ly-8577 and 8578; Table 1). We augered the sands throughout the shelter, sampled all exposed sections and excavated 4m^2 of the deepest and richest deposit. This disclosed approximately 150cm of continuous cultural stratigraphy, which included shellfish, fish and bird bone, gourd (*Lagenaria siceraria*) fragments, remains of ovens, and artefacts that included basalt flakes, shell fish hooks, cordage, and plaited *Pandanus* and *Freycinetia* mat fragments. Smaller excavations at Akatanui, Angairao, and the upland shelters at Taga showed generally shallow stratigraphy and much less abundance and diversity of cultural material.

Radiocarbon dates on charcoal samples, unidentified to taxa, indicate that the base of the Tangarutu site dates to between AD 1150 and 1250 and the rockshelter continued to be used until *c.* AD 1550 (see Table 1 and Figure 3). The base of the Angairao rockshelter



Map by Jacob Bartruff and Douglas Kennett
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Source: IKONOS Imagery (Space Imaging)

Figure 1. Map of Rapa showing the location of rockshelters, fortifications and sediment cores discussed in the paper. 1 = Akatanui; 2 = Anarua; 3 = Angairao; 4 = Taga; 5 = Morongo Uta; 6 = Potaketake; 7 = Tanga; 8 = Tevaitau; 9 = Ororangi; 10 = Vairu; 11 = Ruitara; 12 = Kapitanga; 13 = Noogurope; 14 = Pukutaketake; 15 = Tukou Core 2.

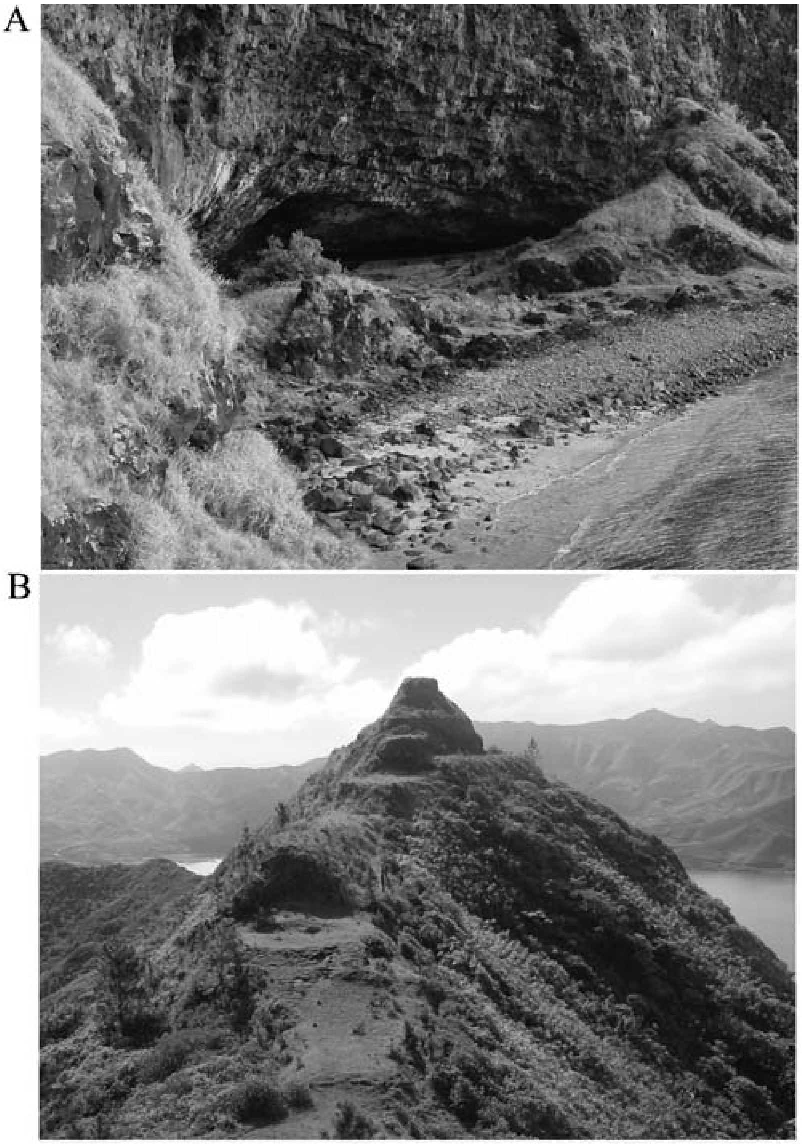

Figure 2. Photographs of the A) Tangarutu Rockshelter (above) and B) Tevaitau Fortification (below).

