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RESEARCH UPDATE

Eroding Heritage: An Island Context

Sue Hamilton and Mike Seager Thomas

Introduction

In the following we focus on, and briefly summarize, the work of the UCL Rapa Nui Landscapes of Construction Project (LOC) over the past two years, monitoring various aspects of erosion and weathering on the island (Table 1) and its impact on the Rapa Nui (Easter Island) heritage landscape. This work builds on and expands data collected during the British Academy (SG-47054) and AHRC (AH/1002596/1) funded phases of LOC (previously discussed and attributed in *Archaeology International*) (see Hamilton 2007; 2013).

In the 21st century, climate change is identified as a major contributor to the physical erosion of tangible heritage around the world and the associated loss of intangible heritage. The environmental and socio-economic saga of early Rapa Nui, which since 1996 has comprised a UNESCO designated World Heritage Landscape, and particularly the decline or demise of the population and the socio-economic structures that sustained its statue (*moai*) building period (c. AD 1200–1500), is well known. Evoked again and again is the vulnerability of a society with colossal monuments and an intricate lifestyle that fell victim to geographic isolation (Rapa Nui lies in the Pacific Ocean c. 3,500 km off the coast of Chile), a tiny land area, and low biodiversity (e.g. Bahn and Flenley 2011: chapters 11 and 12; Diamond 2006: chapter 2). To many this has served as a warning of how precarious human achievement can be in the face of scarce and vulnerable natural resources, human intervention, and a susceptibility to local, regional and global environmental changes. Deforestation, sediment erosion (contributed to by tree loss, poor soil structure, deep weathering, in places ploughing, and damage caused by introduced animals) and the island's vulnerability to seasonal storms, constant sea spray, and oscillating heavy rain and dryness have collectively served to leave Rapa Nui's exceptional archaeology at risk. This is exacerbated by the topographic locations across the island on which specific categories of monuments were placed, the differing geologies of the architecture comprising these, and the spread of modern development—new buildings and farms in locations that previously had fossil landscapes of surface archaeology, elements of which had lain undisturbed by people since the later 19th century. With the present Chilean policy of land return to the Rapanui and the increasing need for infrastructure to support tourism, the racked-up speed of change has been particularly in evidence over the past two or three years. With this multitude of intersecting factors, it is over-simplistic, indeed sensational, to focus on any single cause for Rapa Nui's dramatically eroding heritage.

Rapa Nui's small size and the clustering around its vulnerable coastline of the majority of one of its primary categories of heritage monument (the *ahu* or ceremonial platform), its near total economic reliance on tourism (c. 70K visitors per annum) and a growing emphasis on the interpretative presentation of monument complexes to tourists,

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heightens the need to develop policies on the relationship between heritage, conservation, tourism and academic research. Sensitive monitoring, control, and management of these require a sustained familiarity with Rapa Nui's landscapes, multi-disciplinary input, and the coordinated discussion, judgments and consensus of many stakeholders. In November 2017, the Ma'u Henua indigenous people's community organization took over management of archaeology within the Rapa Nui National Park, in which the best known of the island's heritage monuments fall, from the Chilean National Park Authority (CONAF). In March 2018, the UCL Rapa Nui Landscapes of Construction Project signed a 5-year agreement with Ma'u Henua to advise on the management of the Park's threatened heritage. This is a new UCL phase, and one of the impacts and legacies of the now concluded AHRC-funded LOC field project. Below we highlight some of the issues that we are currently working on.

Coastal erosion and *ahu*

Coastal erosion is not a new threat to Rapa Nui heritage. Since the original construction of the *ahu* around the coast in deliberate proximity to the sea, it has slowly brought the coastline closer and closer to them. These *ahu*, on many of which *moai* once stood, and on some of which these have been re-erected, are now enveloped in sea spray and in some cases physically battered by the waves. The consequence of this is that the stones comprising them have become pitted with tafoni and—in places—are collapsing into the sea (**Figures 1** and **2**, left).

