Learning from Paleo-Landscapes

Defining the Land-Use Systems of the Ancient Malayo-Polynesian Homeland

by Mike T. Carson and Hsiao-chun Hung

Paleo-landscape investigations contextualize how people have inhabited and coevolved dynamically with their landforms, resource zones, and social-ecological niches during measured time intervals and through extended chronological sequences. Toward illustrating this research potential, changing paleo-landscapes 2500–1500 BC reveal the ancient conditions of the places where people lived in both Taiwan and the northern Philippines, in this case exploring what transpired there during a critical time period that heralded deep transformation of the language history, cultural heritage, economic production, and population demography of Island Southeast Asia as known today. During the time range of interest, the region's coastlines and habitat configurations were substantially different from today's circumstances, prior to change in sea level, accelerated slope erosion, lowland sedimentary buildup, and some of the world's most rapid recorded tectonic uplift. The results show that people in eastern Taiwan at 2200–2000 BC faced a crisis of limited suitable landforms for their particular mode of subsistence economy, thus instigating overseas migration to the northern Philippines as a means to expand into other territories, with continued effects through 1500 BC and thereafter.

Paleo-landscape research aims to learn about the place of human societies in the ever-changing world that we have inhabited in the past and present. The investigative strategy begins with situating material records of datable archaeological layers within their associated landforms and configurations of habitat zones, then proceeds with coordinating the available traces of natural and cultural history into a unified view of the past landscape (paleo-landscape). This approach shares much in common with geoarchaeological studies of sites in their original ecological contexts (Butzer 1982; Wilson 2011), applied at a large scale of an inhabited landscape. When focusing on a narrowly measurable time interval, paleo-landscape reconstructions may be viewed as snapshots or slices in time, understood as components within longer sequences of continous landscape evolution.

By virtue of illustrating the paleo-landscapes wherein real people generated material outcomes of archaeological records, we can clarify the environments that people inhabited, how they used their available zones, and how they adapted to their changing conditions. In one such documented example, the first settlement of Remote Pacific Oceania occurred when people at 1500 BC in the Mariana Islands targeted a narrow range of seashore niches that no longer existed just a few centuries later, due to changing sea level and coastal ecology, resulting eventually in today's broad coastal plains and beaches becoming entirely disconnected from the original paleo-landscapes (Carson 2011, 2014*a*, 2014*b*; Carson and Hung 2015). In other Remote Oceanic islands such as Fiji and New Caledonia in the central Pacific, the founding populations at 1000 BC lived in paleo-seashores that should not be conflated with modern-day settings (Nunn and Heorake 2009), contrary to the continued practice of surface-guided archaeological surveys. In a more extreme case, the migration routes of the first people entering the Americas prior to 12,000 BC, during the last ice age, need to be reframed in their paleo-landscape parameters (e.g., Anderson and Bissett 2015; Clark, Mitrovica, and Alder 2014; Faught and Gusick 2011; Madsen 2015).

In whatever case-specific example may be chosen, paleo-landscape studies emphasize that people in any point in time have inherited the outcomes of countless generations of preceding natural and cultural history, thus stressing the vital role of researching long-term chronological change. Accordingly, a view of "archaeological landscape evolution" (Carson 2016) examines the multiple concurrent factors that have shaped landscapes through time, necessarily accommodating a generous range of natural and cultural processes, many of which

Mike T. Carson is Associate Professor of Archaeology at the Micronesian Area Research Center of the University of Guam (303 University Drive, Mangilao, Guam 96913 [mtcarson@triton.uog.edu]). **Hsiao-chun Hung** is Senior Research Fellow in the Department of Archaeology and Natural History of the Australian National University (Canberra, Australian Capital Territory 0200, Australia). This paper was submitted 15 I 17, accepted 31 X 17, and electronically published 12 XII 18.

 0011-3204/2018/5906-0007$10.00. DOI: 10.1086/700757

were interactive. This scope of research resonates with niche construction theory, recognizing that people live in niches, adapt to them, and modify them in ways that affect future generations (Odling-Smee, Laland, and Feldman 2003). Niche construction theory has been productive for archaeologists and others, exploring the origins of plant and animal domestication, emergence of sedentary lifestyles, and other themes as reviewed by Laland and O'Brien (2010) and Smith (2015). Without necessarily adhering to any particular theoretical paradigm, the material-based records of paleo-landscapes can substantiate the contexts that once existed at different points in time as a means to explore other research themes, as we articulate here.

While paleo-landscape studies could be performed anywhere or in any time period, here we focus on Taiwan and Island Southeast Asia at 2500 BC through 1500 BC, during the time believed to have been pivotal in the geographic spread of pottery-making traditions, sedentary farming communities, and speakers of Malayo-Polynesian (MP) languages (Bellwood et al. 2011). The pottery horizon definitely occurred and can be dated, but degrees of inference have been necessary to link this material record with the linguistic history and with farming practice. The specific modes of past land use, including possible rice farming among many other options, can be assessed most accurately when referring to actual paleo-landscape configurations. This particular case reveals a more complicated picture than meets the eye in the present-day landscape, due to significant change in sea level, slope erosion and redeposition patterns, and tectonic movements.

Our illustrative example clarifies the context of one of the world's major events in language history, resulting in people speaking tightly related MP languages throughout most of the Asia-Pacific region (fig. 1). Linguistic history confidently outlines how the innovations defining the MP subgroup of Austronesian developed when a subset of Taiwan's early Austronesian population departed to settle in Island Southeast Asia and interacted with other preexisting groups there (Blust 2013; Ross 2005). Linguistic study alone cannot pinpoint the dates or the particular locations involved, nor can it ascertain the motives of ancient people, but instead looks to connect with independent findings from archaeology and now from paleo-landscape research.

The present study enables more precise statements about the past landscape structures and potential land-use systems in the MP homeland during the time of a postulated migration from Taiwan into Island Southeast Asia. Otherwise, in the absence of knowing about those paleo-landscapes, numerous hypothetical scenarios have been vague and untested. Contextual grounding has been problematically missing for studies of the origins of agriculture, demographic growth, and other past events

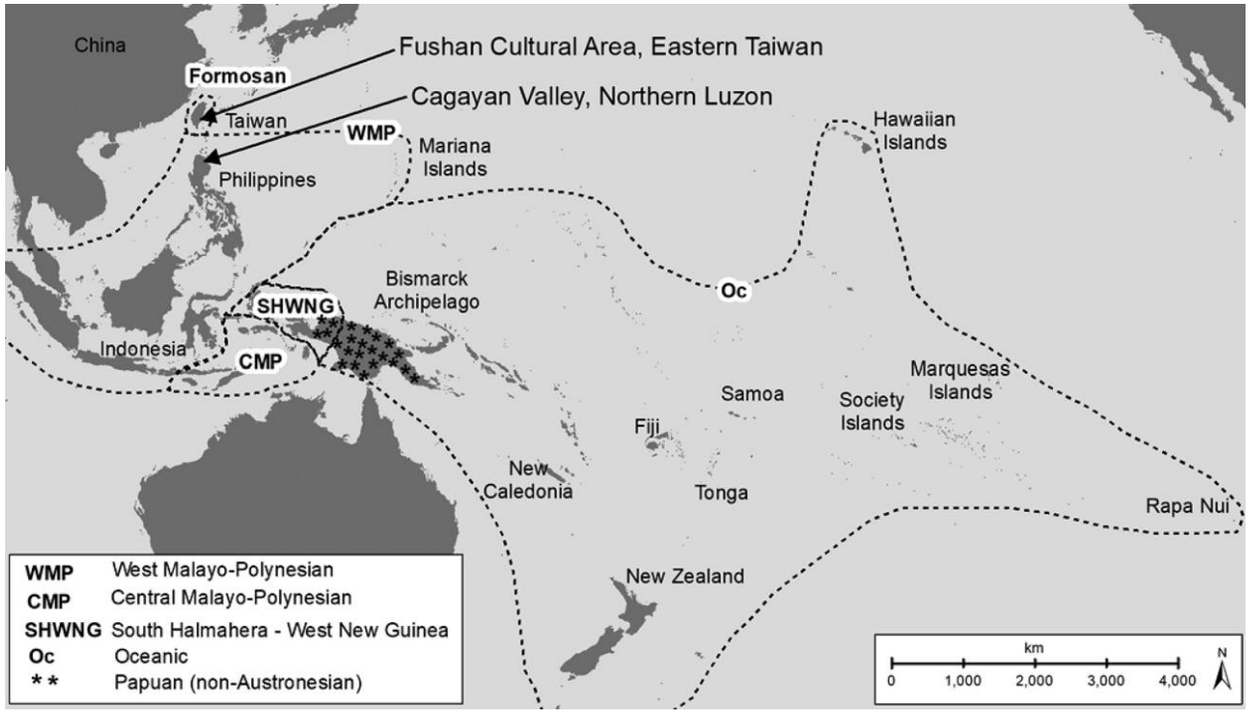

Figure 1. The Malayo-Polynesian homeland in the Asia-Pacific region, noting distribution of major language families and places mentioned in the text.

(or processes) that occurred in paleo-landscapes that now are divorced from modern landscape observations.

Regarding previously untested notions of the MP dispersal, proposed models have focused on how to explain the apparent spread of language communities, pottery-making traditions, and sedentary farming lifestyle as the presumed markers of an ancient MP horizon while acknowledging that people already had been living as hunter-gatherers throughout Island Southeast Asia for several thousands of years. These models have referred to the development of rice agriculture and resultant population growth (Bellwood 2005), demands for maritime and tropical forest products (Chang and Goodenough 1996:51), searches for new trade contacts (Thiel 1988:127), and social motivations to establish new founding lineages (Bellwood 1996). Countering viewpoints have questioned the role of agriculture as compared with other modes of subsistence economy, instead suggesting a more diverse cultural usage of past landscapes (Barker and Janowski 2011). Still others have cautioned that the real world is a complicated place, thus arguing against accepting any single explanatory hypothesis about population demography, migration, or agricultural expansion as the orthodox hegemonic narrative of ancient migrations from Asia into the Pacific (Terrell and Welsch 1997; Terrell, Hunt, and Gosden 1997). All of these ideas share the qualities of untested speculations lacking relevant supporting evidence, yet now a more complete and accurate picture of the paleo-landscape may prove to be compatible or incompatible with any of the previously hypothesized scenarios.

Knowledge about the MP homeland can reveal more about the essential foundation of a much larger phenomenon of the spread of MP-speaking communities and their modes of inhabiting diverse landscapes, not only through Island Southeast Asia but also into the previously uninhabited islands of Remote Pacific Oceania (Blust 2013). Most clearly in the remote islands where nobody had lived previously, the MP language communities reflect a shared cultural history of ocean-crossing migrants, linked with archaeological records of when people first inhabited each of those isolated islands in a long sequence, beginning by 1500 BC, if not earlier in the Mariana Islands, and continuing as late as AD 1300 in New Zealand (Bellwood et al. 2011). While the apparent MP diaspora proceeded over several centuries, its origins can be traced to a homeland context prior to 1500 BC and potentially much earlier in Island Southeast Asia and connected at least partially with Taiwan.

This research was concerned with clarifying the kinds of landscapes that people inhabited and how they developed their distinctive land-use systems in the MP homeland at the beginning of the MP diaspora. The investigation therefore first needed to refine the geographic scope and chronological parameters of the postulated MP homeland, then target the areas of specific archaeological sites where the paleo-landscapes could be reconstructed and examined. The same logical strategy could apply in other cases, and the present study therefore can be instructive toward more research of the paleo-landscapes related to other events or processes in world cultural and ecological history.

The Archaeological Problem of MP Origins

Historical linguistics studies have defined a first appearance of the MP grouping as separating from Taiwan into Island Southeast Asia (Blust 2013), so the search for an archaeological signature of this event logically needs to focus in this region (fig. 1). In principle, a material signature can be found in Island Southeast Asia with links to a preexisting homeland area in Taiwan. Given the fact that the next major episode of MP cross-regional expansion into Remote Oceania involved a distinctive pottery-bearing cultural inventory at 1500 BC in the Mariana Islands (Carson 2014*a*, 2016), the older MP-associated archaeological sites must have included related pottery traditions prior to 1500 BC. The oldest known pottery so far in Island Southeast Asia includes the findings as described here in the northern Philippines, dated as early as 2200–2000 BC (Hung 2008; Hung et al. 2011), thus a deeper connection with Taiwan should concentrate on this time interval.

Radiocarbon dates at 2200–2000 BC apply to a set of sites in eastern Taiwan and another limited set in the northern Philippines, all sharing a distinctive tradition of red-slipped earthenware bowls with diagnostic rim forms, foot rings, pedestals, and other characteristics (fig. 2). This pottery style began slightly earlier in Taiwan, about 2500 BC, where it had developed from a long chronology of changing styles extending back to 4000 BC (Hung and Carson 2014), and then it appeared abruptly with the first-ever pottery horizon in the Philippines. The earliest pottery-bearing sites in the Philippines furthermore have yielded baked-clay pendants, spindle whorls, stone barkcloth beaters, and Taiwan nephrite (jade) ornaments all pointing congruently to origins in Taiwan (Hung 2005, 2008; Hung et al 2007). The pottery-bearing horizon thereafter spread into more areas of the Philippines and much of Island Southeast Asia by 1500 BC and even more extensively by 1000 BC, but those later episodes involved qualitatively different forms of pottery and changing landscape contexts that should not be conflated with our present focus on the initial MP dispersal.

The radiocarbon chronology of a materially traceable "pottery trail" has been instrumental in framing investigations into the MP homeland. While a complete reiteration of several hundred radiocarbon dates would detract from our current study, the most confident dating results of key sites are summarized in table 1, referring to sites along the eastern coast of Taiwan and in the northern islands of the Philippines. Larger-scale regional reviews have been compiled for Island Southeast Asia overall (Spriggs 2007), as well as in finer detail for specific areas of Taiwan and the northern Philippines (Hung 2008). More dating results continue to be accrued, including new findings as incorporated in table 1.

