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Running to stay in place: An adaptive escalation model for the *latte* period

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Abstract—Archaeological data from a large inland area in south-central Guam show that cultural adjustments, including technological and social adaptations, enabled the ancestral Chamorros of the Mariana Islands, Micronesia, to remain farmer-fishers despite environmental challenges associated with a major climatic oscillation, from the Medieval Warm Period (MWP, c. A.D. 800–1350) to the Little Ice Age (LIA, c. A.D. 1350–1900). People responded appropriately to the difficult conditions of the LIA, such as increased aridity, typhoons, and related harvest shortfalls, by "running faster" (building upon and adding to earlier practices). This "Red Queen Principle" is invoked as part of an adaptive escalation model for the *latte* period cultural system. Eventually the tolerance limits for stresses to the system were exceeded during prolonged and violent clashes with Spanish colonizers in the late 17th Century, as farming conditions continued to deteriorate. Tests of the model are suggested.

Introduction

This paper has been considerably modified from a paper presented at the annual meetings of the Society for Human Ecology in 1999. That paper was prepared for a symposium on the human dimensions of climate change, and it presented the Marianas case as a cautionary tale: the environmental knowledge accumulated in the relatively simple cultural system of the ancestral Chamorros enabled them to adapt successfully to a major climate shift over several centuries but not to withstand the stresses associated with the Spanish onslaught. The paper's take-home message was that contemporary calls for drastic actions to combat climate change should be tempered by humility in the face of our ignorance of the environmental processes that shape the complexity of the modern, interconnected "world system." The purpose of the present paper is to present an adaptive escalation model of culture change that can account for data from south-central Guam as well as within the Mariana archipelago during the *latte* period. In trying to understand long-term culture stability, the model privileges physical environmental effects in shaping human behavioral responses, linking specific social and technological accommodations that in combination enable a cultural system to persist.

Cultural Adaptive Systems

As open systems comprised of matter, energy and information, cultural adaptive systems are concrete (as opposed to conceptual and abstract systems) *sensu* Miller (1965:202–203). Open concrete systems have "at least partially permeable boundaries, permitting sizeable magnitudes of at least certain sorts of matter-energy or information transmissions to cross them." The main components of a cultural adaptive system include its technological organization, which intercepts and transforms matter and energy from the environment and buffers the system from anticipated perturbations; its sociological organization, which regulates production and consumption of materials; and its ideological organization, which guides and mediates human actions *vis-à-vis* information generated by the system. From these abstractions comes a more "down to earth" view of culture that considers physical environmental conditions and human responses to them in dynamic relations that are not always in equilibrium. In archaeology the clues to the latter lie in the detailed study of material remains such as artifacts and human-constructed features such as house floors, burial pits, walls, etc. and in a search for regularities in the spatial patterning of these remains. I hope that by bringing attention to the challenges that have "shaped" the *latte* period cultural system, this paper will illustrate the usefulness of archaeological study and provide the reader with an appreciation for the creativity and persistence of the prehistoric occupants of the Marianas.

The Manenggon Hills Project

The data in this paper come from a multi-phased archaeological project carried out in the Manenggon Hills area of south-central Guam in the 1990s by Micronesian Archaeological Research Services (Hunter-Anderson 1994a). Presently the site of the Leo Palace Resort, the Manenggon Hills project comprised approximately one percent of Guam's land area, some 1350 acres (5.46 sq km). To date it remains the most comprehensive archaeological investigation of inland cultural behavior, spanning over a thousand years of prehistory.

In the following pages, data from the Manenggon Hills project are presented and interpreted to mean that appropriate technological and social adaptations enabled the ancestral Chamorros to succeed as farmer-fishers despite the environmental challenges presented by a major climatic oscillation, from the Medieval Warm Period (MWP, c. A.D. 800–1350) to the Little Ice Age (LIA, c. A.D. 1350–1900). Simply put, during the MWP, reliable rainfall produced favorable agricultural conditions. With the shift to LIA-associated less-reliable rainfall, agricultural productivity declined. In response, the islanders made several technical adjustments, for example, in settlement pattern, crops, and ceramics, to buffer against harvest shortfalls. They also adjusted socially. As finite island resources were increasingly contested, especially arable land and access to fishing locales, kinship affiliations became more exclusionary and defensive/offensive alliances formed and re-formed. These modifications manifest a kind of adaptive escalation, as invoked by van Valen's (1973) "Red Queen Principle": more intensive responses to obtain needed resources enable a system to persist, albeit at greater cost.

Systemic tolerances for internal and external perturbations were exceeded during the late 17th Century, when severe disruptions to subsistence and settlement patterns were sustained over the thirty-year-long wars of resistance to the Spanish, ultimately resulting in pacification by the early 18th Century. Adding to the misery of war, LIA climate was also at its worst in the 16th–18th Centuries, when northern hemisphere temperatures dropped substantially and stayed down. In the Marianas this translated into more and severe droughts, taxing the ability of the agricultural system to produce adequately and probably fostering a settlement shift toward aggregation in coastal and inland areas. As will be suggested later, this process may be reflected in the 17th Century truncation of the archaeological record at Manenggon Hills, a less optimal setting for human support than nearby areas to which its occupants repaired as the LIA deepened.

The paper is organized as follows. First, geographical features that presented on-going challenges to prehistoric human life in the Marianas are summarized, followed by a brief description of pre-colonial Chamorro history and customs and archaeological observations on the formative centuries of ancestral Chamorro culture, called the *latte* period by archaeologists. Key findings from the Manenggon Hills archaeological project in southern Guam are then reviewed, interpreted as cultural responses to changes in climate with the onset of the LIA. These responses, which are modifications of earlier practices, are argued to reflect a process of adaptive escalation that encompassed the entire archipelago well prior to Spanish entry. The paper concludes with some suggestions for tests of the adaptive escalation model.

Marianas Geography

Situated in the northwestern Pacific between 13 and 21 degrees North Latitude, the Mariana Archipelago comprises a chain of 16 volcanic peaks spanning a distance of c. 2500 km. There are numerous submerged sea mounts and shoals formed by older reefs in the region as well (Figure 1).

The Mariana Archipelago is the product of the slow-motion clash of the Pacific and Philippine tectonic plates that continues to elevate the eastern edge of the Philippine plate, producing raised island arcs that have progressed westward over time (Dickinson 2000;Tracey et al. 1964). Arc-like formations of volcanoes,

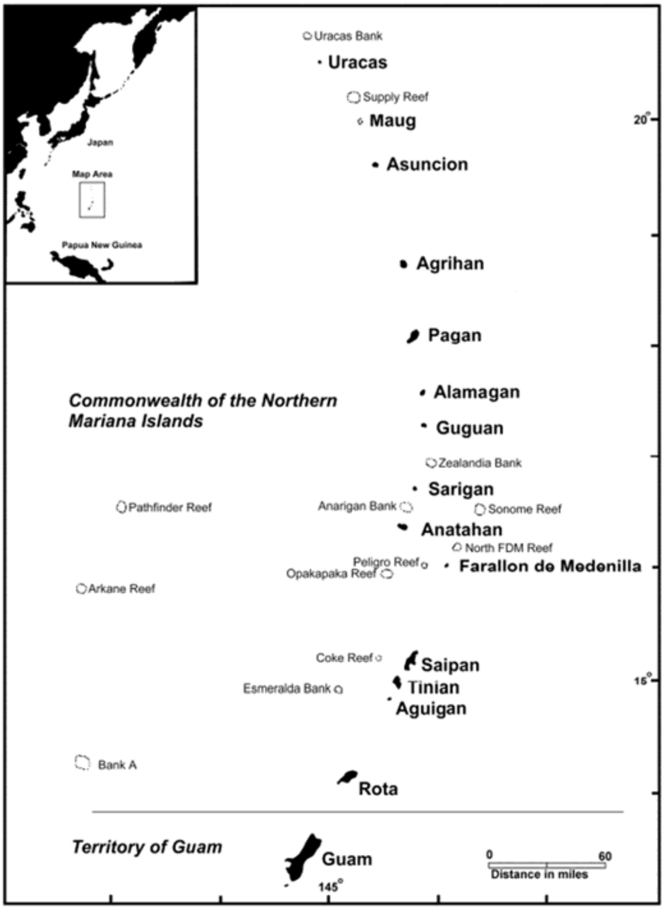

Figure 1. The Mariana Archipelago in the western Pacific Ocean (after Starmer 2009). Note the submerged sea mounts and shoals to the west.

some extinct, others still active, testify to this process. At the southern end of the archipelago, an older arc of five islands terminates at Guam, the largest, at 212 sq mi (549 sq km). Saipan and Tinian are about half the size of Guam, Rota even smaller, and tiny Aguiguan, near Tinian, is a steep-sided, elevated flat-topped limestone rock. Ancient limestone overlies major portions of each of these volcanic islands.