Over the past decade LOC has surveyed >100 *ahu*, most of them around the coast, and we have a growing database on the condition of, and range of threats to these, which we have shared with Ma'u Henua. A number of *ahu* reconstructed in the later 20th century have become major tourist attractions (e.g. the *ahu* complex at Tahai). Most of these are now safe from collapse but all of those by the sea remain vulnerable to the effects

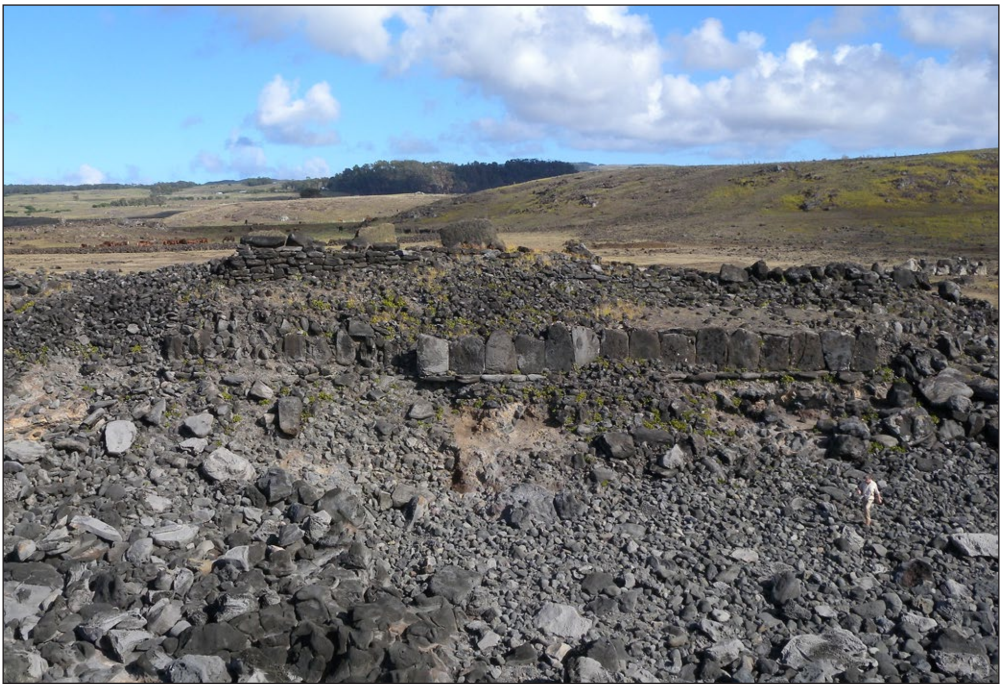

Figure 1: The rear of Ahu Ura Uraŋa Te Mahina, on the south coast of the Island. Sea erosion of the low cliff on which it stands has reached its rear wall, and is causing it to collapse (in the photo, the collapse is advancing from the left to the right). The bases of three prone *moai* are partially visible at the top of the surviving platform. Photo: Adam Stanford.

of salt. Others, also tourist attractions, but more important archaeologically because they have not been reconstructed, are being steadily degraded by ongoing wave action. For example, at Ahu Ura Uraŋa Te Mahina, a low sea cliff has reached the seaward wall of the platform (**Figure 1**), and at Haŋa Tee o Vaihu, the coastline is advancing along the platform, as well as from its back. Others, and parts of others, not on the tourist circuit but of no less importance, are already in a state of terminal breakdown.

High-cliff instability and retraction, due to undermining by wave action (rather than direct wave action on the *ahu*), has resulted in the historic disappearance of Ahu Riki Riki, which was recorded in the late 19th century (Thompson 1891: 513), and the partial loss of Ahu Motu Toremo Hiva and Ahu Te Nui, data from both of which have had to be saved by rescue excavation.

It is also important to note that Rapa Nui's *ahu*, coastal and otherwise, are not just discrete ceremonial platforms. Most form part of a complex of structures, which might include crematoria, usually on their seaward sides; adjacent, contingent paved ramps to the sea; coeval un-recorded coastal breakwaters; water sumps; and a range of associated inland features. These are all also under threat, though often of a different sort, and require the same level of monitoring, recording and protection. A rare paved ramp to the sea at Ahu Haŋa Teteŋa, for example, which has been denuded by ongoing animal and human traffic to a spring at the water's edge, is close to disappearance (**Figure 2**, bottom right), as are two sea washed crematoria to the rear of Ahu Haŋa Poukura (**Figure 2**, top right). Thus each coastal *ahu* has unique, contextual elements for which there are no single or simple solutions to reduce ongoing erosion.

Figure 2: Coastal *ahu* are open to many threats. Left: tafoni in the rear wall of Ahu Haŋa Poukura caused by the re-crystallization of absorbed salt within the rock. Top right: also to the rear of Ahu Haŋa Poukura, the remains of a sea-washed crematorium. Bottom right: a paved route to a freshwater spring at the shore's edge at Ahu Haŋa Teteŋa, which is being degraded by wave action and by people and animals accessing the spring. Photos: Sue Hamilton (left) & Mike Seager Thomas (right).