The problem for archaeologists has been to obtain firm evidence of what actually existed in terms of food resources

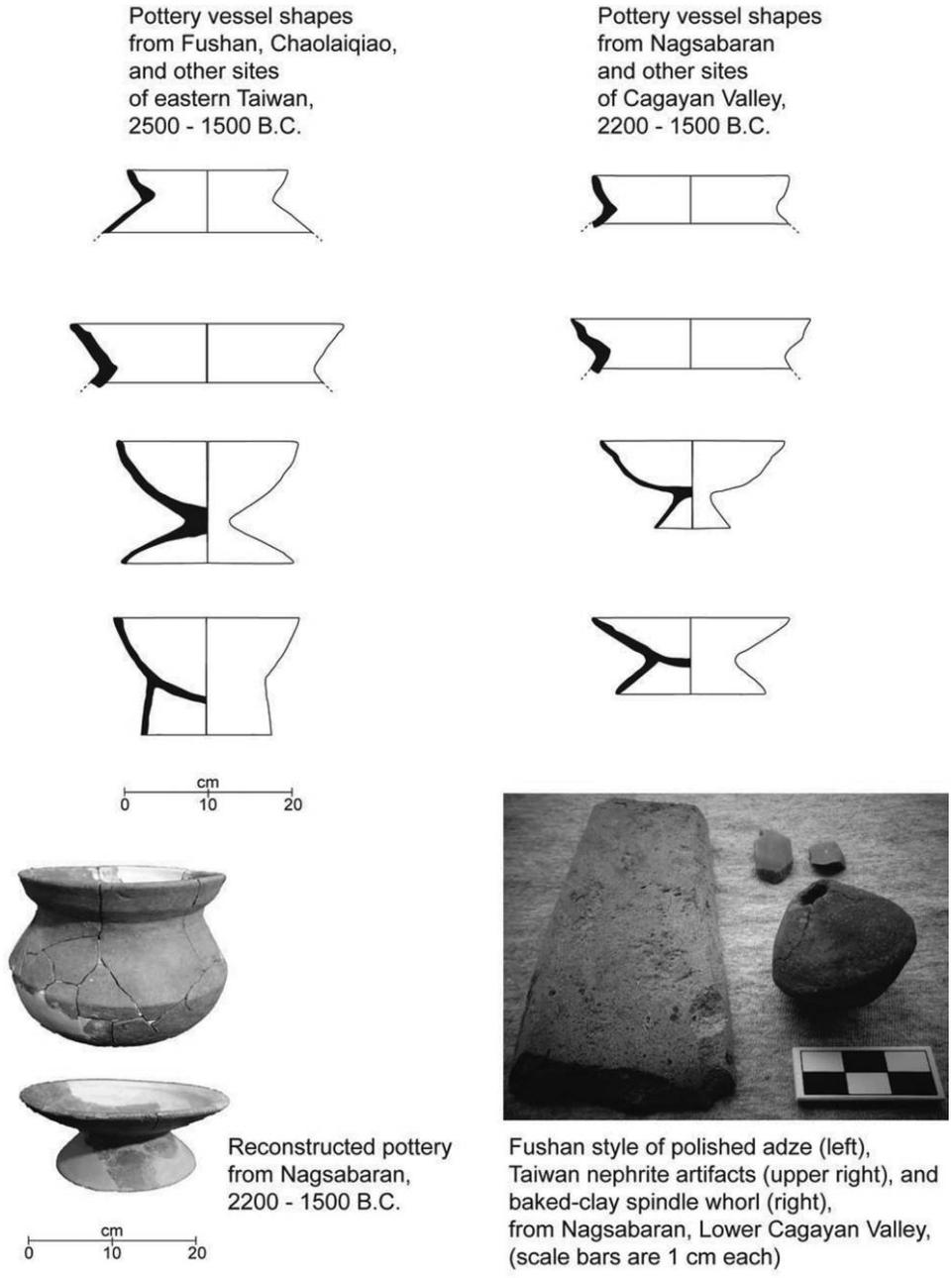

Figure 2. Comparison of the diagnostic artifacts of the Fushan Cultural Sites of eastern Taiwan at 2500–1500 BC and of the northern Philippines at 2200–1500 BC. A color version of this figure is available online.

and landscape management at the beginning of the MP dispersal. Until now, the pottery-bearing sites involved in the initial MP dispersal have not been examined in terms of their paleo-landforms and habitats, nor have they provided direct evidence of whether or not rice or any other crop actually had been cultivated as part of the ancient land-use system. Rice farming was abundantly evident in later periods and historical records, but a direct linkage with the initial pottery-bearing horizon has not yet been confirmed. Predating the pottery horizon, archaeological sites throughout the Philippines and Indonesia have reflected the activities of hunter-gatherers and have shown no evidence of a food-producing economy dependent on domesticated plants or animals.

Within our ancient time range of more than 3,500 years ago, people inhabited landscapes bearing little resemblance to modern-day observations, such that the paleo-landscapes can

Table 1. Summary of radiocarbon dating results mentioned in the text

Site and provenance	Laboratory no.	Dated material	Conventional radiocarbon age (years BP)	Calibrated calendar years (2-σ calibration, %)[a]	Reference
Eastern coast of Taiwan:					
Fushan:					
Cultural layer	NTU-5428	Charcoal	3880 ± 190	2891–1882 BC (95.4)	Wu and Deschodt 2012
Cultural layer	Wk-28153	Charcoal	4071 ± 30	2853–2812 BC (12.35); 2745–2726 BC (2); 2696–2559 BC (66.8); 2536–2491 BC (14.3)	Wu and Deschodt 2012
Beneath cultural layer	NTU-1298	Coral limestone	3870 ± 40	1916–1663 BC (95.4)	Huang 1991
Beneath cultural layer	Beta-398458	Coral limestone	4240 ± 30	2431–2183 BC (95.4)	This study
Beneath cultural layer	NTU-1169	Coral limestone	4580 ± 50	2878–2595 BC (95.4)	Huang 1991
Chaolaiqiao:					
Cultural layer	Wk-17754	Charcoal	3704 ± 32	2200–2019 BC (93.6); 1994–1982 BC (1.8)	Hung 2005, 2008
Cultural layer	Wk-17011	Charcoal	3736 ± 43	2287–2025 BC (95.4)	Hung 2005, 2008
Shanyuan:					
Modern site surface	Wk-28157	Marine shell	4204 ± 30	2381–2127 BC (95.4)	Hsieh and Liew 2010
Batanes Islands, northern Philippines:					
Torongan Cave:					
Cultural layer	Wk-14642	Food residue on pottery	3329 ± 40	1730–1721 BC (1.6); 1697–1510 BC (93.8)	Bellwood and Dizon 2013
Cultural layer	OZH-771	Food residue on pottery	3860 ± 70	2561–2536 BC (1.4); 2492–2136 BC (94)	Bellwood and Dizon 2013
Lower Cagayan Valley of Luzon, northern Philippines:					
Nagsabaran:					
Cultural layer, beneath shell midden	Beta-437271	Rice grain charcoal	2550 ± 30	801–744 BC (54.9); 686–665 BC (9.9); 686–665 BC (9.9); 644–551 BC (30.6)	This study
Cultural layer, beneath shell midden	GX-28379	Charcoal	3050 ± 70	1493–1481 BC (.6); 1454–1110 BC (94.4); 1097–1091 BC (.3)	Tsang, Santiago, and Hung 2002
Cultural layer, beneath shell midden	GX-28381	Charcoal	3390 ± 130	2031–1413 BC (95.4)	Tsang, Santiago, and Hung 2002
Cultural layer, beneath shell midden	ANU-13016	Charcoal	3510 ± 30	1918–1748 BC (95.4)	Hung 2008; Hung et al. 2011
Cultural layer, beneath shell midden	Wk-23392	Pig tooth	3940 ± 40	2568–2520 BC (13.2); 2499–2332 BC (77.4); 2327–2299 BC (4.8)	Hung et al. 2011; Piper et al. 2009
First land clearing and burning	Beta-436818	Charcoal	3760 ± 30	2287–2125 BC (83.2); 2091–2044 BC (12.2)	This study
Magapit:					
Cultural layer, within shell midden	N-5397	Charcoal	2760 ± 125	1288–746 BC (92.1); 686–666 BC (.7); 644–553 BC (2.6)	Aoyagi et al. 1993
Cultural layer, within shell midden	N-5396	Charcoal	2800 ± 140	1469–753 BC (94.7); 682–669 BC (.3); 611–593 BC (.4)	Aoyagi et al. 1993
Cultural layer, beneath shell midden	Beta-416881	Charcoal	2800 ± 30	1027–891 BC (91.4); 879–848 BC (4)	This study
Cultural layer, beneath shell midden	Beta-416882	Charcoal	2810 ± 30	1050–895 BC (95.4)	This study
Cultural layer, beneath shell midden	Beta-426160	Animal bone	2860 ± 30	1118–929 BC (95.4)	This study

Table 1 (*Continued*)

Site and provenance	Laboratory no.	Dated material	Conventional radiocarbon age (years BP)	Calibrated calendar years (2-σ calibration, %)[a]	Reference
Cultural layer, beneath shell midden	Beta-426159	Animal bone	2900 ± 30	1207–1141 BC (16.6); 1134–1004 BC (78.8)	This study
Cultural layer, beneath shell midden	Beta-416880	Rice grain charcoal	2910 ± 30	1209–1011 BC (95.4)	This study
Andarayan:					
Cultural layer	SFU-86	Charcoal	3240 ± 160	1934–1114 BC (95.4)	Snow et al. 1986
Cultural layer	Not reported	Rice husk inside pottery	3400 ± 125	2026–1431 BC (95.4)	Snow et al. 1986
Gaerlan:					
Cultural layer	NUTA2-7939	Animal bone	3485 ± 30	1890–1740 BC (92.4); 1712–1699 BC (3)	Ogawa 2005
Cultural layer	NUTA2-7938	Animal bone	3555 ± 30	2011–2000 BC (1.7); 1978–1868 BC (72.6); 1848–1774 BC (21.1)	Ogawa 2005
Cultural layer	NUTA2-7940	Animal bone	3665 ± 35	2141–1942 BC (95.4)	Ogawa 2005
Irigayen:					
Cultural layer	NUTA2-912	Charcoal	2925 ± 20	1210–1047 BC (95.4)	Ogawa 2005
Cultural layer	NUTA2-914	Charcoal	3025 ± 20	1384–1342 BC (17.6); 1308–1213 BC (77.8)	Ogawa 2005
Cultural layer	NUTA2-913	Charcoal	3165 ± 25	1500–1405 BC (95.4)	Ogawa 2005
Cultural layer	NUTA2-917	Charcoal	3185 ± 25	1502–1417 BC (95.4)	Ogawa 2005
Pamittan:					
Cultural layer	GaK-17967	Charcoal	3390 ± 100	1941–1492 BC (93.6); 1483–1452 BC (1.8)	Tanaka and Orogo 2000
Cultural layer	GaK-17968	Charcoal	3810 ± 200	2868–2803 BC (2.6); 2778–1752 BC (92.8)	Tanaka and Orogo 2000

[a] All calibrations were made at 2-σ (95.4%) with the OxCal program (Bronk Ramsey, and Lee 2013). Calibration data sets were INTCAL13 for charcoal and animal bone or else MARINE13 for coral and shell (Reimer et al. 2013). A marine reservoir correction (ΔR) of 73 ± 17 was calculated for marine samples from the coast and offshore islands of eastern Taiwan (Yoneda et al. 2007).

reveal more informatively about the MP homeland. As we will illustrate in this work, today's extensive coastal lowlands and valley floors did not exist prior to 1500 BC (fig. 3), such that any ideas of past land-use systems instead need to account for substantially different landforms and configurations of natural resources. None of the relevant archaeological site layers are detectable on present-day ground surfaces, but rather they all have been buried beneath more recent sedimentary units produced in notably different contexts, due to fluctuations in sea level and water tables, tectonic movements, and changes in patterns of soil formation, erosion, and redeposition.

New research clarifies the ancient settings in both eastern Taiwan and the northern Philippines, including the roles of different land-use practices among other components of social-ecological landscapes. The investigative strategy has entailed (1) documentation of sites dated within the time range of interest, (2) reconstruction of the shapes of landforms and configurations of usable habitats during the time when those sites were occupied, and (3) identification of preserved botanical and faunal remains, reflecting past environments and subsistence economies.

Refining the Focus in Eastern Taiwan

Several sites of Taiwan's eastern coast consistently have shown shared characteristics of red-slipped pottery and other material signatures, sustained 2500–1500 BC. The classic artifact inventory was described at the Fushan Site (Lee and Yeh 1995, 2001:74), giving its name to the "archaeological culture" of this area and time period, now documented at many other sites on hilltops and ridgetops around Dulan Bay and the central eastern coast, as well in a few sites in the northern Philippines beginning about 2200–2000 BC. Research of the MP homeland therefore must examine these sites in eastern Taiwan, particularly in the buried archaeological layers predating their oldest counterparts in the Philippines.