In the prehistoric past, as well as today, people have preferred living in the southern Marianas. Their larger size and older geology have endowed them with higher habitat diversity than the islands of the northern arc, and another advantage is that annual rainfall increases southward, favoring the southern islands for agriculture. Still, it is likely that the northern arc islands and submerged sea mounts and shoals in the region were always incorporated into the archipelago's prehistoric cultural systems, for the abundant pelagic fish that they attract. Below is a brief review of built-in environmental challenges to human life in the Marianas, keeping in mind how these would have affected people completely dependent upon local natural resources and non-commercial, non-fossil fuel-based technology: remoteness from large land masses, arid and seasonal climate, typhoons, smaller island size, narrow and discontinuous coral reefs, earthquakes, volcanic eruptions, and sea level fluctuations. Within this nexus of features, Guam enjoys several advantages over its neighbors.

Arid and Seasonal Climate

A drought is a deficit in rainfall, whether on a seasonal basis or over longer periods. In the southern Marianas, the dry season is from about December to June and the rainy season begins around July and continues through November. Rainfall is highly variable in the transitional months of November and June. On average, Guam and Rota receive comparable amounts of annual rainfall (c. 100 in, 2540 mm), while Tinian and Saipan receive about 10 in (254 mm) less; islands farther north in the archipelago are progressively drier. Climatologist Mark Lander (1994:i) has commented on Guam's relatively arid climate:

> Despite the relatively high annual rainfall amounts, Guam suffers deleterious effects of drought almost every dry season: dessication [sic] of grasslands, desiccation and defoliation of some species of trees, significant reduction of stream flow, and significant reduction of the water level in many of Guam's wells. Wildfires burn thousands of acres during many dry seasons. Every three or four years, the dry season is especially dry and prolonged. Wildfires and stress to local crops are thereby aggravated and prolonged...

Severe droughts in the Marianas are associated with the El Niño/Southern Oscillation (ENSO) weather system, which occurs every 4–7 years. "Exceptional dryness during the dry season and a prolongation of dryness into the early part of the rainy season are an effect that ENSO episodes have upon Guam and all of Micronesia" (Lander 1994:i). Figure 2 shows the close association between El Niño droughts and number and extent of wildfires on Guam.

Ancestral Chamorro cultural adaptations to marked seasonality in rainfall likely included growing a wide variety of crops with storable fruits, as well as nuts, tubers, rice, and sometimes collecting wild foods (e.g., Indian mulberry fruits and Federico palm nuts). Year-round-yielding plants such as coconut and

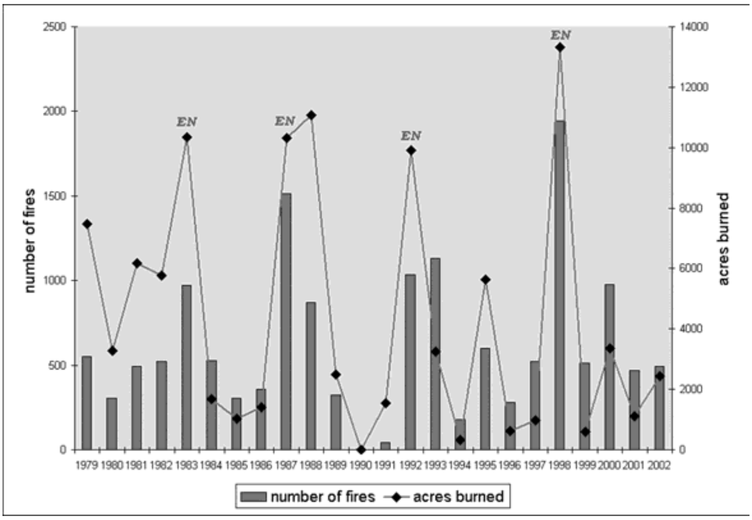

Figure 2. Graph of Guam wildfires and acres burned, El Niño (EN) events. Note the low values for 1990-1991; a typhoon occurred in January 1990, dampening fires for the year, followed by a “normal” rainfall year in 1991 (Lander 1994:Table 1). Fire data from Neill and Rea (2004:Table 3), El Niño frequencies from Oceanic Niño Index, Golden Gate Weather Service, San Francisco.

giant swamp taro would have helped fill in seasonal gaps in crop production. For additional calories, aggregating fish and large-bodied pelagic fish could be stored by drying or pickling.

Typhoons

In Micronesia, tropical cyclones (typhoons in the western Pacific) account for c. 30% of the world’s total, the highest of any region (Abbott 1996) (Figure 3).

The Mariana Archipelago lies within a geographic zone that, on average, receives between three and four of these storms every year (Figure 4).

Typhoon winds can be extremely destructive, although the extra rainfall helps to make up for annual deficits. Typhoons form most often during the wet season but can arise any time of year, and some of the deadliest storms in recent times have occurred in the dry season. There is recent evidence that typhoon intensity is correlated with ENSO episodes (Camargo and Sobel 2005); according to Lander (2004), Guam’s typhoon risk is one year in three for El Niño years and about one in ten for non-El Niño years. Salt-laden typhoon winds disrupt plant reproduction cycles, particularly tree crops, and they destroy all but the most

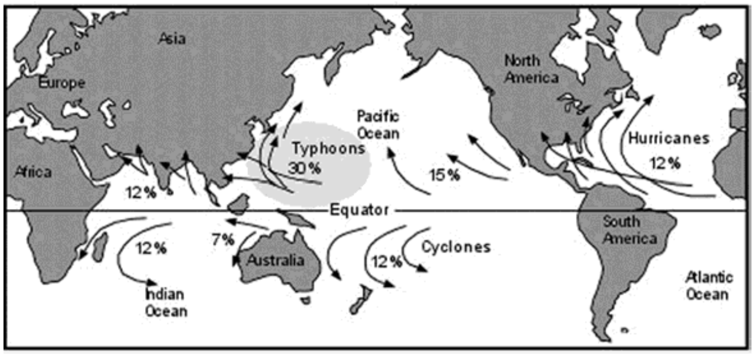

Figure 3. Micronesia in the northwestern tropical Pacific on average experiences more tropical cyclones than any other part of the world. After Abbott (1996).

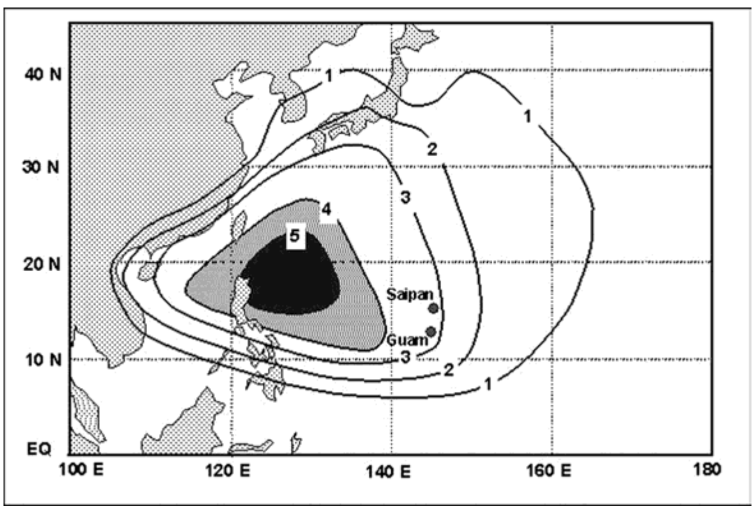

Figure 4. Typhoon frequency in the northwestern Pacific; the Marianas lie in zone 3. After Lander (2004).

well-constructed buildings. Flooding and erosion are other results, the extent and precise location of the damage depending upon the strength and direction of the winds and storm surge. Islands at the periphery of the circulation may receive rain but little wind damage. Sometimes only one island or part of an island may be severely affected by a given storm as it passes through the archipelago. The pace of ecosystem recovery from typhoon damage in part depends upon island size (see below), as well as precipitation patterns, advantaging the southern islands on both counts.

While modern measures against typhoons include technologically sophisticated early warning systems and concrete construction, prehistoric adaptations likely included taking refuge in caves and high ground during storms and spatially dispersed crop planting patterns to minimize total losses. Other measures probably included maintaining wide networks of social relationships within and between neighboring islands that enabled people from badly damaged areas temporarily to join relatives in unaffected parts of the island(s) where new planting stock could be obtained. Storing foods in large pots, subterranean pits, and caches in rock shelters would also have buffered against local typhoon damage to crops.

Other Environmental Challenges

Remoteness, relatively small land masses, narrow and non-continuous fringing reefs, earthquakes, volcanic eruptions, and sea level fluctuations have been additional environmental challenges for human occupation of the Marianas. A major problem with remoteness is that if re-supplies are needed, they can be obtained only at great cost, or for all practical purposes, not at all. The nearest large land masses (the Philippines and Papua New Guinea) are about 1600 mi west and south, respectively. Ocean-going canoes of the designs known from the Marianas (Haddon and Hornell 1975:412–421) could carry relatively small cargoes over long distances, and, despite highly developed local navigation traditions, the tropical seas everywhere are treacherous. Given these realities, longstanding reciprocity between people living within a day's sail of each other makes adaptive sense; see Marck (1986) and Alkire (1978) for the coral islands of the central Carolines. A similar security strategy can be expected to have characterized the archipelago-wide *latte* period cultural system as well, as Rainbird (2004:106) has noted.