stratigraphy dates to *c.* AD 1400, which is essentially the same as the oldest age at Akatanui, while the upland rockshelter at Taga is slightly younger (*c.* AD 1400-1820). This sequence is consistent with our expectation that initial habitation would be represented in the prime coastal rockshelter, then in other coastal shelters and later again in upland areas as the overall pattern of settlement gravitated towards the use of fortified villages around the caldera ridgeline. Consistent with the recent assessment of the East and South Polynesian expansion, the AMS radiocarbon data thus far suggest that Rapa was first inhabited relatively late (*c.* AD 1200-1300). It lies well south of the main line of East Polynesian islands which

Table 1. AMS radiocarbon dates from archaeological sites and a sediment core on Rapa

Lab #	Provenience	Site Type	Material	14C	Error
UCI-14769	Tangarutu E. Section, T1, 150cm	Rockshelter	charcoal	905	20
ANU-11848	Tangarutu, East E2, Spit 23-5	Rockshelter	charcoal	710	70
ANU-11847	Tangarutu, base	Rockshelter	charcoal	650	100
UCI-14771	Tangarutu Weast Section, S3, 112cmbs	Rockshelter	charcoal	600	15
ANU-11849	Tangarutu, NS1, Base Layer	Rockshelter	charcoal	570	70
Ly-8577	Tangarutu, Unit 1, Walczak 2001	Rockshelter	charcoal	495	40
UCI-14768	Tangarutu East, E2, 23-5cm	Rockshelter	charcoal	475	20
UCI-2197	Tangarutu, Unit E2, 123cm	Rockshelter	charcoal	465	25
ANU-11924	Tangarutu, East E2, Spit 2	Rockshelter	charcoal	440	60
UCI-2325	Tangarutu, Unit E2, 10cm	Rockshelter	charcoal	380	25
UCI-14770	Tangarutu Section South, V1, 90cmbs	Rockshelter	charcoal	350	15
UCI-14772	Tangarutu, E1, Spit 11	Rockshelter	Aleurite	345	20
Ly-8578	Tangarutu, Unit 2, Walczak 2001	Rockshelter	charcoal	330	45
UCI-14726	Tangarutu, E1, Spit 4	Rockshelter	Gourd	320	15
UCI-14763	Akatanui, C1, Spit 4	Rockshelter	charcoal	610	15
ANU-11925	Akatanui, Base Level	Rockshelter	charcoal	480	70
UCI-14765	Akatanui, Shelter 3, C1, A1, Spit 2	Rockshelter	Aleurite	385	15
ANU-11851	Angairao E, 2nd Oven, Spit 10	Rockshelter	charcoal	500	50
UCI-14767	Angairao, Shelter E, 2nd oven, Spit 11	Rockshelter	charcoal	375	15
UCI-14766	Angairao, Shelter E, 2nd oven, Spit 11	Rockshelter	charcoal	220	20
ANU-11923	Taga, Test Pit A, Spit 2	Rockshelter	charcoal	370	150
UCI-14755	Morongo Uta (R-1), West Wall Exp. 18cm	Fortification	charcoal	380	20
UCI-2178	Morongo Uta (R-1), Exp. 2, 10cm	Fortification	charcoal	350	20
UCI-2177	Morongo Uta (R-1), Exp. 1, 20cm	Fortification	charcoal	145	20
UCI-14773	Morongo Uta (R-1), West Terrace, 10cm	Fortification	charcoal	130	20
UCI-14762	Ruitara, Exp. 1, 14cmbs	Fortification	charcoal	345	15
UCI-14774	Ruatara, STP#2, 15cm, Terrace below tower	Fortification	charcoal	210	15
UCI-2184	Potaketake (R-2), Unit 1, Feature 4, 51cm	Fortification	charcoal	240	20
UCI-2188	Potaketake (R-2), Unit 1, Feature 3, 30cm	Fortification	charcoal	240	25
UCI-181	Potaketake (R-2), Unit 1, Feature 2, 10cm	Fortification	charcoal	210	25
UCI-14757	Kapitanga, Below Tower, Exp. 3, 33cmbs	Fortification	charcoal	240	15
UCI-14758	Kapitanga, Upper Terrace, Exp. 4, 35cmbs	Fortification	charcoal	195	15
UCI-14759	Pukutaketake, STP#2, 35cm	Fortification	charcoal	235	15
UCI-14760	Pukutaketake, STP#2, 19cm	Fortification	charcoal	145	15
UCI-2190	Ororangi (R-20), Unit 1, Feature 1, RC-3, 12cm	Fortification	charcoal	200	25
UCI-2182	Ororangi (R-20), Unit 1, RC-2, 60cm	Fortification	charcoal	185	20
UCI-2186	Tevaitau (R-18), Unit 1, Feature 1, 20-30cm	Fortification	charcoal	195	20
UCI-2187	Tevaitau (R-18), Terrace E, Exp. 2, 22cm	Fortification	charcoal	140	30
UCI-14725	Vairu (R-3), Tower, Auger 7, 5-10cm	Fortification	charcoal	190	20
UCI-14761	Vairu (R-3), Exp 1, 25cm	Fortification	charcoal	180	15
UCI-2180	Tanga (R-4), Unit 1, Stratum I/II, S1, 20cm	Fortification	charcoal	145	25
UCI-2179	Tanga (R-4), Unit 1, Feature 2, 35cm	Fortification	charcoal	140	20
UCI-14756	Noogurope, Exposure 1, 20cm	Fortification	charcoal	120	15
OZH-279	Tukou, Core 2, 90-2cm	Core	Pollen concentrate	575	40
UCI-17868	Tukou, Core 2, 130-2cm	Core	Pollen concentrate	710	25
UCI-17892	Tukou, Core 2, 180-2cm	Core	Pollen concentrate	2480	60
UCI-14727	Tukou, Core 2, 200-2cm	Core	Pollen concentrate	2235	20
ANU-12098	Tukou, Core 2, 256-8cm	Core	*P. tectorius* (fruit)	3620	300