Before examining the paleo-landscapes of the Fushan-associated sites, the archaeological signature of the "Fushan Culture" can be appreciated as part of a cultural diversification at its time in Taiwan (Hung 2005). As early as 2600–2500 BC, at least five different material culture assemblages occurred in separate parts of Taiwan, locally known as Xuntangpu in the northwest, as Hongmaogang in the north through central west,

Figure 3. Modern-day settings representing the study areas. Upper image shows Dulan Bay of eastern Taiwan, view to north, where sites are situated on the low hills. Middle image shows the HZS (Houzishan) Site atop Monkey Mountain near Dulan Bay, previously a small islet at 2400–2000 BC. Lower image shows the Cagayan Valley in the Philippines, where nearly all of the riverside alluvial terrace formations did not exist at the time of Malayo-Polynesian settlement at 2200–1500 BC. A color version of this figure is available online.

as Niumatou in the central west, as Niuchouzi in the southwest, and as Fushan in the southeast (Hung and Carson 2014). In each of the pottery collections, the older traditions of coarse cord marking were absent or minimal, replaced instead by fine cord marking and variable amounts of red-slipped pottery. By 2200 BC in eastern Taiwan, cord marking had been declining and nearing its termination, in some cases quite radically, as in the Fushan assemblages.

Within the geographic scope of the Fushan-associated sites of southeast Taiwan, the landscape at 2500–1500 BC differed significantly from other parts of Taiwan. Elsewhere, such as on the western coast, with its large alluvial plains that had started to form as early as 2800 BC (Chen et al. 2004), residential village complexes relied on rice and millet farming for a few centuries and then more intensively by 2200 BC (Tsang 2005). In contrast, the eastern coast at that time consisted of sloped hilly terrain surrounded by watery habitats. In eastern Taiwan, today's expanses of coastal plains and riverbank terraces did not begin to emerge and stabilize above sea level until 1500 BC. Those most productive lowlands for rice and millet farming in eastern Taiwan were associated with sites such as Beinan (described by Lien and Sung 1986; see also Lien 2008), and, notably, the stonework village ruins of Beinan were based within the alluvial layers, definitely postdating the Fushan-associated paleolandscape and now dated primarily in the range of 1500–300 BC.

The people of Fushan and other sites in eastern Taiwan at 2500–1500 BC could not have farmed wetland rice in horizontally expansive fields, as seen in later periods, and they must have engaged in a different mode of land use. They must have been aware of rice and millet farming as a primary means of subsistence in other parts of Taiwan. The earlier development in western Taiwan in particular had been encouraged by the extensive lowland alluvial plains and associated habitats that did not exist in eastern Taiwan until much later and postdated the MP expansion.

Here we focus on the area of Dulan Bay in eastern Taiwan, where several sites dating between 2500 and 1500 BC are distributed on the tops of small hills, all about 40–50 m elevation today and overlooking the coastal lowland terrain that actually could not have existed at the time when those sites had been occupied (fig. 4). This same geographic scope coincided with a portion of Taiwan lacking intact archaeological layers predating 2500 BC, likely due to the fact that much of the eastern coastal terrain had been submerged below sea level at that time. The landforms occupied at Fushan and other sites, as described here, did not emerge above sea level until close to 2500 BC. Prior to that time, this area around Fushan consisted of sharply rising slopes of rugged, mountainous terrain. Pre-2500 BC site layers have been verified farther northward along Taiwan's eastern coast, in different landforms than seen in the Fushan area.

The eastern coastal mountain range is among the fastest uplifting geological formations in the world, due to the subduction of the Philippine Plate beneath the land mass of Taiwan, calculated at 8–12 mm per year in the south (around Dulan Bay) and 2–5 mm per year in the north. These rates are calculated by direct radiocarbon dating of corals and shells obtained from measured elevations (Hsieh, Liew, and Hsu 2004; Hsieh and Liew 2010; Liew et al. 1993; Yang and Chen 2013). In addition, sea level at 3000–1100 BC (during the mid-Holocene highstand) stood about 2 m higher than the modern level (Zong 2004), and today's sedimentary units covering river terraces and coastal plain lowlands did not begin to accumulate until after the combined effects of natural sea-level drawdown

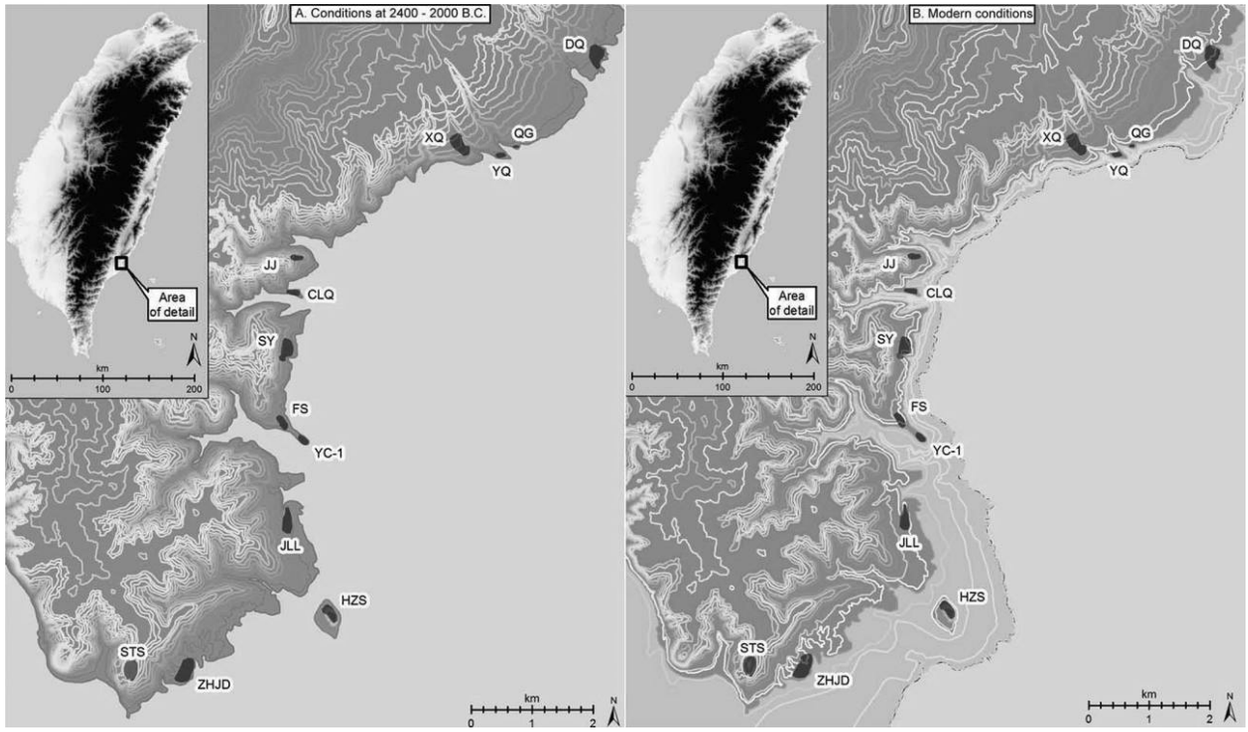

Figure 4. Landscape of the Dulan Bay area of eastern Taiwan, comparing ancient (2400–2000 BC) and modern conditions. A color version of this figure is available online. DQ = Duqiao; QG = Qiguan; YQ = Yuqiao; XQ = Xinqiao; JJ = Junjie; CLQ = Chaolaiqiao; SY = Shanyuan; FS = Fushan; YC-1 = Yuchang-1; JLL = Jialulan; HZS = Houzishan; ZHJD = Zhihangjidi; STS = Shitoushan.

and accelerated slope erosion as enhanced by inland forest clearing.

The present-day lowlands in eastern Taiwan consist of broad horizontal expanses of alluvial clays and silts, all along the coastline and also bordering several rivers and streams, forming ideal settings for wetland rice and other land-dependent farming as seen today. These alluvial layers were measured up to 2.5 m thick in our 2013–2015 sediment coring explorations, overlaying deeper and older surfaces of estuarine and marine sediments. Moreover, the alluvial layers provided the physical surfaces of later-aged sites all postdating 1500 BC and associated with definite rice and millet farming, locally known as the "Beinan Culture" sites (see Lien and Sung 1986).

According to the sediment coring findings, the low-elevation areas around the footslopes of Taiwan's eastern hills were watery prior to 1500 BC, including both estuarine and marine habitats. In particular at Fushan, estuarine habitats were identified around the north and south sides of today's hilly formation, beneath the lowland alluvium between the hill of Fushan and the adjacent hills of other neighboring sites, while a marine ocean-floor setting was identified around the east (seaward) side, beneath today's large coastal plain formation. The estuarine layers were characterized by terrigenous silts, small amounts of water-rounded pebbles similar to those seen in today's riverbeds, and occasional shells of freshwater gastropods. Farther on the seaward (east) side of Fushan, the underlying ocean-floor sediments were composed of calcareous grains and gravel of broken marine shells and corals.

As for the hilltops, where people had been living at 2500–1500 BC, they were not in fact "hills" of 40–50 m elevation at that time but rather surfaces of paleo-seashores, freshly exposed above sea level. The cultural deposits at Fushan had been emplaced over coral limestone, and the counterpart cultural occupation at Chaolaiqiao had been situated over a sandy beach. Those ancient site surfaces apparently were less than 5 m above sea level, but subsequently they have been elevated into their present-day hilly formations due to the rapid tectonic uplift of the eastern coastal mountain range.

During the time span of the ancient habitation at the Fushan Site, people gradually expanded their settlement area to take advantage of increasing land surface made available through tectonic uplift. The cultural occupation here began at some point within the range of 2853–2491 BC according to the radiocarbon dating of charcoal within the cultural layer, overlying a pre-existing surface of coral limestone. In the oldest part of the site, the underlying coral last had been living about 2878–2595 BC, thus indicating that people occupied the site almost immediately when the coral was exposed above sea level. Other dates on the

underlying coral were progressively younger toward the seaward and slightly lower-elevation portions of the site, as young as 1916–1663 BC at the outer eastward margin.

Excavations at several other sites in eastern Taiwan have disclosed much the same artifact inventories and apparent paleo-seashore settings as seen at Fushan. Dulan Bay was among the most densely populated areas of that time period (fig. 4). So far, 13 sites bearing the distinctive Fushan type of pottery have been found on the present-day hilltops around Dulan Bay, and in total they represent a widespread cultural settlement, established very shortly after the emergence of paleo-coastal landforms as described at Fushan.

Chaolaiqiao has produced one of the best documented cases of an archaeological layer of dense Fushan-type pottery and other artifacts, with secure radiocarbon dating (fig. 5). The buried archaeological deposit was in a matrix of beach sand, dated by plentiful charcoal at 2200–2025 BC. The sandy matrix fortuitously preserved food middens of mixed shellfish remains and shark teeth, reflecting the roles of coastal and marine foods.

The archaeological layer at Chaolaiqiao was dated precisely in the range of the oldest pottery-bearing sites in the northern Philippines, so the pottery and other artifacts from Chaolaiqiao have been especially informative for defining cross-regional links. The pottery showed minimal use of fine cord marking, generally regarded as absent in eastern Taiwan by 2000–1800 BC. This form of fine cord marking therefore may be viewed as an indicator of an early dating at the beginning of the MP dispersal while the larger field of general-purpose red-slipped pottery could indicate a broader chronological range.

Further illustrating the paleo-landscape, Chaolaiqiao has yielded the oldest evidence of rice in eastern Taiwan, dated at the cusp of the postulated MP dispersal. The material proof was found in the forms of preserved rice phytoliths in the buried archaeological layer (Deng et al. 2018*a*). The Chaolaiqiao assemblage contained fully domesticated rice, verified by the numbers of fish-scale-shaped edges of rice bulliform phytoliths. Furthermore, the deliberate farming of fully domesticated rice can be associated with discoveries of slate harvesting knives at Chaolaiqiao and other related sites; such knives were not seen in the preceding archaeological layers of eastern Taiwan.

The MP homeland paleo-landscape in eastern Taiwan did not include the broad lowlands most suitable for horizontally expansive rice farming, but instead people occupied several separated low mound-like formations, in most cases with a habitable area of about 50 × 200 m. In these settings, rice farming was possible in small dryland (rain-fed) plots rather

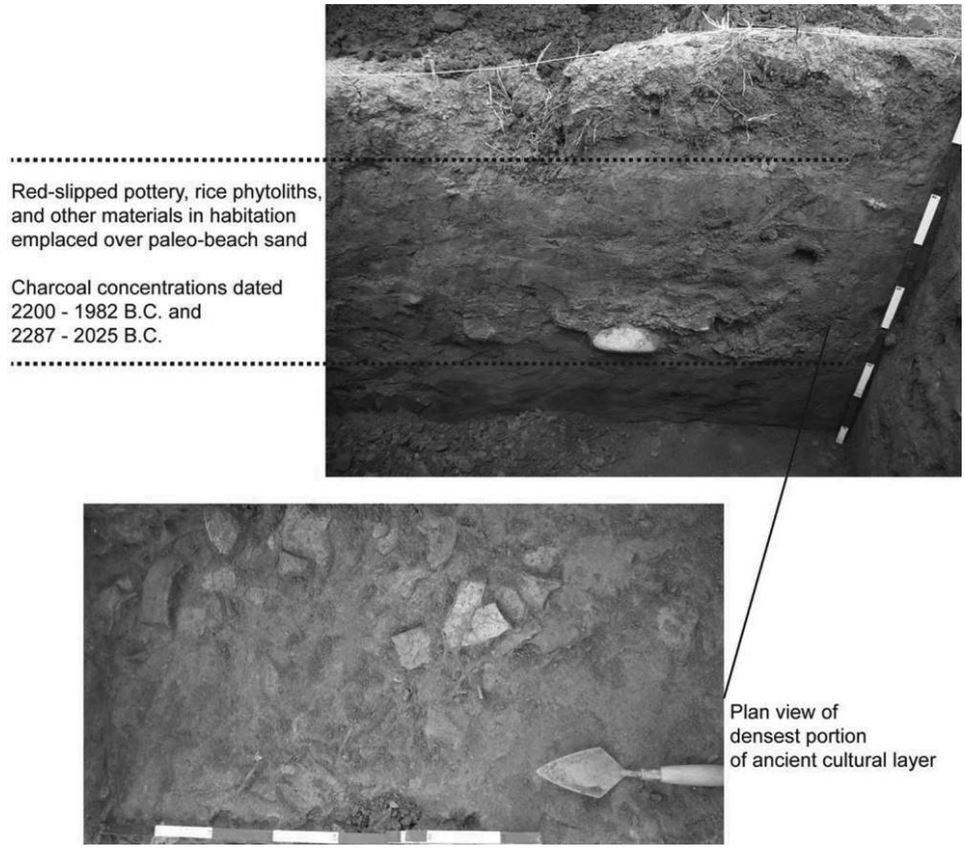

Figure 5. Excavation profile at Chaolaiqiao, eastern Taiwan. Upper image shows the west profile. Lower image shows plan view within densest portion of the buried cultural layer. All scale bars are in 10-cm increments. A color version of this figure is available online.

than in extensive wetland fields, and people likely took advantage of the low-elevation bases of their inhabited landforms that had abutted streams and estuaries. While the eastward-facing sides of the hills overlooked the ocean, the other sides of the hills were bordered by stream drainages and related freshwater zones. The landward (west) sides of the habitations were backed by steep mountainous terrain with dense forests.