Larger landmasses, particularly those with varied geology and topography, exhibit greater habitat diversity and species richness than do smaller land masses (for tropical islands, see Pielou 1979:174–184). Smaller island size restricts the number and kinds of animals (including *Homo sapiens*) that can be supported without external subsidies (Pulliam 1988, 1996). Another effect of smaller island size is that native vertebrates are small and their total edible biomass low compared with marine species. In the Marianas, the only native mammals were forest-dwelling fruit bats; Guam had two species, a larger and a smaller one in the genus *Pteropus* (Wiles 1987; and see the internet resource http://www.fws.gov/pacificislands/fauna/marianabat.html). Native land birds are also small and individuals rarely congregate, reflecting the spatially dispersed sources of food and shelter. Not surprisingly, bats and birds did not comprise a significant dietary element in the Pacific during prehistoric times although archaeological records indicate both sea and land birds were occasionally taken (Steadman 2006).

Many kinds of sea life are supported by the reefs, bays, and estuaries of the Mariana Islands, including numerous species of reef fish, shell fish and other invertebrates, and edible algae. Large pelagic fish occur in the surrounding seas; some are seasonal migrants, others reside near submerged sea mounts and shoals (for a recent assessment see Starmer 2009). In prehistoric times, pelagic species were accessible from ocean-going canoes, but inshore resources in the southern islands were more easily taken by nets, spears, and group surrounds (see Amesbury and Hunter-Anderson 2008). The reefs are more developed in the southern islands than in the north but are still narrow and patchy, and rare sheltered waters tend to occur on the lee sides, away from the prevailing winds that make seas rough for more than half the year.

Despite the apparent abundance of marine resources, sole reliance upon them for human subsistence is unrealistic. At best they can supply animal protein and supplemental calories. Geographer Tim Bayliss-Smith (1975:13) calculated that to support a community of 30 persons dependent only on inshore marine resources would require a minimum of 17.2 km of reefs and reef flats c. 200 m wide. The perimeters of Guam, Rota, Tinian, Saipan total c. 296 km (Bryan 1971; Karolle 1993). Using Bayliss-Smith's 17.2 km for 30 people, these islands could have supported about 516 people as "strandlopers." Given these facts, even the earliest, non-agricultural visitors to the Marianas probably utilized local plant resources and fished from distant shoals as well as inshore. Since several thousand residents lived in the Marianas at European contact (Underwood 1973), the main components of the late prehistoric subsistence system would have been agricultural, with marine resources supplementing for protein and even for calories at times when land-based foods were in short supply.

Because of nearness to a major tectonic plate subduction zone, the Mariana Islands experience frequent earthquakes. While most are mild, some are quite severe. In very strong events, such as the 1993 (Mw 8.1) quake, a major fresh water spring cave mouth opening at Janum on Guam's northeast coast collapsed, preventing access. Many underwater karst features also shifted and broke (Mylroie et al. 2001). Prehistoric cultural adaptations to very strong earthquakes were probably similar to those for typhoons, such as maintaining geographically wide kinship networks for temporary refuge, storing foods and expanding diet breadth to include wild resources. Also, local vigilance regarding the status of fresh water sources was probably automatic after large temblors.

Less frequent are volcanic eruptions in the north, and highly acidic vog rarely drifts south due to prevailing winds. However, proximity to volcanic sources of vog adds to the reasons to avoid the northern islands for permanent settlement, although in the past, as now, people probably visited for short periods. Unlike other volcanically active areas such as the Philippines, where nitrogen-enriched soils are continuously utilized despite eruption-associated dangers, the steep and rocky northern Marianas generally lack soils appropriate for agriculture. In addition to fishing grounds, they could have served as temporary refuges after major storms in the south and from inter-group conflicts late in prehistory.

Globally and in the Pacific, sea level has been far from constant during the Holocene epoch (the last ten thousand years) -- on millennial, century, and shorter time scales. As post-Pleistocene Earth warmed, glacial melt-water pulsed into the ocean basins (Gornitz 2009; see also internet resource http://www.giss.nasa.gov/research/briefs/gornitz_09/). About 7500 years ago, the last pulse is recorded globally, eventually resulting in a rise in sea level in the southern Marianas of nearly six feet (c. two meters) higher than today (Dickinson 2000, 2001). The mid-Holocene highstand peaked between 4750 and 2750 years ago (Dickinson 2000:739), after which began the local post-mid-Holocene sea level draw-down that radically altered Marianas shorelines, enlarged strand areas, and affected fresh water hydrology. Saltwater lagoons contracted into shallow estuaries or were cut off entirely, and sand beaches appeared or expanded, a process that appears to have accelerated around 2000 years ago (Dickinson 2000:207).

With these major environmental changes, island flora and fauna changed too, creating opportunities for some species, difficulties for others. By c. 3500–3700 years ago, previously submerged coastal portions of Guam, Rota, Saipan and Tinian had become marginally habitable, and the first visitors from Island Southeast Asia arrived. These early arrivals appear to have been transient rather than permanent residents, since the archaeological assemblages they left behind contain no agricultural implements and mostly thin-walled, fragile ceramics apparently unsuitable for prolonged heating associated with cooking. The cultural deposits from this time are referred to as "early pre-*latte*" or "early *unai*" period (1500–1000 B.C.) (Hunter-Anderson and Moore 2001; Moore 1983, 2002; Spoehr 1957).

Sea-level decline of some 40 cm by about 2000 years ago, during the "transitional" or "middle *unai*" period, resulted in wider beaches. This was followed by longer-lasting stays by people with a differently oriented culture, attested to by coastal sites of this age that contain the earliest human interments known in the Marianas (DeFant and Eakin 2009). Preliminary analysis of these skeletal remains, as well as their unique grave goods of exotic materials, suggest a different population from that of the subsequent *latte* period, implying that more than one prehistoric migration has occurred in the Marianas within the last 2500 years.

Throughout the Pacific Basin, a sea-level decline of unknown amount c. 600 years ago occurred at the transition from the MWP to the LIA c. A.D. 1300–1350 (Nunn 2007; Nunn et al. 2007). No direct study of this decline's effects on Marianas environments has been conducted but if related to the onset of the LIA, a sea-level decline of this magnitude seemingly would have required some adjustments, particularly in land use practices. While not the subject of this paper, these may relate to technological and social shifts documented at Manenggon Hills. At shorter time scales, sea level fluctuates seasonally and during ENSO episodes by more 1.5 ft (0.46 m) (Lander 2004). During typhoons, locally sea level changes rapidly due to storm surges, as well as during strong temblors. Cultural accommodations to these changes would have included maintaining a diverse fishing technology attuned to sea-level variations and flexible land use practices through various combinations of residential and logistical mobility (Binford 1980) over short and long time periods.

Marianas Climate during the Last Millennium: The MWP-LIA Oscillation

In addition to local environmental fluctuations, regional climate changes have occurred during prehistoric human occupancy of the Marianas. The most pronounced of these is the century-scale oscillation between warmer, wetter climate and cooler, drier climate, namely, from the Medieval Warm Period to the Little Ice Age. This global phenomenon included the Pacific Basin (e.g., see Bradley et al. 2003; Nunn 2007), with a variety of local consequences. Figure 5 shows global century-scale temperature changes using 18 different proxies from north and south hemispheres (Loehle 2007; and see Loehle and McCulloch 2008).

According to these data, the MWP was significantly warmer than the bi-millennial average during most of the period A.D. 820–1040, and the Little Ice Age was significantly cooler than the average during most of A.D. 1440–1740). Paleoclimate in the Marianas has not been studied directly, but paleoclimatic proxy data for the western Pacific region can be consulted. In eastern China the climate was warmest between A.D. 1100-1200, peaking at c. 0.3-0.6 degrees C higher than today (Nunn 2007:66, citing Ge et al. 2003) and southern Japan temperatures were c. 1 degree C higher than today between A.D. 800 and 1200 (Nunn 2007:67, citing Kitigawa and Matsumoto 1995). While aridity in China and Japan is also noted for the MWP, a different situation may have prevailed more to the south, including the Marianas. Nunn (2007:68) has inferred that c. A.D. 900–1100, high rainfall characterized climates in New Guinea, Indonesia, and the Philippines. Since Marianas climate now resembles that of the northern Philippines, this could mean that MWP climate was also wetter in the Marianas at this time. The higher rainfall in these areas may have derived from an extended La Niña-like state in the Pacific Basin during the MWP (Mann et al. 2005, cited in Allen 2006). Additional paleoclimate information on rainfall is available from a stalagmite in southern China (Wang et al. 2005). This study indicates century-scale weakenings of the Asian monsoon has occurred over the last three thousand years, with a major dry episode that corresponds to the LIA.