Disintegration of the *moai*

At no less risk are the island's famous *moai*. The majority of *moai* were carved from volcanic tuff, which was quarried from the inside and the outside of the present crater of Rano Raraku. Approximately 200 tuff *moai* were set up on *ahu* (**Figures 1** and **4**, left), others lie recumbent along the *Ara Moai* (*moai* roads) spreading from/leading to Rano Raraku (**Figure 3**), while many more never left the vicinity of the quarry. They are disintegrating due to the differential expansion and contraction of the minerals comprising the tuff, when subject to changes in temperature, the translocation within them of the cement holding these together, the swelling when wetted of clays formed within the weathered tuff, the rooting of plants and (in *moai* close to the sea) pressures caused by the build up of absorbed salt. Collectively, these cause the *moai* to disaggregate, crack, and the layers of tuff at their surfaces to lift off (Charola 1997: 23–30). This ongoing breakdown of their fabric is highly conspicuous (**Figures 3** and **4**, left).

The *moai* too have contextual differences that determine the extent and types of weathering and erosion to which they have been and are currently subjected (**Table 1**): sea spray and wave action for those near the coast; interference by animals, particularly for the recumbent ones along the *Ara Moai*; and for some at Rano Raraku, protection as a result of burial by colluvium derived from upslope quarry workings.

Many projects have been set up to monitor and collect scientific data on the breakdown, and undertake experimental conservation/stone stabilization treatment, of individual *moai*. These have been used as a proxy for the wider control of their breakdown as a monument category (such as those of the

Figure 3: The profoundly weathered and eroded rear of "Cook's *moai*" on the southern *Ara Moai*. The flow lava inclusions projecting from the tuff give an idea how much material has been lost. Differential weathering of the *moai*'s downward side (not visible in the photo) shows that it was once standing. Photo: Mike Seager Thomas.

Chilean *Centro Nacional de Conservación y Restauración*, which experimented with consolidants and water repellents on a *moai* re-erected on Ahu Haŋa Kio'e, and the Italian conservator Lorenzo Casamenti, who has applied biocides to the re-erected *moai* on Ahu Ature Huke to kill and facilitate the removal of lichen: Charola 1997, 31–33; CTS News 2013). Our survey (commissioned by CONAF: LOC 2013, 2014, 2015) encompasses 35 recumbent *moai* on the *Ara Moai* and a total of 12 recumbent, and standing, *moai* on the outer slopes of Rano Raraku. It differs from the above in so far as it considers a range of types of damage and threat (at least 21 categories) and the best current management strategies to protect the *moai*, many of which are beyond recovery (**Figure 3**), from further deterioration in the wider landscape (such as control of animals and tourists).

Furthermore, our survey is uniquely integrated with research on individual weathering patterns and how these can inform our knowledge of the original placement locales, biographies and settings of *moai* in the landscape, alongside the wider archaeology of the Park. In the case of *moai* along the *Ara Moai* this has usefully contributed to elucidating whether they were abandoned in transport (a view which fits nicely with the theory of a sudden collapse of Rapa Nui society due to resource stress, see Skjölsvold 1961: 378–9), or as we, Katherine Routledge, and a Belgian team working on the same issues, deduced, deliberately set up along routes to and from the quarry (Cauwe and De Dapper 2015; LOC 2014: 26–27; Routledge 1919: 195).

Poike's archaeology and erosion

Our most recent work (LOC 2016, 2017; Scaife in prep.) has been on the Poike peninsular, at the eastern end of the island. Poike's archaeology is less well known than that of other parts of the island but is of no less importance to our understanding of prehistoric Rapa Nui culture. It has a range of archaeological features similar to that present across the island as a whole, including *ahu* with *moai*, *hare paeŋa* (boat-shaped houses), rock art, stone quarries and numerous *taheta* (rock-cut basins to contain rainwater), which on Poike lie within a discrete, integrated landscape, free of modern roads, buildings and established tourism. Here, therefore, it is possible to consider multiple factors of erosion on a landscape scale, as it relates to all these categories of site. Here, also, it is possible to formulate a fieldwork strategy without reference to the mass tourism that troubles, and itself contributes to, the deterioration of archaeology in other parts of the island.