The Fushan-era paleo-landscape was unstable multigenerationally, due to several factors of geology and other natural processes, compounded by the cumulative cultural demands of a growing population. This particular landscape was vulnerable to massive slope erosion, with periodic typhoon-generated rainstorms and floodwaters, ongoing rapid tectonic uplift creating steeper slope angles, and inland forest clearance exposing more topsoil. Meanwhile, increasing numbers of people with each generation consumed more land for residential, agricultural, and other purposes that eventually exceeded the amount of physical land available. An entirely different land-use pattern emerged after 1500 BC with the availability of extensive alluvial lowlands, further stressing the unique character of the paleo-landscape of the older MP homeland.

Discoveries in the Northern Philippines

In the northern Philippines, the abrupt appearance of a pottery-bearing horizon has been represented most strongly in the lower (north) end of the Cagayan River Valley of northern Luzon (fig. 1). The pottery can be linked with the assemblages at Fushan and other sites of eastern Taiwan as noted. Habitation sites have revealed diagnostic red-slipped pottery in variable shapes of bowls, often with a foot ring or pedestal (fig. 2), dated as early as 2200–2000 BC in a few cases through as late as 500 BC overall (table 1). The more narrowly definable fine cord-marked pottery, identified as a "dying art" in eastern Taiwan around 2200–2000 BC, was witnessed in just a single potsherd in the Batanes Islands (situated to the north of Luzon) and so far nowhere else outside Taiwan (Bellwood and Dizon 2013).

New evidence has been obtained from two sites in the Lower Cagayan Valley, namely, at Nagsabaran and Magapit, along with paleo-landscape reconstruction of the area around 2200–1500 BC (fig. 6). The ancient setting can be reconstructed according to knowledge of the slightly higher sea level by about 2 m at 3000 through 1100 BC (Maeda et al. 2004; Nunn 2007*b*), with corresponding effects on the flow of the Cagayan River and its tributaries, combined with measurements of the depths of archaeological layers in multiple locations. Most of the pre-1000 BC site layers are buried beneath today's alluvial plains, and a few are situated on limestone hilltops overlooking the river valley.

During the time range of interest, our research area consisted of an extensive rift valley floor, with scattered patches of low mounded silts and wetlands around the central flow of the river, bordered by limestone hills that had separated east-west due to the valley rift. Habitations were possible in some of those low mounded silts very close to the river's water level, as well as on the tops of hills overlooking the valley floor. Today's ubiquitous alluvial river terraces all across the valley floor formed as massive units of 1–2 m thickness after 1100–1000 BC, and they in turn have been capped by large mounds of discarded *Batissa* sp. shells (*kabibi*) postdating 500 BC. The *Batissa* sp. shells indicate the development of freshwater or estuarine conditions specifically at these locations by 500 BC, while they could not have lived in the older saltwater marshlands of the paleo-coastal zone.

Radiocarbon dates have been reported for six sites of the earliest pottery horizon in the Lower Cagayan Valley (table 1). Here we concentrate on the discoveries at Nagsabaran as early as 2200–2000 BC and at Magapit predating 1000 BC by an unknown extent, but the other four dated sites help to fill the picture of the paleo-landscape. The relevant findings so far have come from Andarayan with two radiocarbon dates overlapping at 1934–1431 BC (Snow et al. 1986), Gaerlan as old as 2141–1942 BC (Ogawa 2005), Irigayen with two dates significantly overlapping at 1500–1417 BC and others continuing thereafter (Ogawa 2005), and Pamittan yielding two dating results cross-confirming at 1941–1752 BC (Tanaka and Orogo 2000).

At Nagsabaran, people occupied post-raised houses over low mounded silty sediments at the water's edge from approximately 2200 to 2000 BC. Near the base of the site stratigraphy in the most recent test pit of 2016, a layer with abundant charcoal and numerous nodules of low-fired clay represented the result of slash-and-burn or land-clearing activity, and the charcoal has been dated at 2287–2024 BC (fig. 7). After the clearing episode, habitations in stilt-elevated houses created patterns of post molds in a silty layer with red-slipped pottery and other artifacts, where charcoal concentrations were dated as early as 1918–1748 BC (Hung 2008; Hung et al. 2011) and 2031–1413 BC (Tsang, Santiago, and Hung 2002). The ancient habitation layer was overcapped by mounds of *Batissa* sp. shells after 500 BC, signifying a change in the local environment along with new forms of pottery and other artifacts.

The initial pottery-bearing occupation layer at Nagsabaran has preserved a useful record of ancient plant and animal remains, including evidence of both rice and a domesticated pig whose biological ancestors must have lived on an external overseas source. A carbonized rice grain was dated at 801–551 BC (table 1), just prior to the buildup of the shell mounds covering the site today, and analysis is under way of the full archaeobotanical assemblage. Vertebrate faunal materials included mostly deer and fish bones. Pig bones and teeth belonged to both the indigenous wild warty pig (*Sus philippensis*) and an introduced species of apparently domesticated pig (*Sus scrofalverrucosus*), directly dated by radiocarbon at 2568–2299 BC (Piper et al. 2009:690–691).

Notably different from the ancient setting at Nagsabaran, the site of Magapit supported a low hilltop settlement overlooking the river prior to 1000 BC (Aoyagi et al. 1993; Aoyagi, Ogawa, and Tanaka 1997; Ogawa 2005). An age of 1500 BC had been suggested according to radiocarbon dating of *Batissa* sp. freshwater shells (Aoyagi et al. 1993; Aoyagi, Ogawa, and Ta-

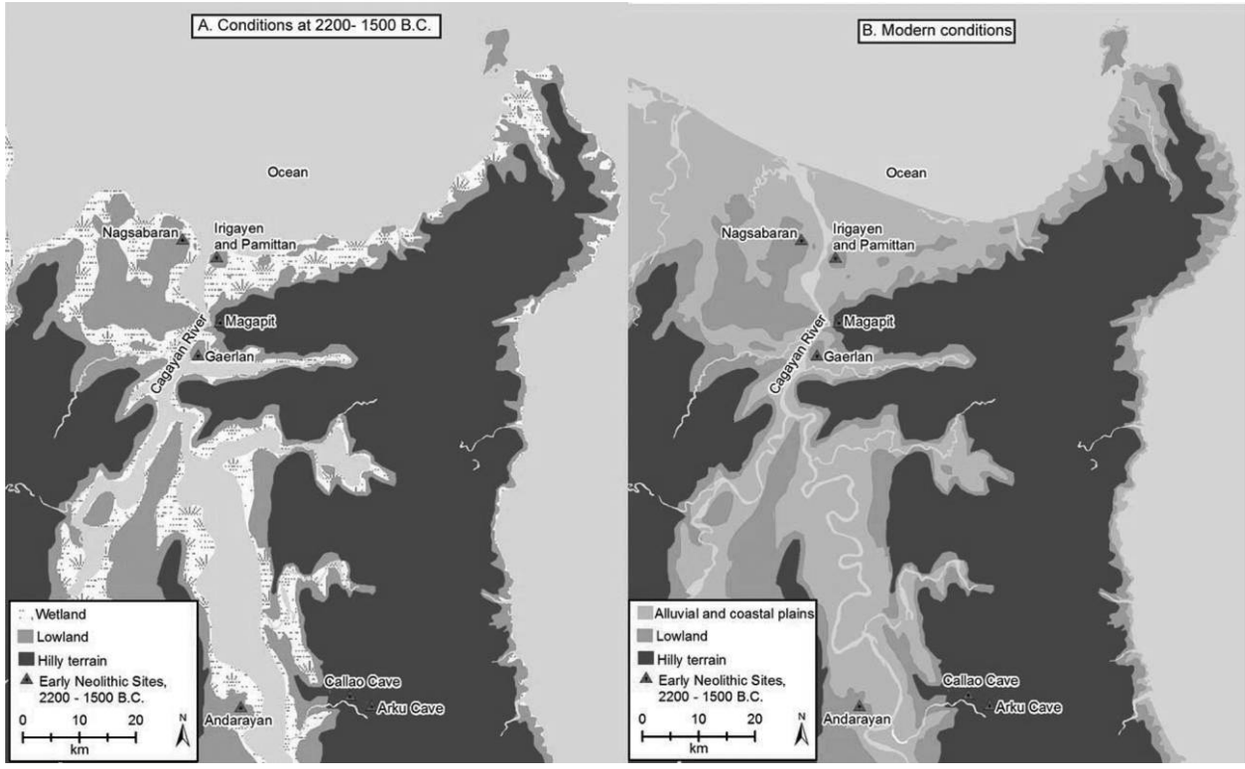

Figure 6. Landscape of the Cagayan Valley area of Luzon in the Philippines, comparing ancient (2200–1500 BC) and modern conditions. A color version of this figure is available online.

naka 1997), possibly affected by in-built older age of limestone and so far incongruent with other dating results as presented here. The deepest and oldest cultural layers of the site have not yet been excavated, definitely older than 1000 BC but by an unknown number of years.

At Magapit, a massive shell mound of *Batissa* sp. shells had formed after 1000 BC, a few hundred years older than the numerous shellmounds in the valley floor closer to the shoreline where saltwater marshlands had persisted until closer to 500 BC. Directly beneath the Magapit shell mound, an excavation during 2015 unearthed an older layer of clay containing broken red-slipped pottery, bones of deer and pigs, abundant charcoal concentrations, carbonized rice grains, and banana phytoliths. Two samples of wood charcoal, one of carbonized rice grain and two of animal bones, were dated by radiocarbon just prior to 1000 BC (table 1). The deepest portion of the site deposit could not be excavated in 2015 or 2016 due to land disputes in the area, so the oldest material has not yet been detected.

Prior to the new findings at Nagsabaran and Magapit, the only dated rice evidence from the Cagayan Valley had been reported at the Andarayan Site, now understood as having been a low-elevation habitation at the river's edge, similar to the Nagsabaran Site and others such as Gaerlan and Irigayen. At Andarayan, a rice husk inside the clay fabric of a red-slipped pottery fragment was dated by radiocarbon at 2026–1431 BC, cross-confirmed with a date on charcoal from the site's pottery-bearing layer at 1934–1114 BC (Snow et al. 1986:3). These dating results refer to the first few centuries of the initial pottery-bearing horizon in the Cagayan Valley.

The paleo-landscape study of the Lower Cagayan Valley has clarified the contexts of the initial pottery-bearing horizon in ancient riverside residential occupations, specifically in low-mounded silty patches near the water's edge in the middle of a wide-rift valley floor. This setting was occupied by people as early as 2200–2000 BC at Nagsabaran and a few other localities such as Gaerlan, Irigayen, and Pamittan. The available terrain at that time did not yet include the extensive alluvial terraces that had formed only after 1000 BC or perhaps closer to 500 BC. The alluvial terraces were superimposed over the oldest red-slipped pottery layers, and they supported the bases of shell mounds with quite different pottery and other artifacts mostly postdating 500 BC, as seen at Nagsabaran and other sites. Currently, these alluvial terraces cover the valley floor and support extensive wetland rice farming, but the older landforms of scattered low-mounded silty patches must have supported a different format of land use. The adjacent limestone hills at that time offered stable land surfaces, but soil productivity was less attractive than in the patches of silt along the valley floor.