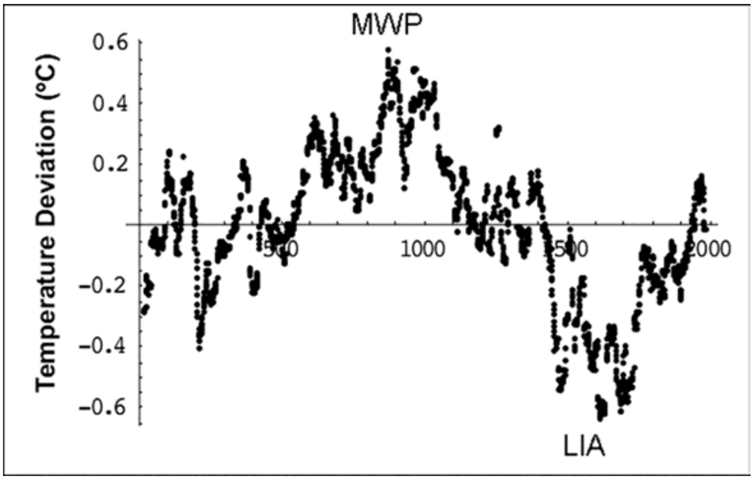

Figure 5. Global temperature variations over the last two millennia. Based on 18 proxies; temperatures were higher during the MWP and lower during the LIA; note the transition at c. A.D. 1350. After Loehle and McCulloch (2008).

The transition to the LIA c. A.D. 1350 was turbulent in many Pacific locales, including lowered sea levels, increased storminess, and cooler sea surface and land temperatures. Some of the most dramatic changes occurred in the central and eastern Pacific (Nunn et al. 2007). In the Marianas, the transition may have had less dramatic landscape effects, although this issue has not been addressed by local investigators. However, analyses of marine shell assemblages from archaeological sites on Guam's west coast, as well as time-progressive seaward placement of prehistoric sites beginning c. A.D. 1027-1293 and continuing through late prehistory (Amesbury 1999, 2007:Table 3) suggest that people were responding to enlarged strand areas as sea level declined.

During the LIA, Pacific climates were cooler, sea levels lower, and the ENSO weather system more active than it had been during the MWP, as studies on both sides of the Pacific including western Micronesia indicate (Anderson 1992; Camargo and Sobel 2005; Langton et al. 2008). In the western Pacific, rainfall amounts and frequencies were more variable (see discussion in Nunn 2007). Presently the Marianas are located in an area with some of the most extreme deviation from average rainfall occurs during moderate to strong El Niño warm phases (Figure 6).

Possibly this pattern held during the LIA but with even more extreme temperature deviations. The Marianas' drought-prone location within the western Pacific, combined with indications that ENSO events were more common and more severe during the LIA, makes it likely that crop harvests in the Marianas were less abundant and less reliable than during the MWP. The LIA may also

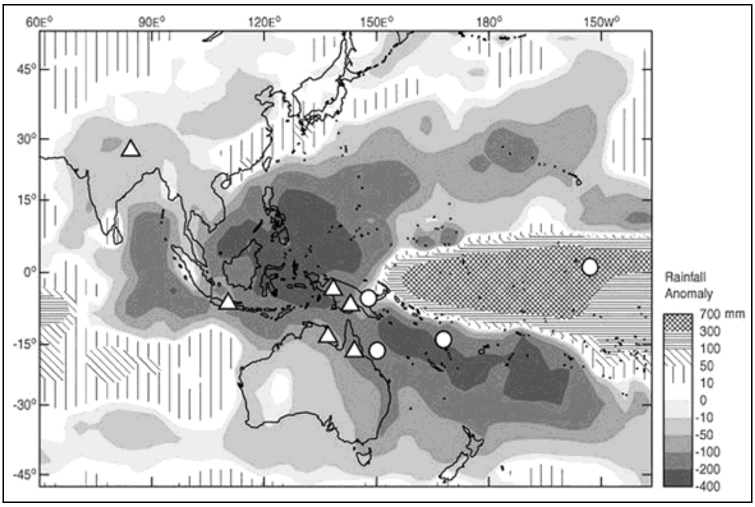

Figure 6. Pattern of annual precipitation anomalies (mm) associated with moderate-strong El Niño events from 1900 to 1998. The Marianas lie within the minus 100-200 mm range. The data are derived from historical rain-gauge records (1900–98) and satellite estimates of oceanic precipitation (1979─98). Locations of sites with paleo-ENSO records are shown by triangles (terrestrial records) and circles (coral records); note the lack of paleoclimate proxies in Micronesia. After Gagan et al. (2004).

have brought more large typhoons to the islands along with more droughts (Camargo and Sobel 2005). Chinese historical records indicate there were more typhoon landfalls recorded in coastal Guangdong, southern China during this period (Liu et al. 2001) (Fig. 7).

Considering the origins and typical pathways of typhoons in the western Pacific, the Guangdong data seem to imply the possibility of more typhoons in the Marianas during the LIA. Higher typhoon incidence, or stronger storms, would have compounded the problems of drought and soil aridity by increasing soil erosion and loss of crops as well as displacements of some settlements, if temporarily.

Pre-Colonial History and Customs

The c. 3000-year-long prehistoric era in the Marianas ended with Ferdinand Magellan's brief and violent encounter with the Chamorros in 1521, followed shortly by Legazpi's claiming of the Marianas for Spain in 1565 and formal colonization in 1668. By 1700, the bloody Spanish conquest was essentially complete; the Islanders had resisted with stealth, spears and sling stones for thirty ears, but guerilla tactics and inferior weapons ultimately proved no match for the

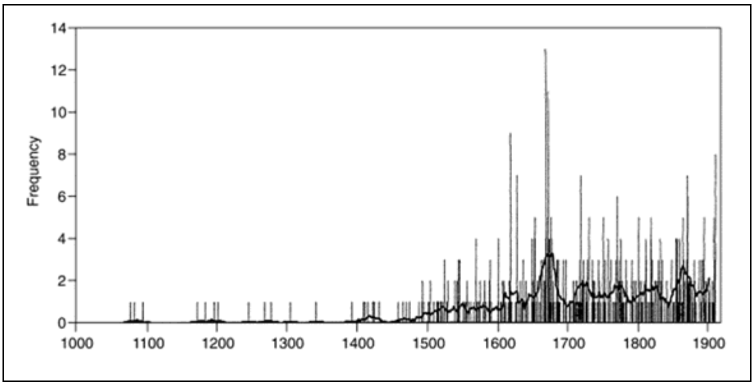

Figure 7. Year-by-year plot of typhoon strikes in Guangdong, southern coast of China during A.D. 1000-1900, based on historical records. The continuous black line shows the twenty-one-year moving averages smoothed from the annual time series. After (Liu et al. 2001).

Spanish military and a determined band of Jesuit missionaries (for details see Carano and Sanchez 1964; Hezel 1989; Lévesque 1992; Rogers 1995). During the government's *reducción* program, some three thousand survivors were settled into a few parish villages on Guam and Rota. The newly converted were obliged to perform daily religious obligations, which included supplying the priests with food and domestic services. The Spanish systematically destroyed the native sailing canoes to prevent escapes, and without access to their customary fishing grounds, the Chamorros ceased ocean fishing, nor were they able to freely visit other islands. Chamorro pelagic fishing history has been reviewed by Amesbury and Hunter-Anderson (2008) and recently summarized by Amesbury (2009). Animal husbandry of introduced livestock diverted subsistence efforts away from fishing as food preferences changed under Spanish domination and control over land and sea.

Over the years the Hispanicized and deeply religious Chamorros learned to fear their abandoned sites, grew foreign crops such as corn and tobacco, changed house-building styles, and adopted Spanish vocabulary while retaining their language's grammar and sound system (Topping 1973). Customs from this historic "*antigo*" period are viewed now as integral to Chamorro culture, less alien that of the prehistoric past.

No ethnographer was present to record the late prehistoric Chamorro cultural system but early European travelers' accounts indicate that late 16th and early 17th Century Chamorro society contrasted greatly with that of the 19th Century. For example, it was minimally stratified, with higher ranked people living on the coasts and lower ranked people in the "jungles and hills" (Driver 1983:213), and while some areas were more densely occupied, especially along

Guam's west-central coast, settlements were relatively dispersed. Regional feasts involving food displays, dancing, and competitive games of skill were held, and inter-group feuding was endemic. Suspicions of potentially hostile encounters kept casual travel to a minimum (see accounts in Lévesque (1992). The early reports and later memory culture records (Freycinet 1829; Cunningham 1992) indicate a form of matrilineality was practiced that included flexible land allocation prerogatives. The aboriginal diet included roots and tubers, tree crops, fish and shellfish. Paddling canoes were used inshore and swift outriggers plied the open sea for fishing and inter-island travel (Driver 1983; Cunningham 1992; Lévesque 1992).