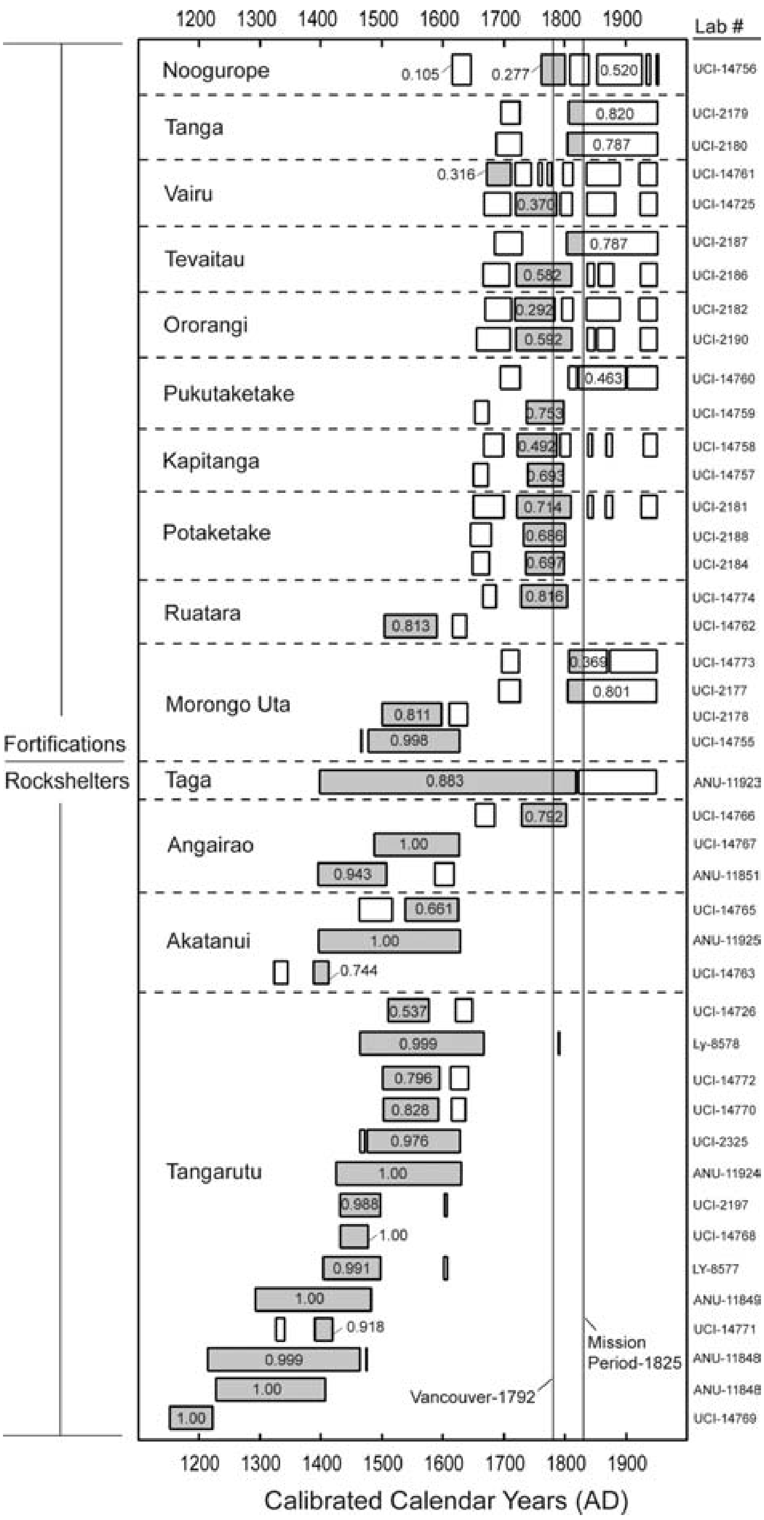

Figure 3. Calibrated AMS radiocarbon dates for rockshelter and fortification sites on Rapa. All dates were calibrated with Calib (version 5.0.1; Stuiver & Reimer 1993) using the southern hemisphere calibration curve. Boxes show calibrated age ranges (2 sigma) for each AMS radiocarbon date with the grey boxes showing the most probable date range given the relative area under the probability distribution indicated by the number inside each box (McCormac et al. *2002; Stuiver* et al. *1998a, 1998b). More detailed information for each AMS radiocarbon date (organized by laboratory #-on right of figure) is provided in Table 1.*

extends south-east from the Societies, through the Gambier and Pitcairn groups out to Easter Island, and its apparent late colonisation might reflect the operation of an early search strategy, which focused first on the main line of islands, discovering others later by offset voyages (Anderson 2003).

Demographic expansion and fortification

Competition for resources in the face of demographic expansion and environmental degradation is one of several driving forces in the development of social and political complexity and clearly played a role in the emergence of Pacific island chiefdoms (Kirch 1984). Fortified hilltop villages in East Polynesia provide the most obvious archaeological evidence for competition and warfare prior to European contact and indicate that inter-village conflict was an important component of social and political life (Best 1993; Burley 1998; Field 2004; Green 1967; Kirch 1984). The hyper-fortified nature of Rapa is often used as an example of Polynesian inter-village hostilities (Kirch 1984: 212). However, temporal trends in the establishment and expansion of fortifications on Rapa have not been identified until now.