The findings at Nagsabaran have confirmed deliberate land clearing and burning at 2287–2044 BC, suggesting preparation

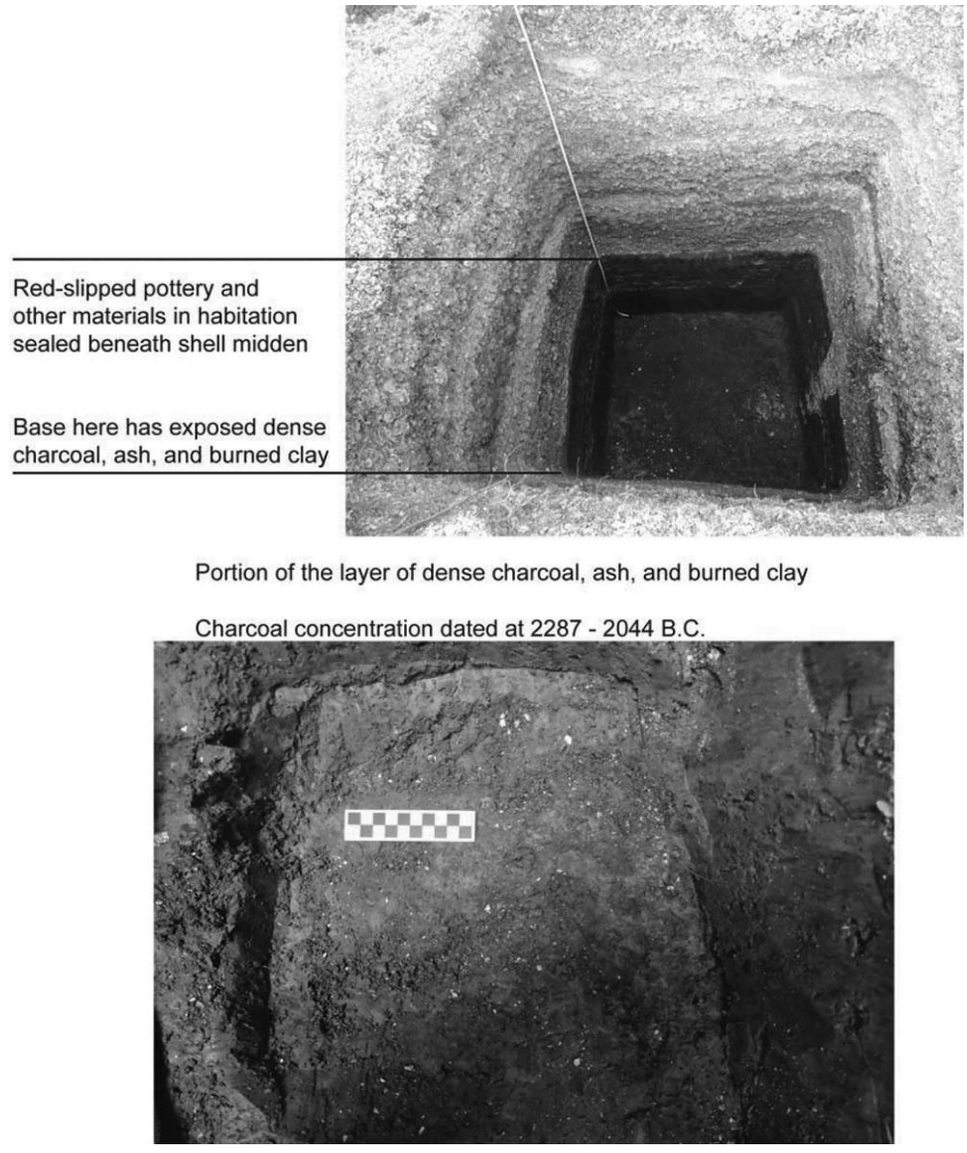

Figure 7. Excavation profile at Nagsabaran, northern Philippines. The upper image shows the pottery-bearing habitation layer, sealed beneath the post-500 BC shell midden. The lower image shows a detail of the layer of dense charcoal, ash, and burned clay, interpreted to reflect initial land clearing and burning at the initiation of the pottery-bearing habitation. A color version of this figure is available online.

for planting crops different from the naturally preexisting forest. Direct evidence for rice in particular was found in an upper layer and dated at 801–551 BC, postdating the result of 1934–1431 BC at Andarayan. Along with the inferred crop growth, the evidence of imported domesticated pig may hint at the likely usage of other domesticated foods, and in any case it suggests a new land-use system during the time of the initial pottery-bearing horizon.

The rift valley floor in Cagayan naturally differed from Taiwan's eastern coast at 2200–2000 BC, but a few similarities can be noted in the cultural usage of these two paleo-landscapes. In both settings, people occupied low-elevation landforms close to the water level, specifically involving freshwater sources of stream drainages and estuarine habitats. While people definitely modified their environments for subsistence food production, the available landforms supported less formalized modes of probably rain-fed crops and managed forests, rather than the intensive wetland rice farming that became possible only after the geological formation of broad alluvial lowlands postdating 1500 BC in eastern Taiwan and even later in the Cagayan Valley.

The proximity to the paleo-seashore and deep-water marine zone was a key feature in eastern Taiwan, but so far the sites of the Cagayan Valley have been found at the edge of an estuarine inlet, by comparison more removed from the ocean. Currently, only one classic paleo-beachfront site in the northern Philippines has revealed an archaeological layer of the early red-slipped pottery horizon, described at Dimolit on the eastern coast of Luzon, dated by three charcoal samples of unclear association at 4500–3300 BC, 2900–1950 BC, and 1900–1300 BC (Peterson 1974). Based on the paleo-landscape findings as shared here, new explorations may search for now-buried layers of paleo-beach sites in other areas.

Conclusions: Paleo-Landscapes in the MP Homeland and Larger Implications

This study has shown the value of accurate presentation of materially definable paleo-landscapes, rather than modern-day theorists imposing their ideas into the past without knowing about the real contexts. In this case, paleo-landscape settings were correlated with the archaeologically attested spread of a pottery-bearing horizon from Taiwan into Island Southeast Asia at 2200–2000 BC, effectively providing a more complete picture than previously has been possible for learning about the actions of people at the time of the major spread of pottery-making traditions, furthermore linked with a dispersal of MP languages and presumably several other aspects of ancient society. Prior to the availability of this new knowledge, varied speculations about land-dependent farming and other notions have been untestable, and in fact, the modern-day landscapes have offered misleading notions about ancient farming and other practices prior to the geological formation of the modern landforms.

As in any paleo-landscape study, the evident correlation of a past environment with a cultural event (or process) provides a context for further consideration. Accordingly, Contreras (2017) reminds us that "correlation is not enough," meaning that a correlation in itself does not constitute a causal relationship between the environmental circumstance and the cultural behavior, but it certainly substantiated the real context within which people behaved. Causality cannot legitimately be considered until a correlation has been demonstrated, as we have shown by illustrating the configurations of ancient landforms and habitat zones correlated with a specific time period and cultural context.

The paleo-landscape reconstructions have clarified that today's ideal alluvial lowlands for maximal wetland rice farming did not exist within the proposed MP homeland in eastern Taiwan at 2200–2000 BC. Nonetheless, rain-fed rice farming in small plots formed one part of the ancient land-use systems in those areas. The limited available landforms in eastern Taiwan could not support the continued demands of a growing population, coupled with the effects of unstable geology further delimiting the number of people who could rely on living there multigenerationally. Meanwhile, the site contexts have revealed that people occupied areas of low-elevation landforms bordered by both freshwater habitats and seashores, suitable for broad-spectrum resource usage beyond a narrow focus on rice farming. In this fuller picture of the paleo-landscape, people needed to find new lands rather quickly, but the context involved a diverse land-use practice that could adjust to varied settings.

The rapidity of people needing to seek new lands is especially striking in the case of Taiwan, triggering population expansions after just a few human generations. Rice farming was established as the dominant mode of land use in western Taiwan by 2500 BC, and the most suitable landforms were occupied almost immediately. As soon as the low coastal landforms in eastern Taiwan had uplifted enough to support settlement after 2500 BC, people began to settle in a number of sites in these new habitats. Shortly thereafter, further migrations occurred across the Bashi Strait into the Philippines in what we infer to have been the MP expansion at 2200–2000 BC.

Given the fact that much of Taiwan's eastern coastal lowlands did not even exist above sea level until after 2500 BC, the influx of people thereafter resulted in a radical shift in the archaeological record (Hung 2005). In places such as Dulan Bay as highlighted here, the archaeological record suddenly transitioned from no cultural presence to a densely populated landscape. For the eastern coast of Taiwan as a whole, pre-2500 BC sites were inhabited farther to the north and in different paleo-landforms.

The timing of the MP dispersal from Taiwan correlated with a brief but sharp period of aridity and cooling around 2200 BC that caused crises for many societies across Asia (Yasuda 2008). At approximately that time, a drastic dry and cool episode has been indicated in pollen records of Taiwan (Liew and Huang 1994). These conditions especially distressed the groups that relied on predictable annual rainfall for agriculture in fixed territories with limited options for expanding or intensifying their land-use patterns. Drought and lowered water tables in eastern Taiwan would have increased vulnerability to erosion by the frequent typhoons that characterize this area, thus reducing the ability to produce enough food for a growing population and thereby encouraging some people to seek new farming lands overseas.

The paleo-landscape of initial MP settlement in the northern Philippines offered opportunities similar to those already known in eastern Taiwan but at a much larger scale, such as in the immense Cagayan Valley. Therefore, the effects of population growth were not as severe as in eastern Taiwan, and they may have been delayed until a few centuries later, around 1500 BC, when the next cross-regional population movements were evident in the cross-regional archaeological record, concurrent with substantially different landscape contexts in the Cagayan Valley and elsewhere. Since the beginning of the pottery-bearing horizon around 2200–2000 BC, the cultural use of the ancient landscape definitely involved land clearing and burning in preparation for formal housing and food production, but the role of rice as a dominant aspect of the land-

use system was attested most strongly in later contexts. These circumstances suggest that people obtained sufficient food and resources from the Lower Cagayan Valley through varied strategies of horticulture and forest management for a few centuries without investing in high-volume production of rice until some centuries postdating the initial pottery-bearing horizon.

A geographic spread of pottery-bearing sites into more parts of the Philippines and furthermore into Indonesia became widely evident about 1500 BC, coincident with the first remote-distance overseas migration into the Mariana Islands (Carson et al. 2013; Hung et al. 2011). This cross-regional record accords with the hypothesis that people were motivated to find new lands only after some centuries postdating the initial pottery-bearing horizon in the northern Philippines. When people expanded into new territories after 1500 BC, they enacted variable modes of land-use practice that did not always emphasize rice farming. During these later episodes in the MP diaspora, people inhabited a diversity of landscapes different from the ancient MP homeland, as examined here, and the ancestral land-use systems should not be expected to have continued unchanged.

This case of the ancient MP homeland ideally will encourage more paleo-landscape research, applicable anywhere in the world and for any time period. These kinds of concrete examples always bear significant potential beyond their individualistic boundaries, and they provide exactly the factual information needed toward developing responsible policies of coping with sea-level rise, climate change, and impacts on water resources and agricultural lands (Nunn 2013; Nunn and Carson 2015). By contextualizing actual human behaviors within their full scope of a natural-cultural setting, we can learn more realistically about what was successful or unsuccessful under specific circumstances.

To the extent that a landscape setting contributed to the outcome of natural or cultural history, it should be included as part of the founding premise or practical parameters of examining a cultural event or process. Otherwise, explanatory hypotheses about the reasons for evident events (e.g., a migration of people from one region to another, the domestication of certain plants or animals in a particular region, or the geographic spread of farming) tend to be advanced without the complete picture of a correlation between the cultural actions and their supporting contexts. Indeed, in a view of landscapes as embodying the results of continual natural-cultural history, paleo-landscape research bears great potential for expanding our knowledge of almost any aspect of the archaeological record or about human-environment relations in general.

Acknowledgments

Guidance from three anonymous reviewers and the journal's editorial team improved our work. Research funding was provided by the Chiang Ching-kuo Foundation (RGO17-P-13) and by the Australian Research Council (DP150104458).

Comments

Ian Buvit
Southern Oregon University, 1250 Siskiyou Boulevard, Ashland, Oregon 97520, USA (ibuvit@gmail.com). 23 II 18

The archaeology of islands, peninsulas, and other coastal environments of the Pacific is today proving more relevant than ever to understand the global expansion of *Homo sapiens* (Kaifu et al. 2015). As an archaeologist interested in the relationship between Pacific Rim cultures and Paleoindians, I found Carson and Hung's article to be highly informative. Carson and Hung mention that, while somewhat far removed in space and time from their study, the investigation of the Pleistocene peopling of the Americas is a case requiring full consideration of changing coastal landscapes. For decades, the debate was almost entirely focused on terrestrial adaptations described in the dominant Clovis First model, with a few far-out thinkers, seemingly, who proposed alternatives involving watercraft (Meltzer 2009). While certainly there is evidence that some people crossed Beringia on land (Potter et al. 2017), I am one who believes discussions about late-glacial social transmission and human migration throughout the Pacific Rim should include boats. Moreover, island and coastal studies, like Carson and Hung's, can contribute to our understanding of Pacific prehistory on a broad scale.

There is much to gain by staying current with hypotheses, analytical techniques, and models being pursued by others, like Carson and Hung in their paper, who investigate coastal sites. For example, their article includes brilliant maps showing diachronic changes in the landscape that are critical starting points for understanding the past. In addition to the topic's relevancy in the broader Pacific Rim, the authors raise two other especially important points: the constantly changing landscapes of island and coastal environments and the immense value of studying human land use on them.

From this perspective, as Carson and Hung so persuasively argue, islands and other marine coasts are, and have been, some of the most dynamic landscapes on earth, sensitive to a wide range of natural processes such as sea-level change, slope movement, and tectonics, which can disturb material evidence of the past. As much as anywhere, surface stability on marine coasts undergoes quick, profound shifts to periods of deposition or erosion. Yet humans have been drawn to these locations for thousands of years, and much is to be gained by investigating archaeological sites in such environments. Carson and Hung, for their part, offer a snapshot of an extremely important location (Taiwan and Island Southeast Asia) and time (between 2500 BC and 1500 BC) when red-slipped pottery coincided with the spread of agriculture. Excavations in Taiwan and the Philippines produced evidence of domesticated rice and pigs. These are part of what is termed the Fushan Culture after the site where it was originally defined in Taiwan. The complex's distinctive ceramic assemblage has been firmly radiocarbon

dated to the critical time period between 4500 and 3500 years ago. The authors describe a particular way of life associated with Fushan assemblages and how it spread to nearby islands.

Throughout the paper, human land use is another very important theme, both diachronically (2500–1500 BC) and synchronically (among Taiwan, the Philippines, and the surrounding area). The authors embrace a concept of landscape evolution, with which I fully agree, that frames archaeological studies around long-term changes brought on by natural and cultural processes. Central to their approach is niche construction theory, which emphasizes human selection of, adaptation to, and modification of very specific environmental zones over many generations. Evidence of land use can provide valuable information about past human behavior. In the case of the MP diaspora, for example, as Carson and Hung describe, it was the placement of rice and millet fields. As the authors point out, however, there is evidence that MP expansion, including beyond the northern Philippines after 1500 BC, involved land use other than for agriculture. As for late Pleistocene and early Holocene hunter-gatherers in the far north Pacific, these choices about where to carry out activities may have had to do with seasonal resources, social norms, technological constraints, or other reasons. Any way, consideration of past land use must be framed in the context of past landscape change, when in some cases the environment was drastically different from one period to the next.