While historic records sketchily portray the late prehistoric ancestral Chamorro cultural system, the processes that shaped its evolutionary trajectory throughout three thousand years of prehistory can be better explored through archaeological and related studies.

Archaeology as Anthropology

For clues to earlier cultural system states, the archaeological record can be "decoded" using ecological principles and ethnographic knowledge (Binford 2001). The goal is to build realistic models of the cultural adaptive processes and to test these models against a variety of independent data. This kind of archaeology has been called processual (Johnson 2004), in contrast to older approaches that stress the expression of ideas embodied in artifacts and features (e.g., pottery forms, burial practices, ornaments), which are taken as signifiers of ethnic origins. Processual archaeology seeks to both describe and explain cultural similarities and differences in all the materials left by a cultural system, not just in its presumed ethnic markers.

Archaeological pattern recognition studies that illuminate changing cultural adaptations help archaeologists discover the dynamic organization of past cultural systems. The Marianas archaeological record manifests a major shift from what Kurashina (1986) has termed a "narrow-spectrum economy" in which human activities were restricted to the shoreline ecotone (a zone of overlapping plant and animal species from two adjacent ecosystems), to a "wide-spectrum economy" that incorporated additional terrestrial resources from inland riverine ecotones, effectively expanding the geographical scope of the local cultural system from the sea to the interior in the larger islands. This pattern reflects the change from the pre-*latte* to the *latte* periods first recognized by Spoehr (1957). Kurashina proposed that "population pressure" motivated the adoption of a wide-spectrum economy during the *latte* period but as will be shown later, this factor alone fails to account for possibly climate-linked cultural adjustments during late prehistoric times.

The *Latte* Period

Despite having the oldest archaeological record in Remote Oceania, beginning c. 3500 years ago (Amesbury et al. 1996; Butler 1994; Carson 2008; Spoehr 1957), the Marianas were not permanently occupied until about two thousand years ago. The first human burials date to this time (DeFant and Eakin 2009), and artifact assemblages after this time contain a greater variety of artifacts than seen in the earlier assemblages (e.g., Hunter-Anderson 2005; Reinman 1977). Many of these are related to land-based activities, likely including agriculture, as well as to inshore and offshore fishing. By the first millennium A.D., intrinsic population increase and/or continuing in-migration resulted in more and different kinds of archaeological sites. By c. A.D. 800 at the earliest and more likely by c. A.D. 1000 (see Spoehr 1957:85; Graves 1986:141), *latte* architecture had been adopted, along with several kinds of volcanic stone tools (adzes, pounders, abraders) related to agriculture and sturdier ceramics reflecting a subsistence focus upon boiled tubers as Butler (1990) has argued. Longer cooking times in stronger pots also could relate to the practice of reconstituting dried foods such as rice, breadfruit and fish. Late in the period, very large ceramic vessels for storing food and water were added to the ceramic inventory (Moore 2002). For a recent summary of *latte* period features, see Rainbird (2004:101–133)

The "Meanings" of *Latte*

No eye-witness drawings of functioning *latte* house foundations have been found, but early written accounts, beginning with Legazpi's in 1565, indicate that stone pillars supported wood dwellings with thatched roofs. At some coastal sites very large *latte*-supported structures sheltered canoes and others were dormitories for youth (for details see Cunningham 2005). While stonework is common among many Micronesian groups (Hunter-Anderson 1997), the distinctive form of stone posts with capstones are unique to the Marianas.

An intact *latte* feature or set (many now are incomplete or disturbed) consists of two parallel rows of tapered stone pillars topped by hemispherical capstones enclosing a rectangular space. Large stone mortars, thought to have been used to husk rice, are often found in or near *latte* sets. In the 1920s, archaeological interest in the Marianas resulted in fieldwork by Hans Hornbostel (n.d.), who excavated several prehistoric sites and mapped the distribution of *latte* ruins on Guam and Rota. Later surveys have located *latte* in nearly every island habitat, from ridge tops to valley terraces to wetland margins to back-beaches, most with close access to fresh water (Hunter-Anderson 2005). Later in the *latte* period, *latte* were erected in the far northern part of the archipelago; Egami and Saito (1973:213) dated the Regusa *latte* at c. A.D. 1325 (see also Takayama 1982).

The use of stone pillars and capstones in Latte Period architecture went beyond the simple need to support a house; after all, dwellings had been built in the Marianas without stone posts for many centuries before the pillar and capstone style came into use, and wood post structures continued to be built during the *latte* period (Hunter-Anderson 1994a, 2007; Peterson and Carson 2009). The adaptive significance of *latte*, notwithstanding their structural support function, is that they served as long-lasting markers of resource claims when the builders and users could not be continuously present. In this anthropological interpretation, *latte* architecture was a useful symbolic idiom that conveyed important information, critical for regulating inter-group competition for land and other resources. That *latte* architecture never went "out of fashion" but continued to be used into early historic times, when some of the largest stones were hewn on Tinian and Rota (Morgan 1988:134–140), suggests a process of competitive "inflation" (see below) aided by iron tools. Modern technology played a similar facilitating role in 19th century Yap where ever-larger "stone money" discs (with, however, lower value than older smaller discs obtained the hard way) were hewn with iron tools and transported by ship rather than canoe and raft (see Fitzpatrick 2002; Gilliland 1975).

Specific adaptive contexts in which *latte* and other *latte* period practices were modified and invented can be explored by considering detailed archaeological findings from the Manenggon Hills project in south-central Guam. These data indicate a complex relationship between local geography, large-scale climatic processes, and human ingenuity in solving problems.

The Manenggon Hills Archaeological Project

The Manenggon Hills project area is located about one mile (2.5 km) inland from the east coast of Guam (Figure 8).

Forty-nine of the 84 prehistoric sites found yielded datable charcoal. Sixty-one prehistoric occupations at these sites ranged from the 5th through 17th Centuries (Figure 9).

These data show that while people were present before the start of the *latte* period, there was an apparent occupational hiatus until A.D. 800. Until the 1100s the area saw very light usage of the area, after which the number of occupations per century increased exponentially over three centuries and then declined radically in the 1500s to nearly the same number before the jump in the 1400s. Could this pattern simply represent a rapid rise and fall in regional population, or something else?

An analysis of the kinds of sites utilized provides some clues. For a first-order pattern recognition study of land use over time, the sites were classified into three types, Storage/Camp, Habitation, and Rockshelter. Habitation and Storage/Camp sites included open localities (as opposed to Rockshelters, where

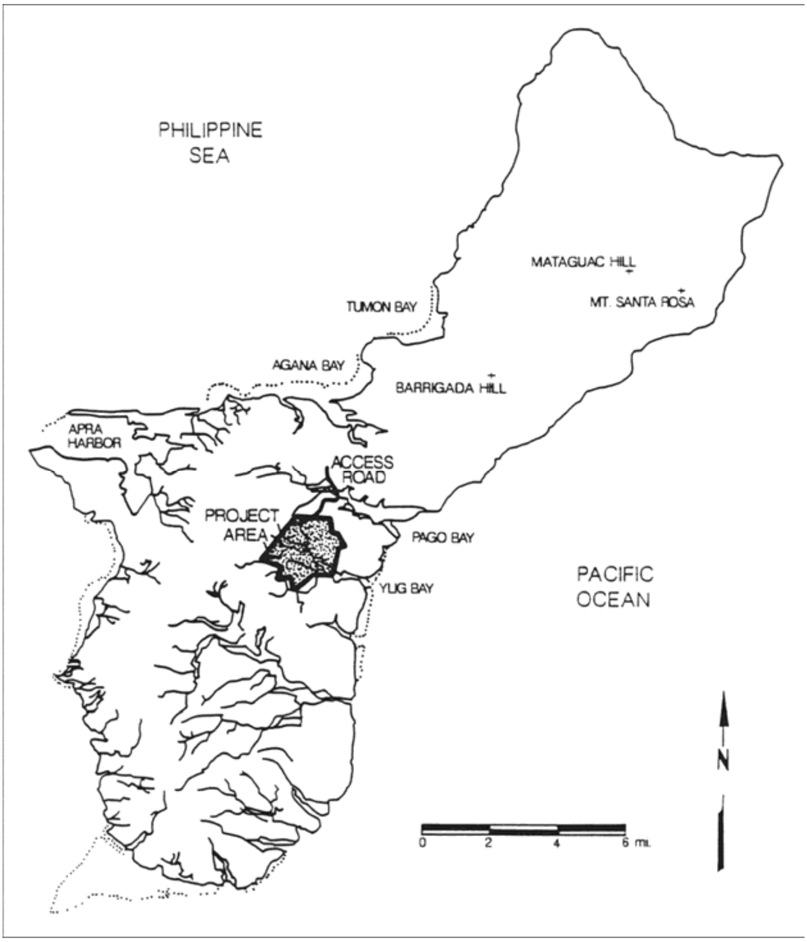

Figure 8. The Manenggon Hills project area (stippled) in the upper Ylig River drainage comprises 1% of Guam's land area.

living space was severely limited). Open sites with aboveground features, such as *latte* sets, embedded stone mortars, and/or substantial hearths were termed Habitations. The underlying logic was that since people had taken the trouble to install "site furniture" (a term coined by Binford [1979] to denote key features that orient site traffic flows), they stayed longer and performed a greater variety of activities at them than they did at sites without such furniture. Also, the labor investment represented by permanent features suggests repetitive use of these sites, making these investments worthwhile.