In 1920-21, John Stokes, from the B.P. Bishop Museum, Honolulu, documented 35 fortified and non-fortified hilltop sites (Stokes ms). Subsequent work by the Norwegian Archaeological Expedition (Ferdon 1965; Heyerdahl & Ferdon 1965; Mulloy 1965), and more recently by Walczak (2001), has focused on documenting and mapping the most prominent fortifications. The main forts were located on the principal ridge separating the Ha'urei Bay watershed from the smaller drainages and bays around the outer coast of the island. At least one fort was paired with each of the primary external drainages. Usually the highest available mountain crest was selected and each fortification was surrounded by steep slopes or cliffs. According to historical accounts these naturally defensive locations were augmented with a series of palisades (Vancouver 1801), and most of these sites have defensive ditches cut through ridgelines around and within their domestic sectors. The forts are prominent features on the landscape and appear in 1m resolution satellite imagery (IKONOS; Figure 4a).

Previous excavations at Morongo Uta by the Norwegian Archaeological expedition in the 1950s revealed hearths, stone filled cooking pits, pits interpreted as storage features, and tools including poi pounders and adzes (Ferdon 1965: 9-21; Mulloy 1965: 23-60). Our excavations at Ororangi, Potaketake, and Tevaitau revealed similar features and a survey of the remaining fortifications suggests that they are common. Although there has been some speculation that the forts were only ceremonial features (Walczak 2001), the evidence indicates residential settlement. Excavation and auger testing discloses dark soils imbedded with charcoal and domestic debris, including fish bone, mollusc shells and basalt adze flakes. Hearths and fire pits were commonly encountered during our excavations and some of these features were carved directly into the underlying basalt. There were also some unfortified domestic terraces that were closely associated with fortifications (Smith 1965). Determining the relationship between fortified and non-fortified terrace settlements awaits further study.