I will end with a statement that stood out slightly more than the rest: "Without necessarily adhering to any particular theoretical paradigm, the material-based records of paleo-landscapes can substantiate the contexts that once existed at different points in time as a means to explore other research themes, as we articulate here." I think this resonates a fundamentality that well-founded geoarchaeological underpinnings (i.e., numerical chronologies, landscape reconstructions, interpretation of natural formation processes) have in archaeological science. Without these critical data, we are prone to mistakes, misinterpretation, and misguidance.

Jean-Christophe Galipaud
Institut de Recherche et de Développement and Museum National d'Histoire Naturelle, 57 rue Cuvier, CP 51, 75231 Paris Cedex 05, France (galipaud@arkeologie.net). 11 III 18

The paper is an in-depth review and offers several avenues for comments. It addresses questions of immediate relevance for our understanding of the Neolithic expansion process across Island Southeast Asia and Oceania.

I understand the wish or necessity for the authors to restrict the scope of this exercise to East Taiwan and the north of the Philippines during the initial MP dispersal, but I do not agree with their justification of this choice, namely, that "later episodes involved qualitatively different forms of pottery and changing landscape contexts that should not be conflated with our present focus on the initial MP dispersal."

I believe that limiting the discussion to the immediate MP homeland may highlight the natural conditions that made the Austronesian diaspora toward the east possible but does not address the more important issue of the diaspora elsewhere in Island Southeast Asia, at least not beyond the putative homeland where rice farming can be seen as the reason for expansion following Bellwood's (2001, 2005) farming and language dispersal model. The focus on rice cultivation as the obvious reason for land use in the past for these coastal communities can obliterate some other important realities, for instance, the proximity of the sea for economic, transport, and spiritual purposes.

The paper quite clearly demonstrates anew that activities in East Taiwan during the Fushan period and in northern Luzon around the Cagayan Valley during the same period are related. It also quite clearly reminds us that the Mariana Islands discoveries are part of the same process, hence allowing the association of initial dispersal events with the spread of Austronesian languages.

By emphasizing the coastal nature of the new environments and the evident dependency on marine products by these people, the paper hints at the obvious—the observed connections between east (and perhaps south) Taiwan, the Philippines, and Micronesia provide strong evidence for the emergence of maritime-oriented communities. In this context, it is necessary to address the cultural importance of rice cultivation for these communities.

What we see appearing here is not only the embryo of a Neolithic culture which exceeds the borders of Taiwan and spreads toward the nearby islands but also the possible beginnings of a more global movement carried by values inherited from China and matured on the west Taiwan coastal plains with the development of rice agriculture. For example, red-slipped ceramics, often with complex decorative forms and later human faces, are increasingly associated with burials in urns and are found in new maritime-oriented coastal settlements across Island Southeast Asia and the Pacific. The importance of pottery in both functional and spiritual contexts and the sudden increase in the technology for efficient interisland travel across the region are important aspects of the "Neolithic package" (fully polished stone adzes, a variety of shell artifacts including bracelets and beads, tattooing chisels, fishhooks, bark cloth beaters, and stone net sinkers (Bellwood 1997:219–30, 2002:26) and highlight sociocultural aspects of this culture (Galipaud et al. 2016; Spriggs 2011).

In the Lesser Sunda Islands, red-slipped ceramics are present as urns in large coastal cemeteries as early as 1000 BC (Galipaud et al. 2016). While there is no evidence of rice in the recently excavated site of Pain Haka, in eastern Flores, for instance, the size of the cemetery and the nature of grave goods (coral and large seashells) does points toward a well-established shared regional maritime culture by 1000 BC with obvious cultural roots in the Taiwan-northern Philippines interaction sphere.

A similar maritime expansion is attested by at least 1200 BC for the southwestern Pacific, and the Lapita sailors share not

only a red-slipped ceramic with complex forms and face designs (Spriggs 1988) but also some genetic affinities (Skoglund et al. 2016).

Importantly, it does not matter so much if rice is not the dominant crop on these islands, and it actually does not matter so much if rice disappears in similar Neolithic contexts further south and east. It also, I believe, is not of great relevance to assess whether or not those early explorers transported pigs and chickens to newly settled lands. What matters is the evidence of a shared culture around symbolic objects such as red-slipped ceramics and jade ornaments, and also obsidian in similar natural contexts outside of Taiwan. This evidence shows that there were massive changes in the way Neolithic people perceived the world. The much earlier economic development witnessed in China and Taiwan facilitated the emergence of new actors taking advantage of newly discovered coastal environments. Therefore, I believe that it will be fruitful to extend the scope of such an approach to encompass all early Neolithic settlements in the Southeast Asian islands as well as in Oceania. Rather than trying to model an ideal early Austronesian diaspora in a local area, it is only by recognizing its rapid evolution and adaptation through space and time that will allow us to fully understand this period.

Quentin Mackie
Department of Anthropology, University of Victoria, Victoria, British Columbia V8P 5C2, Canada (qxm@uvic.ca). 14 III 18

Assembling a variety of proxies for past landscapes and then using these to create a way of navigating the present is familiar territory to archaeologists worldwide. When sea level, that most fundamental cartographic datum, is unmoored then the archaeologist may struggle to cast their imagination into radically differently shaped worlds. Islands become archipelagos, and archipelagos become islands, with the rise and fall of the sea. Working as I do on the west coast of Canada, it is exciting to read of another area where sea-level history plays a fundamental role in the long-term adaptive constraints and possibilities of past peoples, and also a prominent role in puzzling archaeologists in the present. Reading that some of the apparent, relative sea-level change is the result of direct depositional formation processes (e.g., shell discard) or anthropogenically induced erosional processes that allowed intensive wetland rice farming stimulates a range of thoughts from the perspective of the Northwest Coast.

In common with the MP example, environmental change on the Northwest Coast is a product of both human and natural agency. For example, it has recently become clear that large stretches of the British Columbia coast were enhanced by the construction of "clam gardens," stone walls at zero tide that trapped sediments and increased shellfish productivity, in some cases even turning non-clam-bedrock shelves into productive intertidal zones (Lepofsky et al. 2015). Until about 2005, knowledge of these features (which can reach over 1 km in length) was not widely shared or recognized, and most archaeologists walked right over them, following their true calling of terrestrial archaeology. Similarly, a spectacular wetland site just east of Vancouver at Pitt Polder has been shown to include large gardens of broken rock, designed to enhance the productivity of Wapato (*Sagittaria latifolia*). These features are interpreted as evidence of niche-based coevolutionary interactions between humans and plants at 3800 cal BP (Hoffmann et al. 2016). Human use of marine resources, especially shellfish, are now known to enhance forest productivity (Trant et al. 2016), and the resultant middens can be interpreted as monuments in their own right (Grier, Angelbeck, and McLay 2017). These and many other subtle aspects of resource management and enhancement are recently reviewed by Mathews and Turner (2017). The net result is a movement away from viewing the Northwest Coast First Nations as anthropological outliers, "complex hunter gatherers," and toward considering the multiple dimensions of human-environment interaction. "Niche construction," yes, but so much more when liberated from false dichotomies such as "food producer" and "food collector."

Another point of shared interest is the variety of sea-level histories noted by Carson and Hung. The causal factors in their areas seem to be primarily tectonic and eustatic, with the addition of localized anthropogenic influences. On the Northwest Coast, a complex interplay between eustatic and isostatic forces produced wildly different sea-level histories in the late Pleistocene—ranging from 200 m above modern to 150 m below modern, simultaneously (McLaren et al. 2014; Shugar et al. 2014). The average annual rise and fall could 10 cm for millennia at a stretch. With moving relative sea levels, archaeological site locations are in otherwise very unsuspected places, causing a serious challenge in finding sites older than about 5,000 years in most areas. However, while fine-grained paleo-environmental reconstructions are necessary, they are not sufficient. In some places and times, sea level was rapidly rising, perhaps 5 m in a single human lifetime. Rapid transgression as a process has few environmental or cultural analogues, but we can infer that the terrestrial vegetation will be killed, producing ghost forests and logjams. At the same time, transgression may pump iron and organic nutrients into the nearshore. Shrinking land may compress populations, and the relentless rise of the ocean may produce an environment which is, as Leary (2009) puts it for Doggerland, mournful, eerie, and infused with loss. Memories of drowned paths and places will persist, as people fish at their great-grandparents' natal villages. Conversely, where sea level is falling 5 m in a lifetime, the intertidal zone becomes stranded and a barren death zone will appear, perhaps taking a lifetime to revegetate, enabling uncomfortable dust storms, and discouraging people from simply following the falling waters. The authors' comments that a full range of paleo-landscapes need to be considered in the First Peopling of the Americas question are well taken. It is not adequate to merely understand the ancient environment in isolation: many possibilities of cultural behavior must be recognized. For example, Anderson and Gillam's (2000) cost-surface

modeling exercise (which is rightfully influential and widely cited), does not incorporate paleo-coastlines, and passages of water more than 1 km wide are treated as absolute barriers to human movement. The latter is a radical projection of a terrestrial archaeological bias, combined with inadequate paleolandscape data. The affordances of the paleo-environment only exist in relation to human desire and available technology.

Carson and Hung maintain that materially defined paleolandscapes allow for correlation and causation to be determined from the archaeological record, contrasting this with modern-day theorists who seek to impose "their ideas into the past without knowing about the real contexts." Tension between method and theory is itself an old story in archaeology. I certainly admire the authors' strong empirical grounding and agree with their argument for long-term environmental and cultural history to be considered together. At the same time, I agree with Gosden and Head's (1994) assertion that the notion "landscape" should be welcomed as a "usefully ambiguous" concept, mediating between or mutually constituting humans and their environments. The past is a foreign country, but it is also over, and ancient landscapes exist only in the present day. It is largely through sensitive application of theory that we can effectively populate these lost worlds.

Patrick D. Nunn
Sustainability Research Centre, University of the Sunshine Coast, Locked Bag 4, Maroochydore DC, Queensland 4558, Australia (pnunn@usc.edu.au). 4 II 18

The key message underpinning Carson and Hung's insightful paper remains worth reiterating. The most elegant expression of it that I know was by William R. Dickinson (1995:1) in his 1994 presidential address to the Geological Society of America: "The widespread impression that civilization is the only disjunct influence on an otherwise fixed tapestry of nature is a dangerous misperception that can lead to much folly."

Studies like that by Carson and Hung move beyond any charge of "folly" and also demonstrate the insights that can be gained by reconstructing paleo-environments alongside human behavior. Their story of how an absence of valleys in eastern Taiwan prior to 2500 BC forced its inhabitants to pursue food-acquisition strategies that contrasted with those of people in less tectonically active western Taiwan solves a long-standing dilemma. The subsequent transformation of the island's east-coast landscape and the opportunities it provided for enhanced food production demonstrates how environmental change can drive societal changes, a narrative that parallels the well-documented alternations of Holocene livelihood-settlement pattern driven by relative sea-level change in continental East Asian deltas (Chen et al. 2008; Wang et al. 2013).

This study also shows how island environments and island societies are different from those of continents, how they invariably require interpretations cognizant of water as more of an opportunity—an adaptation option, in modern parlance—than a barrier. It is becoming clear that ancient island societies in every part of the world were far more oceanic than commonly realized by those who once viewed them solely through continental lenses and established interpretive orthodoxies that unfortunately still pervade most conversations about island futures today (Gillis 2014).

If we admit that landscape had a profound effect—as in eastern versus western Taiwan—on human behavior and that, in order to understand this properly, we need to reconstruct paleo-environments, the question arises of how far back in time we should usefully go. Undoubtedly, the deep roots of the MP diaspora lie in Sundaland, the vast area of land exposed by lower sea level during the Last Glacial Maximum 18,000–22,000 years ago. It is now certain that Sundaland's lowland landscapes were dominated by vast deltas and broad well-watered river valleys that proved magnets for hunter-gatherers and conceivably hosted some experiments in agriculture (Bird, Taylor, and Hunt 2005; Wang et al. 2009). A range of insights, from phylogenetics to material culture (Jinam et al. 2017; Palmer 2007), establish connections between the former inhabitants of Sundaland and those of Japan and the Philippines, which provides a context for the understanding of the establishment and breakup of the MP homeland.

Geographers today appear to have fewer reservations than anthropologists and archaeologists about environmental change driving past cultural transformations. It was not always thus, of course, but the kind of cautions duly expressed by Carson and Hung about correlation not being enough would today perhaps not be given such pondered consideration in other disciplinary contexts. If it looks, sounds, and behaves like a duck, it probably is one. And there have been numerous compelling studies of climate-environmental change dislodging human societies from their evolutionary trajectories; recent studies from Belize (Akers et al. 2016), western Japan (Kawahata et al. 2017), and the Peloponnese (Weiberg et al. 2016) exemplify the point.

Carson and Hung demonstrate the causal links between landscape change and food production well but they are more circumspect about the possibility of concatenated climate-driven societal changes stimulating cross-ocean exploration and settlement. I do not share the authors' circumspection in this instance. It has long seemed to me that rapid postglacial sea-level rise along the Pacific fringes of continental Asia must have led to displacement and overcrowding and eventually forced the development of the extended maritime skills needed to eventually discover and colonize islands hundreds of kilometers offshore (Nunn 1999, 2007*b*); why else did the achievements of western Pacific seafarers in 1500 BC so far surpass those of people in other parts of the world at this time?