Storage/Camp sites were defined by the presence of one or more subterranean pits and no aboveground features. The storage function of some of

Figure 9. Number of sites occupied per century in the Manenggon Hills project area; some sites were occupied during more than one century. Note the up-tick in the 1400s.

the pits was inferred from their round-bottom shape and lack of charcoal within the pit fill. Other kinds of pits were shallower and their fill contained abundant charcoal; these were interpreted as earth-ovens where food was prepared for relatively large groups. It is possible that the smallest pits were agricultural planting pits, for example pits at the site dated to the A.D. 400s, the earliest site found in the project area (Moore 2005).

A Rockshelter designation was given to sites with cultural deposits that had accumulated under large limestone boulders. From their limited artifact assemblages, these small sites may have afforded temporary refuge from the weather and/or for caching equipment such as gardening tools, sleeping mats, and water jugs, and thus provided logistical support for longer stays in the immediate area.

Table 1 shows the site counts (in parentheses) and percentages of sites by type during the A.D. 900s-1600s. Highlighted percentages of site types in the table show a change in proportions of Habitation vs. Storage/Camp sites from the 1200s through the 1500s. During the 1200s and 1300s, Habitation sites were well over 50% of the total whereas beginning in the 1400s and into the 1500s, Storage/Camp sites were over half of the total and Habitation sites a third or less. This reversal in proportions of dominant site types appears to be unrelated to population increase. In the bottom row of the table, bold numbers in parentheses are site totals during the 1400s (21) and 1500s (9), showing that regardless of the decline in total sites, the proportions of Habitation and Storage/Camp sites remained similar through these two centuries.

Figure 10 depicts this information graphically. Storage/Camp sites account for most of the rise in occupations during the 1400s, and this site type remained dominant in the 1500s, although total numbers of occupations declined. Finally, in the 1600s just prior to abandonment of the area, site proportions returned to a configuration like that of the 1200s–1300s. While not precise, and use of century intervals has its own problems, these data suggest a general picture of changes in land use beginning about the time of the transition to the LIA.

Explaining Changes in Dominant Kinds of Sites over Time

From the above analysis, the hypothesis of population increase over time (from whatever source: immigration and/or intrinsic increase) does not explain the changes in proportions of site types, nor the addition of Rockshelters to the land use system beginning in the 1200s, since this kind of site is not strictly residential. Also, the site occupation curve is not S-shaped as would be expected for a population that increased until carrying capacity was reached and then leveled off. The archaeological facts suggest instead changes in land use, i.e., *in the organization of activities*, especially after the 1300s, and then abandonment or very low occupancy after the 1600s.

It is reasonable to ask where people went, or if they were in the area, why their archaeological traces are so faint after the 1600s (some of the several undated lithic scatters may have been generated at this time). I suggest they mainly decamped to more favorable locales within the upper Ylig River Valley and to the south, in a process of late *latte* period aggregation for security. Hornbostel's distribution map of *latte* features shows a major aggregation just south of the project area (Figure 11). Given that the 1600s-1700s saw the most severe and sustained temperature declines in the northern hemisphere during these centuries (e.g., Goosse et al. 2008), more reliable rainfall nearby can be proposed to have prompted such moves. While these recorded *latte* distributions are likely palimpsests that obscure the sequence of occupation at particular locales, the concentration of *latte* in the upper portions of the Ylig and Talofofo valleys suggests these areas were favored late in prehistory and may have received population from the Manenggon Hills project area after 1600.

When interpreting any local data set, it is wise to consider larger contexts. For example, trends in land use inferred from Manenggon Hills data took place during a time in the Marianas which saw, among other developments, the rise and spread of *latte* architecture throughout the archipelago; the practice of caching sling stones; more durable and larger ceramic bowls and jars; and the addition of rice to the crop inventory (Hunter-Anderson et al. 1995). Not all these practices began at once; for example, the beginning of *latte* architecture and sling stone

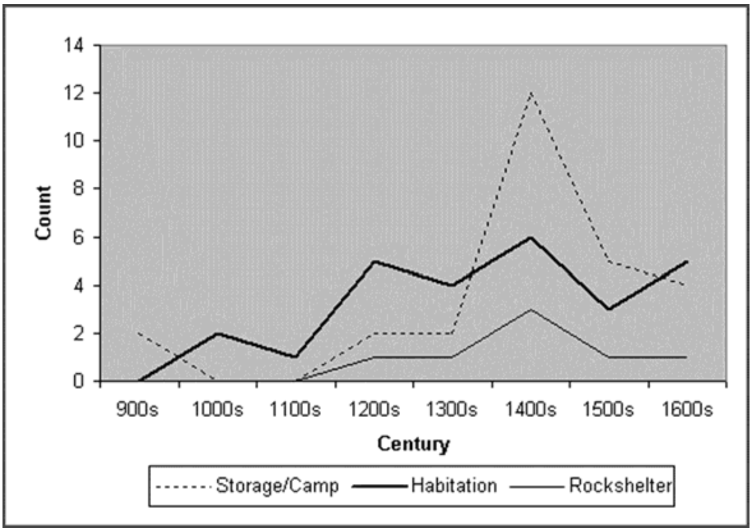

Figure 10. Graph of site frequencies by type during the *latte* period at Manenggon Hills.

Table 1. Site types occupied by century (multiple dates indicate some sites were occupied for more than one century; from Hunter-Anderson 1994a:IV:1.9─1.13).

Site Type	900s	1000s	1100s	1200s	1300s	1400s	1500s	1600s
Storage/Camp	100 (2)			25 (2)	29 (2)	57 (12)	56 (5)	40 (4)
Habitation		100 (2)	100 (1)	62 (5)	57 (4)	29 (6)	33 (3)	50 (5)
Rockshelter				13 (1)	14 (1)	14 (3)	11 (1)	10 (1)
TOTAL	100 (2)	100 (2)	100 (1)	100 (8)	100 (7)	100 (21)	100 (9)	100 (10)

caching appear before the use of large ceramic vessels and the cultivation of rice. When these data are arrayed chronologically (Figure 12), a cumulative sequence of cultural responses related to century-scale changes in climate, although general and imprecise, emerges.

A climate-based interpretation for these observations is that the MWP was a favorable time for agriculture on Guam, followed by a less-favorable time for agriculture, and that the ancestral Chamorro cultural system changed in response, building on prior knowledge and practices. For example, in the early *latte* period,

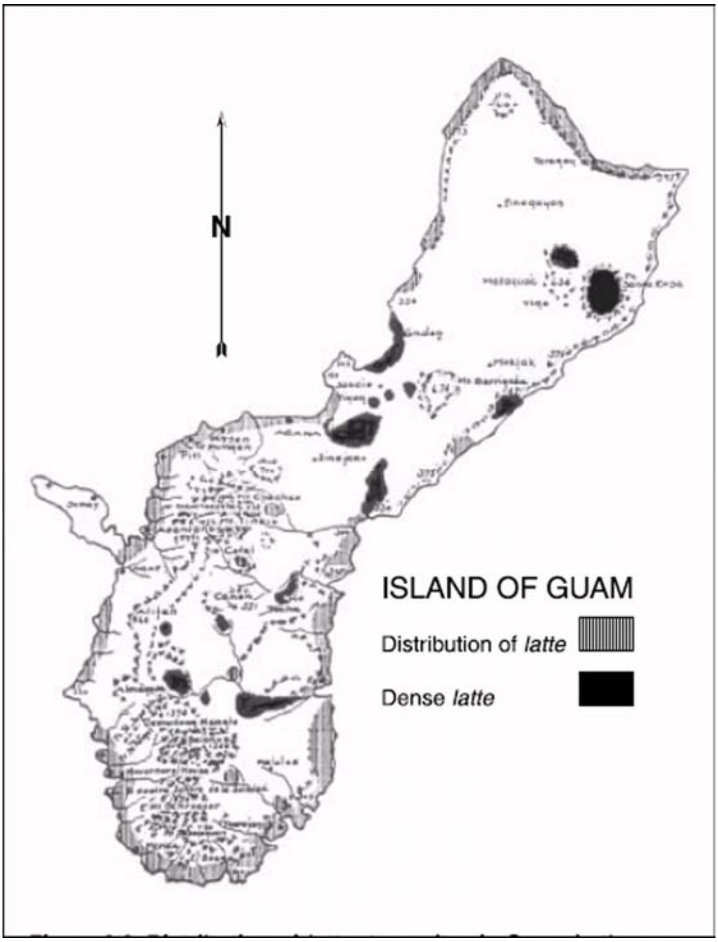

Figure 11. Hornbostel's (n.d.) sketch map of *latte* feature distributions on Guam in the 1920s. Note the dense area of latte in the upper Ylig drainage just south of the Manenggon Hills project area and an even larger such area in the upper Talofofo drainage.

which roughly coincides with the beginning of the MWP, populations in the southern Marianas expanded along the coasts and into upland areas, as noted by Kurashina (1986). Harvests were relatively reliable, and to offset temporary losses from typhoons and local demographic imbalances, cultural practices included wide kinship networks within and between the islands. This helped to spread agricultural risks and lessen social tensions by providing mobility options in times of temporary stress. Swift sea-going canoes facilitated these security measures.