As temporally diagnostic artefacts were scarce, we have relied upon radiocarbon dating to determine the age of fortification. Twenty-two AMS radiocarbon dates were obtained from ten fortifications (Table 1). These dates were calibrated with Calib (version 5.0.1; Stuiver &

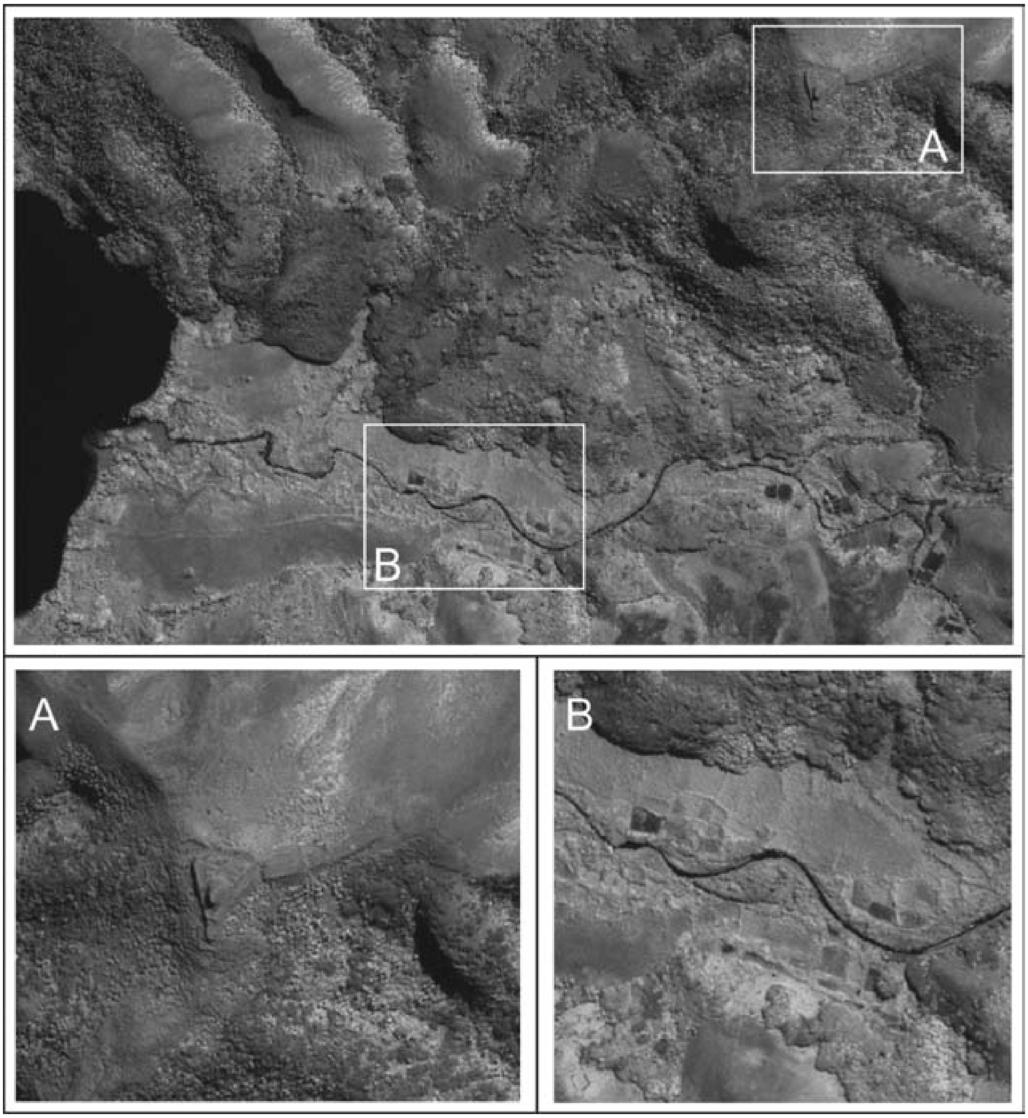

Figure 4. IKONOS satellite image of the Hiri Bay drainage showing A) Morongo Uta and B) active (dark) and inactive (light) taro terraces.

Reimer 1993; Stuiver *et al.* 1998a, b) using the suggested southern hemisphere correction curve (McCormac *et al.* 2002). We have taken a conservative approach to calibration because many of these dates fall within an unstable portion of the calibration curve and have multiple intercepts or ranges. Two sigma ranges are shown in Figure 3 and the greatest area of probability is shaded in grey (McCormac *et al.* 2002). All date ranges after AD 1825 were excluded because the fortifications were abandoned when the missions arrived (Davies 1827; 1961).