The extent of Poike's archaeology and the nature and scale of the natural threats to it are such that it will be impossible to save everything. The challenge for the archaeologist, even while attempting to mitigate the threat to individual sites, is to devise and execute a prioritizing strategy that will maximize the amount of data saved, and take advantage of what in some cases may be a narrow window of investigative opportunity provided by a differing range of types and periods of erosion. Our work on it provides a useful case study of the wider, multiple erosion factors affecting Rapa Nui's heritage.

On Poike, deep weathering of the bedrock has rendered its surface sediments unstable with the result that its lower slopes are now mantled by colluvium (Mieth and Bork 2005), which, along with the archaeology buried by it, is slowly being stripped away by sheet and gully erosion, leaving three of the peninsula's four known *ahu* under immediate threat of collapse. Erosion is exacerbated today by cattle scuffing and trampling and the scouring out of car tracks. In addition, the disaggregation of tuff *moai* (**Figure 4**, left), and the weathering of other culturally modified stone is ongoing. Environmentally-driven deterioration of these sorts are associated with archaeology across the island, but are not much studied.

The re-deposition of sediments as colluvium and therefore erosion on the peninsula probably dates from the period during prehistory when it was first deforested (Mieth and Bork 2005) but this probably accelerated in the 19th century, when sheep farming arrived on the island, and again in the 20th, when parts of it were ploughed. Later, in places, it was planted with *Eucalyptus*, which, while checking the extension of erosion upslope, may, owing to the deposition of slowly degrading leaf litter, have increased run off and therefore erosion downslope.

Sediment erosion on Poike is characterized on the ground by localized slumping, the formation of terracettes, gullying, localized sea cliff collapse and, as the surface vegetation is lost, massive sheet erosion. It is shown to be active today by the deposition of red, surface weathered sediments on the sea cliffs below the mouths of the gullies, the pedestaling of residual cultural stones on the eroded surface (**Figure 4**, bottom right), and ongoing damage done to the archaeology (**Figure 4**, top right) (LOC 2016: 5–7). The resulting collapse of elements of Poike's heritage monuments can be sudden rather than gradual and this necessitates decisions, about the viability and value of preventative action or investigative intervention, to be made and instituted in advance. Accelerated surface erosion—during La Niña in the summer of 2016–17—of the denuded sediment pedestal on which Ahu Viri Viri o Tumu stands (**Figure 4**, top right), for example, resulted in the sudden partial collapse and destabilization of the *ahu's* rear wall.