During the climatic transition to the LIA, weather events became even less predictable than before. As noted above, detailed information on sea level and temperature changes is unavailable for the Marianas, but more intensive use of interior land in southern Guam may have been prompted by agricultural difficulties related to these changes. Higher elevations receive more rainfall, on average (Figure 13), an important geographic factor favoring more plantings in upland locales. While the Manenggon Hills project area was not the most favored locale in southern Guam; the upper Talofofo drainage and a large portion of southern Guam averages more annual rainfall (Lander and Guard 2003).

Domesticated rice (*Oryza sativa*) was added to the Marianas crop inventory at about this time, or at least increased significantly, reflecting a need to increase storable produce in addition to any symbolic value rice may have had (Hunter-Anderson et al. 1995). Possibly imported from the Philippines, upland rice could be grown at the edges of interior wetlands. Pollen analyses of sediments from six wetlands in the Manenggon Hills project area, one very close to a *latte* site, M221, did not reveal any rice pollen but pollen from other economically important plants coconut, *Cocos*, and breadfruit, *Artocarpus*, was present (Ward 1994:Table 9.A.2). Another type of analysis, for plant phytoliths (silica body formed in plant tissue), found a phytolith from the glume portion of *O. sativa* associated with additional phytoliths that may have come from other parts of rice plants, were observed in paleosediments cored at the edge of a perched wetland ("Lost Water Marsh") on the Naval Magazine in southern Guam (Hunter-Anderson 1994b; Umlauf 1994). The dating of the deposition of the rice glume phytolith is somewhat uncertain because the radiocarbon date of the layer in which it was found derives from bulk soil with relatively low carbon content.
However, the sample was dated to the late *latte* period-early historic period, c. 500–270 years cal BP (Hunter-Anderson 1994b:Table 3, Fig. 3). Adjacent to the marsh an archaeological site with 45 *latte* features has been documented. Four radiocarbon dates from four of the *latte* features ranged from cal. A.D. 1211–1680 at 2 sigma (DeFant pers. comm. 2010), all of them possibly occupied after cal. A.D. 1300 and two apparently by cal. A.D. 1400. This could indicate that the site was occupied relatively late in the *latte* period.

As indicated in Figure 9, the number of site occupations increased rapidly in the project area and peaked near the beginning of the LIA. The increase was not only numerical; there was a striking reversal site type proportions (see Table 1). The LIA saw a higher proportion of Storage/Camp sites with pits than Habitation sites. The shift in land use could represent additional efforts in food production and storage by drying and preserving of produce near where it was grown. In this upland locale, rainfall would have been somewhat higher and harvests somewhat better; on the other hand, more labor was involved, particularly with the cultivation of rice, and the costs of food production generally were increasing. These conditions would have required on-site vigilance to prevent thefts from

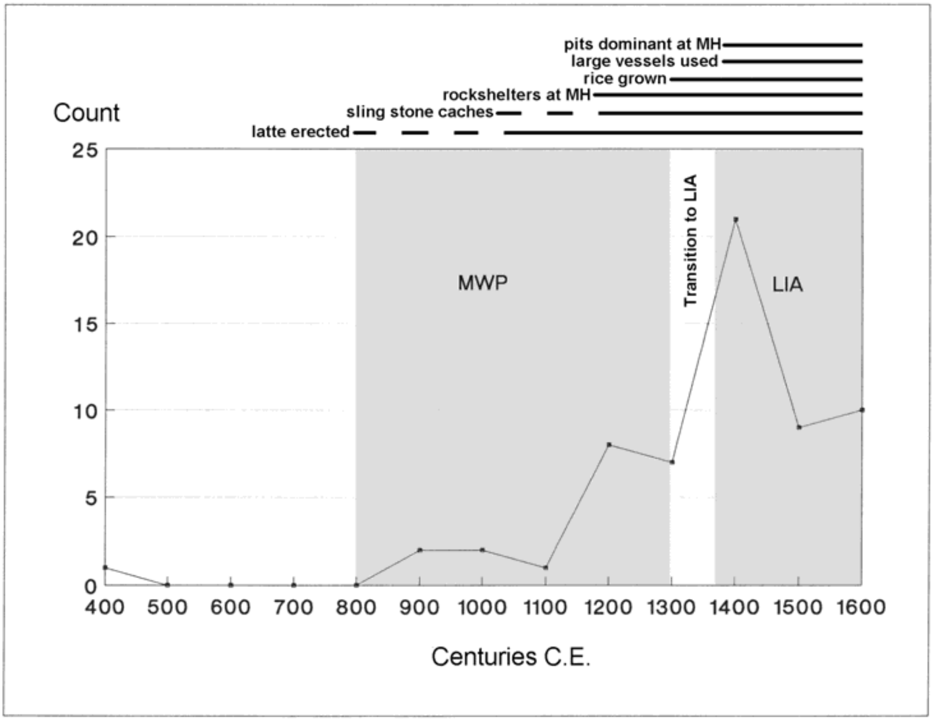

Figure 12. Manenggon Hills site occupations over time, MWP, LIA, transition to LIA and approximate onsets and temporal spans of selected cultural practices. Dashed lines indicate less certain onsets.

stores and fields. Another technological adjustment during the LIA was the addition of large ceramic vessels, likely for food and water storage; these pots were still in use during early historic times (Moore 2002).

Despite these efforts, total agricultural production in the Marianas may have declined over the LIA centuries, shortages made up for in part by more extensive use of marine resources from the far northern islands and distant shoals, as well as more intensive collection of shellfish and other reef species. Competitive tactics, including widespread use of *latte* architecture (even as far north as Pagan), as well as maintaining sling stone and spear fighting skills, would have escalated as land encroachments became a serious threat to food security. Sling stones have been found in early *latte* period sites, but caching them at potentially contested sites later in the period suggests more regular use of these weapons late in the *latte* period. Human bone spear points are known from *latte* period sites and ethnohistorically (Driver 1983; Russell 1998). One prehistoric case of their evident use in causing death has been documented, in cemetery group A2 at the

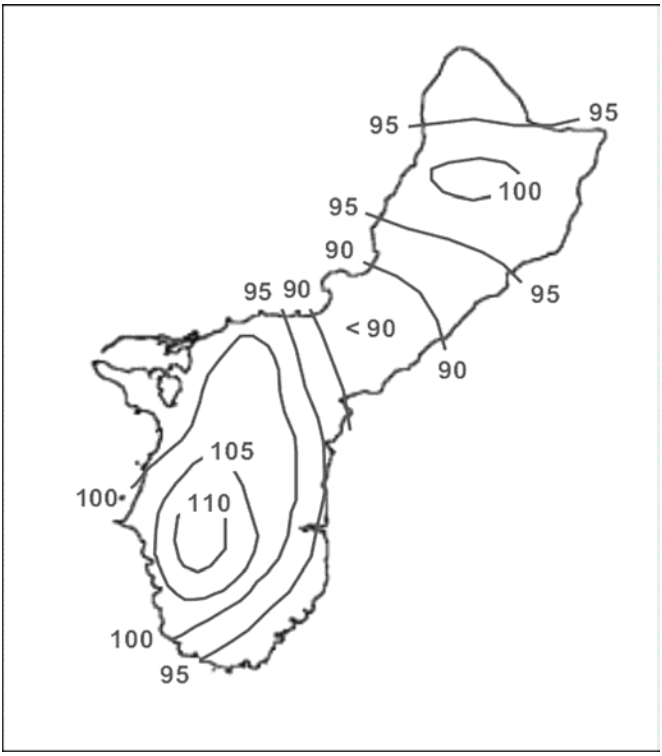

Figure 13. Mean annual rainfall in Guam (inches) based on a map prepared by the Guam Natural Resources Conservation Service in 1987. The Manenggon Hills project area lies within the 95-100 in range. After Lander and Guard (2003).

Apotguan site, Guam. Embedded in the ribs of this interment (Burial 57) were 10 spear points; the burials in this cemetery were dated within a range of A.D. 1300–1700 (McNeill 2002:176), i.e., during the LIA.