Two fortifications, Morongo Uta and Ruatara (Figure 1, #5 & #11), have early date ranges between *c.* AD 1450 and 1550. The early dates from Morongo Uta are consistent with two dates acquired by the Norwegian Archaeological expedition from this site (AD 1560 ± 250 and AD 1620 ± 241), but the error range is significantly smaller. Two additional dates from Morongo Uta indicate settlement at this location just prior to the Mission Period (AD 1825) and dates from the related site of Tevaitau (Figure 1, #8) suggest relatively persistent settlement in the vicinity of Hiri Bay from AD 1450 to 1825. The late eighteenth-century date from Ruatara is also suggestive of persistent settlement, but this requires verification. The radiocarbon dates from the remaining eight fortifications all have multiple intercepts, but the relative area under the probability distribution suggests that they most likely fall between AD 1650 and 1825. Some of these sites were undoubtedly among the fortified communities observed by Vancouver in 1791. Overall, these data suggest that people started using hilltop fortifications 200-300 years after colonisation and that fortified settlements proliferated rapidly on the island during the eighteenth century prior to European contact and the collapse of island population in the wake of introduced European diseases (Hanson 1970).

Anthropogenic environmental change

Remnant dry stonewall terrace features line many of the alluvial valley-bottoms of the island and are indicative of the former extent of *Colocasia esculenta* (Taro) pondfields (Figure 4b). From oral traditions and other sources, Stokes (nd) and Hanson (1970) suggested that *C. esculenta* was the staple food from the time of initial settlement. The numerous stonewall features indicate that the level of corm production matched that of the better known Pacific production systems of the Hawaiian islands and New Caledonia. Some of the valleys are still used for cultivation but this represents only a small proportion of the total available arable land. Many of the abandoned or fallow terrace systems remain waterlogged and are now dominated by introduced agricultural grasses (e.g. *Paspalum subjugatum*), sedges (e.g. *Carex* spp.), rushes (e.g. *Schoenoplectus subulatus* subsp. *subulatus*) and adventive herbs (e.g. *Commelina diffusa*).

Sedimentary cores were taken from swamps located in the main embayments of Ha'urei, Hiri, Anarua, Angairao, Akatanui and Anatakuri in an attempt to locate materials spanning the pre- and post-colonisation era to document the nature and timing of human impact at each site (Prebble 2006). One of the longer and most representative sequences comes from the head of Ha'urei Bay in a swamp that lies next to the largest river delta and associated estuarine tidal flats (Tukou, Core 2; see Figure 1, #5; Figure 5). This 4m sediment core was located 60m from the interface between the swamp and estuary and 60m from an eroded embankment with abutting remnant stone-wall terraces. From the swamp surface down to 290cm, the core was sub-sampled at 10cm intervals for palynological analysis. The bottom 190cm of the sequence is located beneath the current spring high tide line and consists of silty sand imbedded with gastropod and mollusc shell debris overlying inorganic basal clays. Four pollen concentrate samples from a range of depths were directly AMS radiocarbon dated (Table 1). A *Pandanus* fruit located from a depth of 256-8cm (56cm below spring high tide level) was also directly dated to 2710-1210 BC, the earliest date obtained from the core.