To me, the sequence proposed by Carson and Hung—of population growth in eastern Taiwan following lowland emergence (2500 BC) forcing out-migration to the Philippines (2200–2000 BC) and thence to the islands of Micronesia—is entirely plausible. A comparable scenario was proposed for Fuzhou (Rolett, Zheng, and Yue 2011) and is implicit in studies of so-

cietal disruption on tropical Pacific Islands around AD 1300, plausibly caused by a prolonged food crisis driven by sea-level fall and global cooling (Nunn 2007*a*).

Finally, it seems to me extraordinary that so few anthropologists give any credence to the possibility that climate-forced sea-level rise during the Holocene changed land-based peoples into sea nomads, most of whom—for perhaps a few millennia—became more comfortable on their boats than on land. What other explanation can there be for the apparently purposive voyages of discovery by Lapita peoples and their northern Pacific counterparts? Where is the evidence of the pioneer voyagers, the exploratory landings, that you might expect to have preceded purposive voyaging? Could it perhaps be that sea nomads monitored these islands, regularly assessing their fringes for possible sedentary occupation? Some data suggest this (Kusuma et al. 2015; Nunn 2016). And why indeed were the earliest Lapita settlements in so many places built on stilts out across reef flats, the adjacent land unoccupied? Could it be, as Carson and Hung remind us, that we still suffer under the yoke of "modern-day theorists" who uncritically impose their prejudices on the past "without knowing about the real contexts"?

Glenn R. Summerhayes
Anthropology and Archaeology, University of Otago, PO Box 56, Dunedin, New Zealand (glenn.summerhayes@otago.ac.nz). 26 II 18

The paper by Carson and Hung is an important and refreshing one. For the first time, a major paleo-landscape reconstruction is provided, giving us a glimpse into the landscapes faced by the prehistoric peoples from east coast Taiwan and northern Luzon between 2500 and 1500 BC. Such reconstructions are critical in allowing a deeper understanding of the nature of these settlements and in providing a useful background for constructing models incorporating population pressure constrained by the local landscape changes in explaining the movement of people out of Taiwan and into the Philippines. I agree with the authors, who emphasized the problems faced by archaeologists in actually getting data on "food resources and landscape management at the beginning of the MP dispersal." This paper meticulously looks at this problem and sets out for the first time the limited role of rice in this "ancient land-use system." Rice was important in later occupation, but its role earlier on was restrained by environmental constraints. It is made abundantly clear that the landscapes we see today were not the landscapes faced by these early people. The reconstruction of the landscape around Fushan between 2500 and 1500 BC is brilliant. Rather than living on hilltops we see today, this landscape was one of paleo-seashores "freshly exposed above sea level." They occupied this area as soon as it was available. It is argued that a completely different land use system developed by 1500 BC, allowing alluvial lowlands we see today. The landscape reconstructions at Nagsabaran are also important, demonstrating that the earliest settlement was made up of people living in stilt houses over "low mounded silty sediments at the water's edge." This was not the case with later occupation.

Knowledge of past landscape has also been critical in modeling the nature of early Lapita settlements and their impact on the environment (Summerhayes, Leavesley, and Fairbairn 2009). Most of the earliest Lapita settlements in the Bismarck Archipelago at 1350 BC were made up of stilt village occupation either over water or near the water's edge, with landed villages occurring much later in time (Gosden and Webb 1994; Kirch 2001; Summerhayes et al., forthcoming). Understanding past landscape use and the role people played in landscape change is crucial in understanding past societies.

Last, I wish to point out that eastern Taiwan is also linked to colonizing events further to the east. At the same time things are happening in Taiwan and northern Philippines (2500–2000 BC), there is evidence for the movement of people out of eastern Taiwan and into the Yaeyama Islands about 250 km to the east. Here the Shimotabaru culture formed a short-lived colonizing population (Summerhayes 2018; Summerhayes and Anderson 2009). The paleo-environmental reconstructions undertaken on the Shimotabaru sites are crucial in interpreting the nature of settlement (Summerhayes and Anderson 2009:78–79). Incorporating the Shimotabaru culture into this movement out of Taiwan shows another colonizing event, but one with short-lived outcomes.

Yijie Zhuang
University College London, Institute of Archaeology, 31–34 Gordon Square, London WC1H 0PY, United Kingdom (y.zhuang@ucl.ac.uk). 5 III 18

As a non-Southeast Asian archaeologist who is interested in long-distance cultural transmission in general, I read Carson and Hung's article with an appreciation of their great efforts in reconstructing the paleo-landscapes of prehistoric populations in Taiwan and Island Southeast Asia and demonstrating their significance in regional interactions. There is little doubt that strong interregional connections existed between these two regions, which saw the comings and goings of people, goods, and ideas. Much research has been conducted to disentangle these events initiated by farmers, hunter-gatherers, and seagoers living in different landscapes, and numerous theories have been proposed to understand these processes. Disagreements, however, persist and seem to have widened with more geographic regions and more data now entering into the debate. One of the key issues that has long been neglected is the lack of understanding of local landscapes, which were, as the authors put it, the "founding premise" of any kinds of interactions and should be the "practical parameters" of any kind of examinations of cultural processes. This scarce attention to the paleo-environmental contexts often leads to simplistic explanation of prehistoric interactions, as if people could always move easily and freely in any direction and to any new environment. In this sense, this

article is a timely contribution to the field in order to bring the related debates and questions forward.

Unlike the studies of typical agrarian landscapes in inland areas where evidence of sedimentary processes and landscape formation is often traceable, unpacking coastal landform processes is often challenging due to either the loss of or weak signature of such processes. The most important achievement of Carson and Hung's article is to robustly synthesize paleoenvironmental data, based on their detailed surface surveys, with archaeological evidence of prehistoric subsistence economies (e.g., phytoliths and charcoal from archaeological sediments). Carson and Hung's illustration of these landscape mosaics or variable environmental niches is significant. This helps to make sense of the initial founding of farming, its importance in the local land use that was primarily focused on the exploitation of mosaic local sources, and why farming spread. The conditions of population and societal growth in many regions of Southeast Asia are constrained by environmental conditions and changes. The environment in eastern Taiwan, for instance, was characterized by hilly terrains between 5,000 and 4,000 years ago. As such, it did not support the horizontal expansion of rice fields and perhaps large-scale transformation of such hilly terrains to agrarian landscapes. The subsistence patterns at the sites mentioned in Carson and Hung's article and other contemporary sites are indeed quite curious. Rice did not certainly account for the majority in these archaeobotanical assemblages; rather, millets were predominant amongst the cultivated crops. Presumably there are existing links for the transmission of these crops from the mainland into Taiwan (from where and how, whether as a package along with mass migration or other means, remain controversial). How these crops adapted to the new environment is crucial to assess the significance of these new crops in transforming or not transforming local societies and their landscapes. Carson and Hung's work provides new insights on how the society incorporated new crops into indigenous subsistence patterns and how those groups developed and responded to environmental and ecological bottlenecks in this drastically changing landscape with active tectonic activities once the ecological threshold had been reached and could not support further socioeconomic growth.

Similarly, the new environment encountered by the immigrants moving into Island Southeast Asia was equally challenging. Connections between Taiwan and some areas such as the northern Philippines, as manifested by their similar pottery assemblages, are clear. Evidence of rice farming is, however, scattered, which is in accordance with the reconstructed landforms surrounding these rice-bearing sites. Environmental realities also affected prehistoric migrants in their new settings. It is often assumed that rice farming, once established in the homeland, remains an attractive subsistence strategy to both the new immigrants and local indigenous in a new environment. This assumption has many problems, as it fails to consider why and how the immigrants would invest substantial effort in their new homes to construct a suitable habitat for rice growth and whether it was sustainable. Ecologically, is it always the case that rice farming was the most optimal mode of food production in prehistoric Island Southeast Asia, especially when other resources were available? Is it wet rice or dry rice that was brought into new environmental habitats? Evidence from elsewhere seems to suggest it was dry rice that first arrived in some places. Was this also the case for the sites in the northern Philippines? Carson and Hung's survey offers new evidence for these questions. Their paleo-landscape reconstruction helps to understand the patchiness of local landscapes, which determines trajectories of prehistoric farming regimes and subsistence economies. Dry rice—compared with wet rice, which required more labor and other investment—would have been better suited for such terrains.

As an outsider of the debate on issues surrounding the Island Southeast Asia prehistory, I see great theoretical and methodological values of Carson and Hung's article in furthering our knowledge of prehistoric interactions, some of which also face the research of East Asian prehistory. An important direction to further unpack such unique society-landscape dynamics would be to more accurately reconstruct the subsistence strategies of rice farming, marine food consumption, and other food production activities and assess how local societies cope with potential environmental challenges, either short term (several generations) or longer term (e.g., the so-called 4.2 ka BP event). With their unique pattern of social evolution and adaptations to local environments revealed, the Southeast Asian case might provide new insights into the old question on the resilience and mobility of human societies faced with environmental challenges.

Reply

We are grateful to our colleagues for their consensus in support of our work and, moreover, for outlining several implications and directions of paleo-landscape research. The comments encourage us to consider how our paleo-landscape findings for eastern Taiwan and the northern Philippines at 2500–1500 BC could be applied in other geographic areas and time periods. Following these comments, we may expect a surge of new thoughts about Asia-Pacific archaeology, as well as generally about integrating the materialistic nature of paleo-landscape studies with the social inquiries of anthropological archaeology.

Within the limits of this research article, we focused on the opportunities and constraints that people met in their landscapes at the beginning of an impressive population dispersal in the Asia-Pacific region that would unfold over the course of more than 3,000 years and across diverse contexts. Could we evaluate how people used their available landscapes, and then could we trace how their land-use patterns may have been reenacted or modified in the cognitive templates of "transported landscapes" when later generations of people moved into new territories? Could we identify something about the paleo-landscapes in specific places and times that would have prompted

people to migrate overseas in search of new territories? Our colleagues agreed with us that the answers were "yes" to these questions, plus now we can expand on the results to explore a multitude of other questions.

Ian Buvit, Patrick Nunn, Quentin Mackie, and Yijie Zhuang emphasized the general and global implications of paleo-landscape research for creating holistic narratives of integrated natural-cultural history. Ian Buvit clarified how our approach could interface productively with a number of research programs, not only in the fields of geoarchaeology and paleo-ecology but also in broader perspectives such as niche construction theory. Patrick Nunn called for more of this scope of work to stress the interrelations between physical and cultural aspects of landscapes, moving beyond both environmental determinism and cultural determinism. Quentin Mackie reminded us that our empirically based reconstructions of ancient landscapes can open new ways of thinking about diverse social and cognitive issues, embracing a liberal view of what landscapes are and how they could be studied. Yijie Zhuang highlighted how the physicalities of ancient landscapes could offer a confident way of exploring how people managed their resource habitats, with powerful implications for studying the origins and spread of farming systems, among other research topics.

All of our colleagues noted the potential for paleo-landscape research beyond our selected case study to answer larger questions in world archaeology. Jean-Christophe Galipaud, Patrick Nunn, and Glenn Summerhayes shared their views of how to address the various steps in the extended story of ancient migrations across the Asia-Pacific region. Yijie Zhuang expanded on the relevance for learning more about the emergence and spread of rice and millet farming systems in East and Southeast Asia. Ian Buvit and Quentin Mackie illustrated how paleo-landscape studies could change our views about ancient Beringia and the first peopling of the Americas. Furthermore, Glenn Summerhayes and Quentin Mackie commented on the practicalities of paleo-landscape investigations for finding different kinds of ancient sites in the first place, and Ian Buvit joined them in stressing the crucial nature of these primary data sets for generating new substantive research, regardless of any particular theoretical paradigms.

In terms of scrutinizing our specific case study and its immediate regional inferences, the Asia-Pacific commentaries by Jean-Christophe Galipaud, Patrick Nunn, and Glenn Summerhayes found our data presentation to be convincing, and they agreed with the logic of our interpretations of how people used their landscapes in eastern Taiwan and in the northern Philippines at 2500–1500 BC. Our colleagues noticed that the factual basis of our paleo-landscape research now allows us to assess the roles of farming, horticulture, forest management, and other elements of past land-use systems during one of the key movements of Austronesian people in their long story of migrations across the Asia-Pacific region. Otherwise, we have been missing the substantive support for testing radically different opinions and hypotheses about the roles of migration, land-dependent farming systems, demographic dynamics, environmental change, first-founder ideologies, sea nomadism, and more.

Our colleagues advised that our one case study here did not answer every question in Asia-Pacific archaeology, and more work would be needed for addressing other aspects as they outlined. Depending on the question being asked, we would need to look in different areas, time periods, and lines of evidence. We regard our current study as a solid start toward clarifying the complex landscape histories of the Asia-Pacific region, and we hope to see more paleo-landscape investigations throughout this region and worldwide.

In our view, the circumstances of land-use practice and migration episodes from eastern Taiwan into the northern Philippines at 2500–1500 BC likely were different from the contexts in other parts of the Austronesian or MP world and continuing through AD 1000 or later. We imagine that our colleagues in other regions will appreciate these sentiments, for example when building models of how people inhabited their environments and migrated through their landscapes at different time periods from the Pleistocene through Holocene. In our Asia-Pacific regional focus, the role of rice farming clearly lost prominence for the groups who migrated farther overseas into the Remote Pacific after 1500 BC, and accordingly we should acknowledge the different landscape contexts throughout a long series of migration episodes. Those groups still maintained certain of their older inherited cultural traits and traditions, for example, as seen in the continuation of red-slipped pottery at least through 500 BC, but eventually this tradition dwindled. Whether red-slipped or not, pottery making entirely disappeared from the cultural inventories of the people living eastward in Polynesia after AD 1000. Concurrently, the conditions of climate, sea level, and other aspects of the natural environment created differing scenes for people to engage in their land-use practices, such that their "transported landscapes" were ever-changing constructs with variable outcomes.