Other cultural adjustments during the LIA that are not so easily recognized in the archaeological record, but are expected to have occurred under the circumstances, include contraction of once-wide-reaching social networks and formation of unstable defensive/offensive alliances. Such alliances reflect the dynamically changing perceived strength and weakness of territorial groups, judged in part by wealth displays at regional ceremonies and the ability to construct and maintain *latte* features and perform necessary rituals associated with their use. Social network contraction serves to minimize increasingly burdensome sharing obligations and may have accompanied the emergence of the minimal social stratification that was recorded in early historic accounts and later memory culture documents. For example occupants of inland areas like

Manenggon Hills may have been re-defined as lower-ranking, distant relatives of higher ranking families, bound to one another through clan and kinship histories. Inland dwellers' agricultural labor would have been critical to the success of the larger cooperating group, and in-kind reciprocity is likely to have characterized their personal relationships, as suggested in the Pobre account of Rota.

Supporting the proposed contraction of larger inter-island social networks in the Marianas during the LIA, are the findings of Graves et al. (1990: 227), who analyzed chemical composition and vessel forms in Latte Period pottery. Their study found similarities in pottery from Guam and Rota on the one hand and in pottery from Saipan and Tinian on the other, as if residents in each island-pair limited their social interactions, including exchanges of pottery, to the nearer island. The assemblages from which the ceramic samples came were not dated precisely enough to distinguish when they were produced within the *latte* period. According to the theory favored here, these sub-regional separations occurred late in the *latte* period although it is also possible that geographic pottery differentiation began during the MWP or transition and then intensified during the LIA; clearly, more dating refinement and research into this issue is needed. Nonetheless, it seems reasonable to see the forming of large island/small island "partnerships" as a variant of a strategy by populations on smaller landmasses to minimize deficits or vulnerabilities generally by linking with larger populations on a larger land mass, thus increasing access to the resources available to participants (see Pulliam 1988, 1996; Kelman 2009).

The Red Queen Principle and Adaptive Escalation

Persistence of older practices and addition of new ones aimed at solving similar problems in the face of environmental changes in the late prehistoric Marianas appears to conform to the "Red Queen Principle" in ecology (Figure 14).

The Red Queen Principle (van Valen 1973) is based on ecological observations that competitive interactions between co-evolving species produce intensified behavior that, over time, results in the maintenance of each species but at greater cost. Consider forest trees competing for sunlight, resulting in height increases for all trees with no net increase in sunlight for any, even as they spend more resources in order to sustain their height (see Heylighen 2009). Under this analogy, the ancestral Chamorros' response to the challenges of LIA climate, especially drought, less reliable rainfall, and more damaging storms, resulting in deficient harvests, was "to run faster." One of the costs of running faster was making social adjustments, such as recognizing minimal social stratification and redefining who were close kin (i.e., those whose requests cannot be denied). This had the effect of lessening obligatory burdens but also increasing local labor demands.

In cultural evolutionary terms, a self-organized system such as that of the ancestral Chamorros, when perturbed at first responds by trying to maintain stability within existing capabilities, and if these are inadequate, by addition and re-organization of some components, enabling the system to continue in a modified but still recognizable form. This is the essence of the adaptive escalation model proposed here for a relatively simple cultural system where energy sources were entirely local and human behavioral adjustments to environmental perturbations could be made that allowed the system to persist without radical changes, albeit at greater cost in labor and materials.

Ironically, the practices that had served the Chamorros well during climate change may have increased their vulnerability to attacks by the Spanish. For example, territorial rivalries reduced the Islanders' ability to mount a decisive and effective defense against the Spanish, as former alliances shattered and failed to re-form. While the Spanish burned village food stores and residents scattered, agricultural cycles and reciprocal exchanges were disrupted, and critical labor shortages developed, as young men were involved in guerilla-style raids and retreats. It is hardly surprising that after three decades of such asymmetrical conflict, women and children were the first to seek assistance from the priests, who offered protection and food for the price of conversion to Catholicism (see Rogers 1995; Lévesque 1992).

Some Suggestions for Future Research

Testing the adaptive escalation model for the *latte* period should include a search for data that contradict the model's goodness-of-fit with available observations. It has been shown that certain archaeological changes are evident after c. A.D. 1300, i.e., during the LIA, such as extension of *latte* features into the northern parts of the Mariana archipelago, rice being a consistent component of the agricultural repertory, adoption of larger and more robust ceramic vessels, increased use of pits, caching of sling stones, occasional evidence of violent death in human burials and so on. If these and other features argued above to be signs of system stress are found regularly to occur during the early *latte* period as well, i.e., during the MWP, then the criterion of goodness-of-fit will not have been met and the model can be rejected. However, if these features and perhaps others that point to the same set of responses to LIA conditions are consistently found only after c. A.D. 1300, then the model can be retained and tested further.

Further testing would include efforts to disconfirm its main propositions and formulating hypotheses implied by them. For example the proposal that rainfall during the MWP was more reliable than during the LIA could be evaluated empirically. Independent paleoclimate proxies could be consulted, such as oxygen isotopic ratios in Marianas stalagmites, as at Dongge Cave in China by Wang et al. (2005), cited above. Such isotopic ratios can be used to track

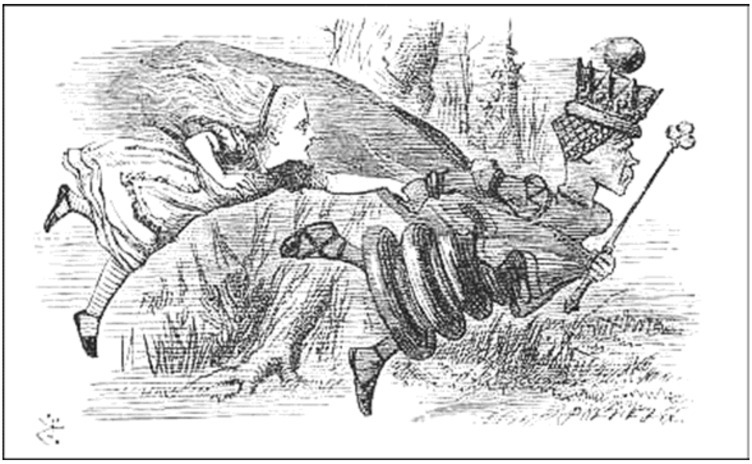

Figure 14. "A slow sort of country!" said the Queen. "Now, here, you see, it takes all the running you can, to keep in the same place."

precipitation amounts over time on an annual basis. Work on Guam's stalagmites for such information is in progress on Guam by Jenson and colleagues (Sinclair et al. 2008). Similarly, empirical evidence could be sought against the proposition that the LIA in the Marianas brought more frequent droughts as well as more frequent typhoons associated with ENSO. Recent statistics for Micronesia appear to favor the idea that typhoon frequency in the Marianas is higher during decades dominated by ENSO (Lander pers. comm. 2010), and the relationship between typhoon landfalls on the southern Chinese coast and typhoon frequency in the Marianas should be further studied, as suggested by the work of Liu et al. (2001).

Further tests could include analysis of Marianas artifactual assemblages for patterns that could relate to coastal/inland interactions throughout the *latte* period. For instance, spatial and temporal patterns of exchanges of ceramics and other artifacts between the Manenggon Hills project area and adjacent coastal areas and valleys through time are of interest; if evidence for such local exchanges increases after the LIA, this could indicate a contraction in social networks as proposed above. On a broader geographic scale, there should be no discernible differences over time in exchangeable items such as ceramics between northern and southern portions of Guam, indicating that social interactions at this scale did not significantly contract during the LIA as postulated in the model.

The suggested move to the Talofofo River Valley coinciding with abandonment of the Manenggon Hills area during the late Latte Period could be investigated through comparative artifact studies; if there is no evidence for increased usage of better watered areas of southern Guam after the 1600s, this would tend to negate the proposition that people "voted with their feet" as conditions worsened during the LIA.

Another area for future research prompted by the findings at Manenggon Hills and related to the adaptive escalation model is mortuary analysis, including comparative studies of skeletal populations from sites along the Ylig and Talofofo drainages. Such studies could investigate nutritional and health status of local populations as well as genetic differences and similarities. If the model is incorrect, deteriorating nutritional and health status of inland groups should not be evident, and there should be no clear relationships between occupants of the upper portions of these drainages and coastal groups. These are some of the many potential directions for future research into the *latte* period, which is the payoff for proposing an explanation that is capable of generating open-ended lines of investigation and inference, even if only in preliminary form, as Lakatos (1995:6) has noted.

I have offered my account of *latte* period archaeology at Manenggon Hills in this spirit, realizing that the culture history approach undertaken by many in Pacific archaeology over the last several decades has served us well by generating a great many archaeological observations. In my paper I have tried to show the utility of adopting a more explicitly scientific interpretive framework, one that brings a new viewpoint and new kinds of analyses, linked to the real-world adaptive problems of human populations living on islands in the past and presently.

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