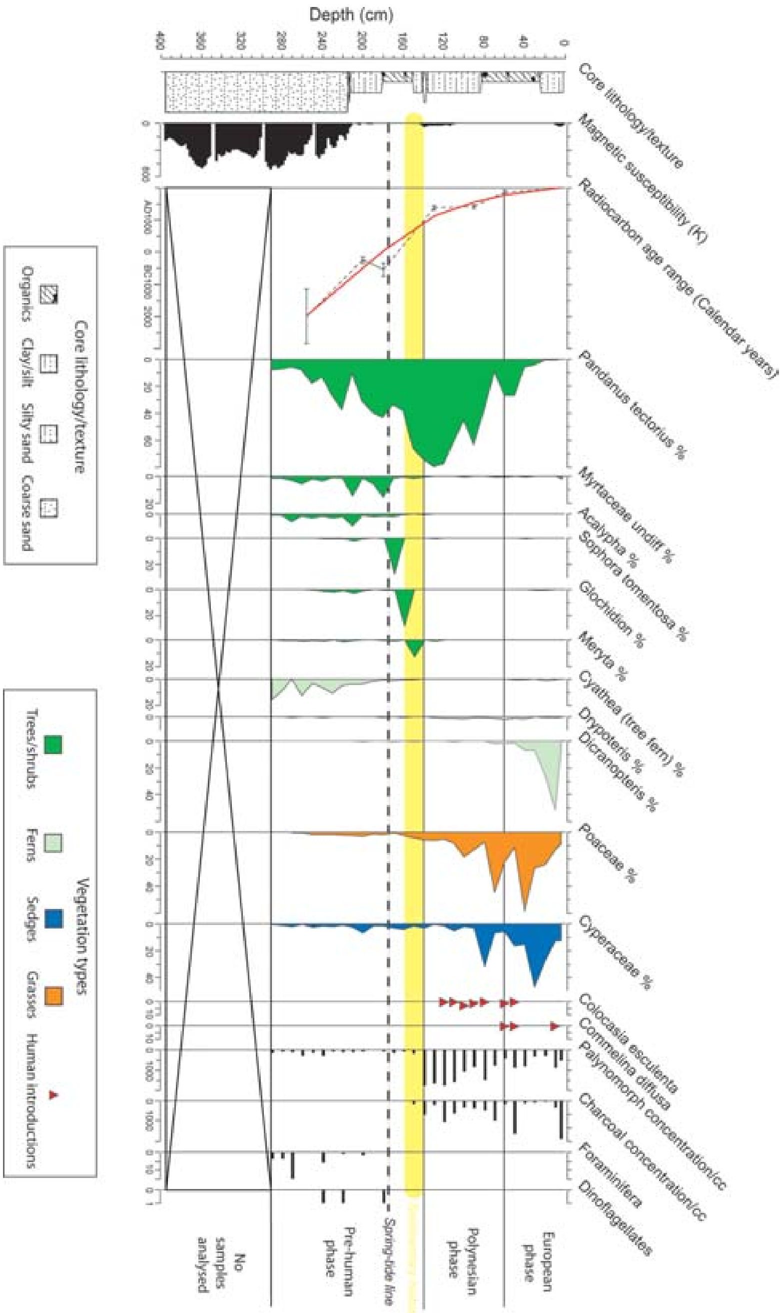

Figure 5. Summary pollen and charcoal stratigraphic diagram for Tukou Core 2 samples (n = 30), Ha'urei Bay. The main vegetation groups are presented as a percentage of the total pollen sum (N = 300). Charcoal concentrations are measured as per cm^3. *The presence/absence of Colocasia esculenta pollen and a range of European adventive species (Sonchus sp., Commelina diffusa, Ludwigia octovalvis) are indicated by the black triangles. The AMS radiocarbon ages for this core was calibrated with Calib (version 5.0.1; Stuiver & Reimer 1993) using the southern hemisphere calibration curve (2 sigma range). Each age probability is based on the probable date range given the relative area under the probability distribution (McCormac* et al. *2002; Stuiver* et al. *1998a, 1998b).*

A stratigraphic plot of the palynological data is presented in Figure 5. The pollen-based stratigraphy can be separated into three phases; a pre-human coastal forest phase (280-165cm; *c.* 2000 BC to AD 1200), a Polynesian agricultural phase (165-60cm; *c.* AD 1200 to 1825) and a post-European contact phase (above 60cm; AD 1825 to present). The base of the pre-human phase shows a dominance of fern spores representative of taxa now marginal in the lowlands (e.g. *Cyathea* tree ferns) as well as an increase in tree and shrub pollen consisting mostly of *Pandanus* (probably *P. tectorius*). The sediment stratigraphy of this phase is characterised by a loose organic horizon overlying mid-Holocene aged estuarine or marine sediments. Counts of foraminifera and dinoflagellates in samples at depths below 250cm suggest the site was inundated by the sea during this period of sediment deposition. The overlying organic horizon includes leaf and wood fragments, roots, seeds of *Celtic insularis* (a shrub now restricted to upland areas) and fruits of *Pandanus*, and coupled with the palynological record, suggest a dense coastal swamp forest canopy dominated by *Pandanus*. This coastal swamp forest was established on a formerly exposed shoreline, probably in response to maritime influences as late Holocene sea-level stabilised in the region by *c.* 1400 to 900 BC (Bard *et al.* 1996).

Sediments representing the Polynesian agricultural phase start at 140cm and are positioned just above a sedimentary hiatus that may be a product of rapid erosion associated with initial colonisation. This phase starts sometime before AD 1350 and probably as early as AD 1200 with initial settlement. Human impacts on the landscape at this time are signalled by increasing sedimentation rates and more evidence for burning, likely related to agricultural expansion, as indicated by larger charcoal concentrations in sediments above 140cm. The appearance of *Colocasia esculenta* pollen at 120cm (AD 1400), an unequivocal human introduction, is a clear indication of expansive agricultural activity by *c.* AD 1400. *Pandanus tectorius* pollen start to decline at AD 1350-1390 (130-2cm) as grass pollen and spores of seral fern taxa (*Dicranopteris* and *Dryopteris*) increase in conjunction with more colluvial sedimentation overlying the loose organic horizon of the pre-human phase. After AD 1400 tree and shrub pollen continued to decline in conjunction with further increases in grass (Poaceae) and sedge (Cyperaceae) pollen that far exceeded levels represented in the pre-human phase.