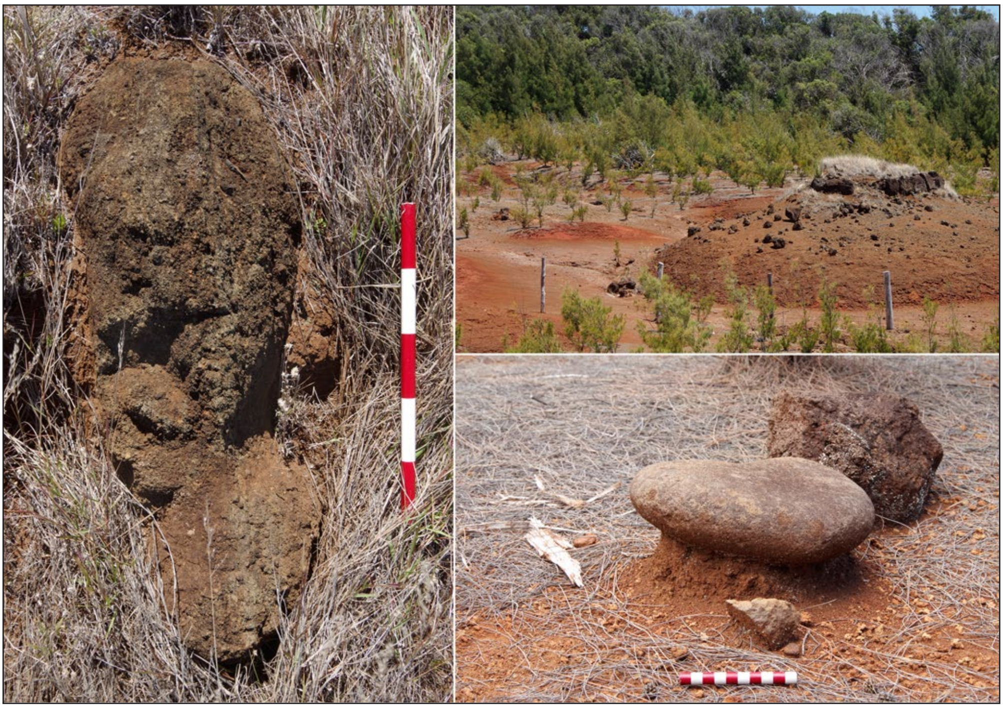

Figure 4: Erosion on Poike. Left: a small, heavily weathered *moai* to the rear of Ahu Hati Te Kohe. (The head of the *moai* is to the bottom of the picture). Top right: deep gully and sheet erosion around Ahu Viri Viri o Tumu in 2016. La Niña in the summer of 2016–17 was 'the tipping point' for its rear wall, which has now lost more stones. The trees (*Casuarina*) in the foreground and to the front of the *ahu* were planted in an attempt to inhibit further erosion. The trees in the background are *Eucalyptus* which here surround the eroded area. Bottom right: out of situ cultural stones pedestaled by ongoing sheet erosion. Photos: Mike Seager Thomas.

The displacement and mixing of archaeological material on Poike's deeply eroded surfaces, on the one hand, and the burial of this by colluvium on the other, have rendered survey of the areas so affected pointless, irrespective of the researcher's agenda. However, we obtained useful archaeological and environmental data from a number of locations. These included: areas which because of the local topography had escaped erosion or deposition of colluvium (mostly gentle convex slopes and the outer parts of deep terraces); un-eroded islands of relatively unweathered bedrock, which in different places stood proud of colluvium and the eroded surfaces; *ahu*, whose stony bulk has inhibited runoff, and which now stand on islands of sediment above the eroded surface (we were too late to record the structures that had formerly stood on several other such islands); the erosion front at the edge of the eroded area, including sections through structures standing on the aforementioned sediment islands; and the sides of erosion gullies. Together, these yielded a range of structural, artefactual, and sedimentological evidence of interpretative value, dating from a period prior to the arrival of the island's first colonizers, through the statue-building period down to the present. Most notably, they included a previously unknown *ahu moai* of a type peculiar to Poike (**Figure 4**, left); pollen information on the treed environment in which the Poike *ahu* were built (R. Scaife pers. comm.); and a probable waterlogged basin, which appears to predate the cessation of active volcanism on the island.

For Poike, such locations are predictable, easily accessible in the field, and have high archaeological potential and are thus obvious fieldwork priorities. While the usefulness of each was tempered by our individual research agendas, their study yielded proportionately more useful data than either random or total survey, both of which would inevitably have included much archaeologically sterile ground. This was established by extensive, rather than site or monument-type focused, fieldwork.

The threat in the long term

The natural alternation every few years of El Niño and La Niña is sometimes cited in explanation of threats to Rapa Nui's heritage, even though the island falls outside the area most strongly influenced by these, and records do not allow an unambiguous record of past environmental causes/effects to be plotted (Genz and Hunt 2003). Future predictions for the region, however, point to reduced but more intense precipitation, increasing the likelihood of spreading vegetation fires and therefore sediment instability and loss. Also predicted, is a rise in sea level and the possible inundation of some low-lying land and its associated archaeology during storm events (Quilliam et al. 2014: 63). These are predictions; they may not be realized. But, the shoreline will continue to retract, the *moai* will continue to degrade, cliffs will continue to collapse and, unless action is taken to stop it, Poike and other areas of the island will continue to be stripped of sediment and the heritage monuments these support undermined. These facts need to be faced squarely by all the island's stakeholders—archaeologists, curatorial authorities, the tourist industry, every Rapanui—and a realistic archaeological strategy that accommodates them devised, agreed and implemented. Otherwise, Rapa Nui's archaeology will become a greatly diminished thing of the past.

Conclusion

Archaeology and heritage monuments are the basis of Rapa Nui's main industry, tourism. Alongside research on Rapa Nui's archaeology, the search for a better, more chronologically continuous, geographically extensive, and multi-factor understanding of the intricacies of the threats to the physical fabric of Rapa Nui's heritage and natural environment is essential (**Table 1**). Rather than focusing on single factors or monument categories, our work on Poike and elsewhere allowed us to explore these intricacies at an interconnected landscape scale. Research can but inform the

Table 1: Threats to Rapa Nui's Archaeology.