From the above evidence, we suggest that the sequence of agricultural development at Tukou and elsewhere on Rapa was relatively rapid, starting sometime before AD 1350, and paralleled the expanding use of coastal rockshelters and the establishment of the first fortified settlements AD 1450 and 1550. Deforestation of the swamp and surrounding environs resulted in extensive erosion of soil from the nearby hill-slopes and this process was rapid and largely complete by *c.* AD 1500.

Discussion and conclusions

Our research on Rapa has brought into focus results of a kind that are becoming familiar from research throughout East Polynesia, especially in the more isolated islands, such as Hawaii, Easter Island and New Zealand. They consist of: a chronological sequence that indicates relatively late colonisation (after AD 1000); demographic expansion, environmental change (plausibly anthropogenic in the main), which begins early in the settlement sequence and which involves substantial alteration of the environment including the establishment of extensive agricultural systems. Relatively late in the sequence is an efflorescence in construction of monumental structures. It would be premature to argue that these clusters of data result from similar processes, but there are several explanatory models which are plausible generally and which might be pertinent to the Rapan case.

One hypothesis is that the colonisation of remote islands was followed by population growth, reduction in mobility, settlement/agricultural expansion, and resource depression (Kennett *et al.* 2006). Rapa's remote position reduced opportunities for emigration and social interaction, i.e. the population was environmentally circumscribed (Carneiro 1970). Population expansion after colonisation might have favoured competition for resources and agricultural intensification leading to formalised territoriality. Deforestation, erosion, and sedimentation in valley bottoms would have created prime terrain for pond-field agriculture. Construction of pond-field terraces required substantial labour and it also concentrated agricultural productivity into clearly defined and defensible patches (c.f. Dyson-Hudson & Smith 1978). Competition for these patches would have favoured population growth/aggregation and fostered the strategic building of forts. Continued population increase and fissioning pushed newly established communities into increasingly marginal areas and caused more widespread environmental degradation.

An alternative hypothesis for the construction of massive earthworks and associated structures is that they operated as an energy sink or waste mechanism, diverting a significant proportion of energy away from reproductive and child-rearing behaviours. In turn, this optimised population growth and structure in relation to levels of uncertainty in resource productivity (e.g. Graves & Sweeney 1993; Hunt & Lipo 2001). Such an explanation is particularly plausible in the subtropical region, where agricultural products and maritime resources were less diverse than elsewhere in East Polynesia (Anderson 2001), and where, especially in south-eastern Polynesia, the impact of periodic climatic change, most notably through ENSO variation, was relatively high.

Of course, both hypotheses may be valid. As Dunnell (1999: 247) observes, the waste model of cultural elaboration is not inconsistent with others which might also have been operating in such circumstances, including competitive signalling between intervisible communities, or the creation of monumental structures for ritual purposes.

Our research, so far, shows that the basic sequence of cultural change expected by these model explanations can be observed. Evidence for early settlement (*c.* AD 1150 to 1250) is confined to Tangarutu, the most desirable coastal rockshelter on the island and then expands to less attractive locations (Akatanui, Angairao, and Taga) starting *c.* AD 1350-1450. The use of coastal rockshelters appears to decline after *c.* AD 1550 as pond-field agricultural systems reached their full production capacity in the prograded lowlands and settlement shifted to more defensible highland locations. One of the two early fortifications, Morongo Uta, is located overlooking the largest pond-field system (Hiri valley) of the exterior lowlands as well as others inside Ha'urei Bay itself. The coincident appearance of Ruatara, well-positioned to control areas on the north-eastern side of the island, suggests that these fortified communities developed within the context of intense competition for limited territory. It is within this social and political milieu that fortified communities proliferated on the island by *c.* AD 1700.

The environmental impacts associated with demographic expansion on Rapa are obvious and relevant to contemporary environmental issues. Dramatic environmental changes associated with population growth are well-documented on other Pacific islands and each provides a 'microcosm' of processes occurring today on a global-scale (Kirch 2004). Equally relevant should be the social responses to environmental change, anthropogenic or otherwise, and how these can further exacerbate environmental impacts. Our work on Rapa suggests that demographic expansion and environmental degradation under circumscribed conditions resulted in competition for territory and resources. The establishment of strategically placed fortifications suggests that inter-group warfare on Rapa occurred frequently enough to warrant large investments in defence. Victory in warfare is, in part, related to community size, and population concentration and growth were likely favoured under these conditions. The growth of communities ultimately resulted in intra-village competition, conflict, and fissioning into more marginal territories. Proliferation of fortified settlements on Rapa at *c.* AD 1700 demonstrates how changing social and political conditions impact demography and amplify the effects of environmental degradation.

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