Threats		Effect(s)	Types of archaeology effected	Examples of sites currently or recently effected
Climate	Rain	Mechanical erosion of rock	*Moai*; exterior rock art	Most exposed *moai*; Oroŋo; Rano Raraku
		Mineral translocation & clay swelling in rock leading to disaggregation	*Moai*	Most exposed *moai*
		Sediment run off leading to localized collapse	Any coastal or inland site on in situ or re-deposited degraded lava with a significant slope	Ahu Viri o Tumu (2017) & Hati te Kohe; Viriŋa o Tuki axe factory
		Soil creep		Rano Raraku; Oroŋo
	Sun	Differential expansion of rock minerals leading to disaggregation	*Moai*; rock art	Most exposed *moai*
	Wind	Sediment deflation & sand blasting	Surface features (e.g. artefact scatters and exposed ahu fills); *moai*; rock art	The sediments burying (and protecting) Ahu Hati te Kohe; most exposed *moai* & rock art
Sea	Wave action	Salt re-crystallization leading to rock disaggregation	Coastal *ahu* (particularly their crematoria and rear walls)	Most coastal *ahu*
		Sediment run off and localized physical collapse	Anything close to coast or the edge of a sea cliff	Some coastal *ahu* – e.g. Haŋa Poukura
		Undermining and localized physical collapse		Some coastal *ahu* – e.g. Haŋa Tee & Te Nui; Oroŋo
	Sea spray	Salt re-crystallization leading to rock disaggregation	Coastal *ahu*, *moai*	Most coastal *ahu*
Vegetation	Lichen rooting	Rock disaggregation	*Moai*	Most *moai*
	Shrub rooting	Rock displacement	*Ahu*; *avaŋa*; *hare moa*; *moai*	Ahu Oroi & Taharoa
Cattle & Horses	Rubbing	Physical abrasion	*Moai*	Most *moai* along the *Ara Moai*
	Trampling & scuffing	Physical abrasion & rock displacement	Part buried *moai*; the pavements of *hare paeŋa*, rock gardens and other superficial stone features	Most sites

(contd.)

Threats		Effect(s)	Types of archaeology effected	Examples of sites currently or recently effected
Human impacts	Fire	Vegetation loss leading to the exposure of sediments to rain and wind	All	Puna Pau (2011)
		Rock spalling; oxidization	Many *hare paeŋa* bare such traces but the extent to which these can be attributed to modern fires is uncertain. *Moai* have been reported damaged by recent fires	Unknown
	Infrastructure development	Feature & site destruction	Minor, previously unrecognized sites discovered during development	Various sites around Hanga Roa
		Phenomenological interference	All	Tourist paths around Rano Raraku; Ahu Haŋa Tee (fenced across the plaza in 2011 and walled in 2017) & Te Pitu Kura (fenced across the plaza in 2009); the Explora Hotel in 2007
		Rock harvesting for house & wall building	Inconspicuous rock gardens & collapsed stone features easily accessible from roads	Rock gardens all along the island's southern coast road
	Ploughing	Rock & artefact displacement		On many plots of "returned", former government land around Haŋa Roa and on some squatted land further afield
	Tourists & local residents	Artefact theft	Obsidian scatters	Many exposed scatters
		Trampling	*Ahu*, *moai*, artefact scatters etc.	*Moai* at Ahu One Makihi (2018); many unfenced *ahu*, inconspicuous, part buried *moai* – e.g. at Haŋa Poukura – and other structures
		Vandalism & graffiti	*Moai*	*Moai* ear on Ahu Nau Nau (2008)
	Un- or incompletely published archaeological interventions & restoration	Destruction of archaeological features & distortion of the archaeological record	All. As elsewhere, failure properly to report is a recurrent shortcoming of Rapa Nui archaeology	Ahu Toŋariki; the re-carving of *moai* faces during the restoration of Ahu Nau Nau

future meaning of Rapa Nui's heritage. Documenting its archaeology with research questions in mind, sampling the stratigraphies that erosion exposes, and rescue excavation must be done *alongside*, but not independent of, the monitoring and protection of its eroding heritage. Rapa Nui presents a microcosm of many world heritage issues and reveals a daunting array of threats to the fabric of its heritage. Interestingly, it is current research that increasingly ascribes to Rapa Nui's remarkable prehistory a record of successful ancient environmental management (for example through rock mulching of crops and control of periodic surface flows of water, see Ladefoged et al. 2010; Stevenson, Wozniak and Haoa 1999; Vogt and Moser 2010), a record that now seems to have been more successful at controlling erosion than the many 20th- and 21st-century responses to managing the development and environmental change that Rapa Nui is experiencing with increasing intensity.

Competing Interests

The authors have no competing interests to declare.

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