While noting the values of our case study for understanding the beginning portion of the Austronesian migration narrative, our regional colleagues mentioned a number of avenues that still could be explored. Glenn Summerhayes mentioned that a larger geographic view could help toward understanding the growing landscapes and seascapes of people moving from Taiwan eastward into the Yaeyama Islands of southwestern Japan, as hinted in pottery styles about 2500–1900 BC, and hopefully more of this research soon will solve a long-overlooked aspect of early Austronesian migrations. Building on what we outlined so far, Jean-Christophe Galipaud clarified that while people adjusted to their dynamic landscape settings, they nevertheless upheld long-term continuity in their use of red-slipped pottery, certain burial rites, and by extension a number of religious or ideological contexts that formed long-enduring traditions at least through 1000 BC if not much longer, certainly deserving of more study. Related to those longer lasting contexts, Glenn Summerhayes and Patrick Nunn both mentioned that post-raised houses over intertidal or shallow subtidal zones continued as the major mode of settlement by people moving into the Lapita world of Melanesia through West Polynesia through at least 1000 BC, although those housing formats eventually were unsustainable a few centuries later, after significant change in sea

level and coastal ecology. Patrick Nunn proposed to look deeper into the past, and perhaps we could discover entirely new information about the Pleistocene seashores that now have been submerged beneath the ocean from Southeast Asia through modern-day Australia and New Guinea. Patrick Nunn additionally commented on the role of sea nomads in ancient Pacific-crossing migrations, thus enhancing our view of landscapes and land-use practice to accommodate seascapes and seafaring traditions as well.

Concerning the part of our work related to the emergence and expansion of agricultural farming systems, Yijie Zhuang commented on how our findings could strengthen the growing body of research in China and worldwide. He noticed that wetland rice farming was not always an optimal or desirable mode of land-use practice in the cases that we illustrated in coastal settings, and furthermore these lessons could be applied in other places and times, in both coastal and inland contexts. For instance, more work could differentiate between dryland and wetland farming. Additionally, the remains of both foxtail millet (*Setaria italica*) and broomcorn millet (*Panicum miliaceum*) have been confirmed at sites such as Nanshan in inland Fujian as early as 3000 BC (Institute of Archaeology of the Chinese Academy of Social Sciences, Fujian Provincial Museum, and Mingxi County Museum 2017), at Huangguashan and Pingfengshan in coastal Fujian of southeast China by 2000–1500 BC or possibly earlier (Deng et al. 2018*b*), and at Nangunglidong in southwestern Taiwan by 2300 BC (Tsang et al. 2017). Our other studies in the Lower Cagayan Valley of northern Luzon (reporting in preparation with Zhen-hua Deng) discovered the remains of millets and other plants that could substantiate a more detailed picture of early MP landscapes beyond what we have reported here so far.

We share Yijie Zhuang's opinion that more studies of paleo-landscapes could be highly productive for illustrating more than just rice and millet farming, and indeed we aim to learn broadly about how people engaged in different relative roles of forest management, dryland farming, wetland farming, and other subsistence land-use patterns. Next, when we add the diverse nature of coasts and seashores into these studies, then we can demonstrate more accurately about how people have developed complex land-use and resource-use patterns worldwide. As Yijie Zhuang noted, studies in coastal regions unfortunately have been less prominent than their landward counterparts when building scholarly models about ancient landscapes and land-use systems.

Ian Buvit and Quentin Mackie offered compelling examples of how paleo-landscape studies are critical in making sense of coastal sites worldwide and in reviving the seemingly underappreciated roles of coasts in global reviews of archaeology. They highlighted the implications for learning more about how people used their coastal habitats and resources during variable Pleistocene and Holocene conditions, during the first peopling of the Americas, and through longer sequences of ever-changing coastal settings. Ian Buvit and Quentin Mackie both encouraged for more case-specific empirical studies to build new knowledge, noting how the issues are vastly complex and variable for studying the coasts of Beringia and northwestern America, not only during the late Pleistocene and early Holocene but also during any time period. Ian Buvit noted the potential for more cross-comparisons of ancient Pacific Rim and Paleoindian cultures and their landscapes. Quentin Mackie pointed to a number of new discoveries about the paleo-landscapes and complex lifeways of people along the ancient seashores of British Columbia, portraying the First Nations people and their ancestors as much more than coastal foragers or food collectors.

We hope that researchers in other regions may improve on our approach for exploring how widely certain landscape systems may have been distributed, when they started, when they ended, and what may have caused them to change. A similar logic would apply for studying more about the geographic and chronological definitions of paleo-landscapes that may or may not have correlated with particular artifact traditions, housing formats, burial practice, or other indicators of cultural contexts. Cases of correlations and noncorrelations both should be examined, but we need to begin with outlining the paleo-landscape evidence as a frame of reference. A generous perspective of landscapes would be essential, starting with the physically definable aspects and then coordinating with various lines of evidence about where people lived, what artifacts they made, what foods they ate, and generally how they behaved and interacted with their landscapes. Another intriguing new direction has been emerging in physical anthropological studies about the actual people who inhabited specific paleo-landscapes, for example looking at the biological population structures before, during, and after the spread of farming economies in southern China (Hung et al. 2017).

At this point, building on the case that we have illustrated of the early MP land-use systems and migrations at 2500–1500 BC, we can enlarge our work to compare with neighboring regions at that time and furthermore in a sequence of continuing time intervals. This research program was outlined in a recent synthesis of Pacific Oceanic archaeology (Carson 2018), in a chronological narrative of the different circumstances of people migrating across an ever-growing geographic expanse of the Pacific at 1500 BC, at 1000 BC, at AD 100, at AD 1000, and so on. In this "incremental growth model," certain aspects of natural and cultural histories persisted across each of those incremental steps individually, yet others definitely changed at variable paces and magnitudes. The oldest versus youngest components of the narrative showed only a few but important points of persistent continuity, while the overall picture revealed complex and dynamic operations of natural-cultural landscapes cross-regionally.

Among the most strongly stated themes in the comments, our colleagues consistently stressed the potential for paleo-landscape research to reveal information that we could not detect on the basis of modern-day landscapes and historical references. Our colleagues added to our case study with several examples of how paleo-landscape investigations can revolutionize the way we conceptualize the past, notably in coastal

regions that have been profoundly important in human societies yet somehow have been under-studied until recently. As always, we anticipate more discussions, ideally based on relevant primary data sets, and hopefully a renewed interest in paleolandscapes will provide the inspiration and the scholarly framework for further research.

—Mike T. Carson and Hsiao-chun Hung

References Cited

Akers, Pete. D., George A. Brook, L. Bruce Railsback, Fuyuan Liang, Gyles Iannone, James W. Webster, Philip P. Reeder, Hai Cheng, and R. Lawrence Edwards. 2016. An extended and higher-resolution record of climate and land use from stalagmite MC01 from Macal Chasm, Belize, revealing connections between major dry events, overall climate variability, and Maya sociopolitical changes. *Palaeogeography Palaeoclimatology, Palaeoecology* 459:268–288. [PDN]

Anderson, David G., and Thaddeus G. Bissett. 2015. The initial colonization of North America: sea-level change, shoreline movement, and great migrations. In *Mobility and ancient society in Asia and the Americas*. Michael David Franchetti and Robert Spengler III, eds. Pp. 59–88. Cham: Springer.

Anderson, David G., and J. Christopher Gillam. 2000. Paleoindian colonization of the Americas: implications from an examination of physiography, demography and artifact distribution. *American Antiquity* 65:43–66. [QM]

Aoyagi, Yoji, Melchor L. Aguilera Jr., Hidefumi Ogawa, and Kazuhiko Tanaka. 1993. Excavation of hill top site, Magapit shell midden in Lal-lo shell middens, northern Luzon, Philippines. *Man and Culture in Oceania* 9:127–155.

Aoyagi, Yoji, Hidefumi Ogawa, and Kazuhiko Tanaka. 1997. Excavation and ornaments discovered at the Magapit shell-midden site in northern Luzon. *Journal of Sophia Asian Studies* 15:167–180.

Barker, Graeme, and Monica Janowski, eds. 2011. *Why cultivate? anthropological and archaeological approaches to foraging-farming transitions in Southeast Asia*. Cambridge: McDonald Institute for Archaeological Research.

Bellwood, Peter. 1996. Hierarchy, founder ideology an Austronesian expansion. In *Origins, ancestry and alliance: explorations in Austronesian ethnography*. James J. Fox and Clifford Sather, eds. Pp. 18–40. Canberra: Austraian National University Press.

———. 1997. *Prehistory of the Indo-Malaysian Archipelago*. Honolulu: University of Hawai'i Press. [J-CG]

———. 2001. Early agriculturalist population diasporas? Farming, languages, and genes. *Annual Review of Anthropology* 30(2001):181–207. [J-CG]

———. 2002. Farmers, foragers, languages, genes: the genesis of agricultural societies. In *Examining the farming/language dispersal hypothesis*. Peter Bellwood and Colin Renfrew, eds. Pp. 17–28. Cambridge: McDonald Institute for Archaeological Research. [J-CG]

———. 2005. *First farmers: the origins of agricultural societies*. Malden, MA: Wiley Blackwell.

Bellwood, Peter, Geoffrey Chambers, Malcolm Ross, and Hsiao-chun Hung. 2011. Are "cultures" inherited? multidisciplinary perspectives on the origins and migrations of Austronesian-speaking peoples prior to 1000 BC. In *Investigating archaeological cultures: material culture, variability, and transmission*. Benjamin Roberts and Marc Vander Linden, eds. Pp. 321–354. New York: Springer.

Bellwood, Peter, and Eusebio Dizon, eds. 2013. *4000 years of migration and cultural exchange: the archaeology of the Batanes Islands, Northern Philippines*. Terra Australis 40. Canberra: Australian National University Press.

Bird, M. I., D. Taylor, and C. Hunt. 2005. Palaeoenvironments of insular Southeast Asia during the last glacial period: a savanna corridor in Sundaland? *Quaternary Science Reviews* 24(20–21):2228–2242. [PDN]

Blust, Robert. 2013. *The Austronesian languages*. Asia-Pacific Linguistics Open Access Monographs 8. Rev. ed. Canberra: Research School of Pacific and Asian Studies, Australian National University.

Bronk Ramsey, Christopher, and Sharen Lee. 2013. Recent and planned developments of the program OxCal. *Radiocarbon* 55:3–4.

Butzer, Karl W. 1982. *Archaeology as human ecology*. Cambridge: Cambridge University Press.

Carson, Mike T. 2011. Palaeohabitat of first settlement sites 1500–1000 BC in Guam, Mariana Islands, western Pacific. *Journal of Archaeological Science* 38:2207–2221.

———. 2014*a*. *First settlement of Remote Oceania: earliest sites in the Mariana Islands*. Springer Briefs in Archaeology. New York: Springer.

———. 2014*b*. Paleoterrain research: finding the first settlement sites of Remote Oceania. *Geoarchaeology* 29:268–275.

———. 2016. *Archaeological landscape evolution: the Mariana Islands in the Asia-Pacific region*. Cham: Springer.

———. 2018. *Archaeology of Pacific Oceania: inhabiting a sea of islands*. London: Routledge World Archaeology Series.

Carson, Mike T., and Hsiao-chun Hung. 2015. On the beach in Remote Oceania. In *Field archaeology from around the world: ideas and approaches*. Martin Carver, Bisserka Gaydarska, and Sandra Monton-Subias, eds. Pp. 133–136. New York: Springer.

Carson, Mike T., Hsiao-chun Hung, Glenn Summerhayes, and Peter Bellwood. 2013. The pottery trail from Southeast Asia to Remote Oceania. *Journal of Island and Coastal Archaeology* 8:17–36.

Chang, Kwang-chi, and Ward H. Goodenough. 1996. Archaeology of southeastern China and its bearing on the Austronesian homeland. In *Prehistoric settlement of the Pacific*. Ward H. Goodenough, ed. Pp. 36–56. Philadelphia: American Philosophical Society.

Chen, Wen-shan, Shih-hua Sung, Leh-chyun Wu, Hao-de Hsu, and Hsiao-chin Yang. 2004. Shoreline changes in the coastal plain of Taiwan since the last glacial epoch. *Chinese Journal of Archaeological Science* 94:40–55. [In Chinese.]

Chen, Z., Y. Zong, Z. Wang, H. Wang, and J. Chen. 2008. Migration patterns of Neolithic settlements on the abandoned Yellow and Yangtze River deltas of China. *Quaternary Research* 70(2):301–314. [PDN]

Clark, Jorie, Jerry X. Mitrovica, and Jay Alder. 2014. Coastal paleogeography of the California-Oregon-Washington and Bering Sea continental shelves during the latest Pleistocene and Holocene: implications for the archaeological record. *Journal of Archaeological Science* 52:12–23.

Contrereas, Daniel A. 2017. Correlation is not enough—building better arguments in the archaeology of human-environment interactions. In *The archaeology of human-environment interactions: strategies for investigating anthropogenic landscapes, dynamic environments, and climate change in the human past*. Daniel A. Contereas, ed. Pp. 3–22. London: Routledge.

Deng, Zhenhua, Hsiaochun Hung, Mike T. Carson, Peter Bellwood, Shuling Yang, and Houyuan Lu. 2018*a*. The first discovery of Neolithic rice remains in eastern Taiwan: phytolith evidence from the Chaolaiqiao site. *Archaeological and Anthropological Sciences* 10(6):1477–1484. doi.org/10.1007/s12520-017-0471-z.

Deng, Zhenhua, Hsiao-chun Hung, Xuechun Fan, Yunming Huang, and Houyuan Lu. 2018*b*. The ancient dispersal of millets in southern China: new archaeological evidence. *Holocene* 28:34–43.

Dickinson, W. R. 1995. The times are always changing—the Holocene saga. *Geological Society of America Bulletin* 107(1):1–7. [PDN]

Faught, Michael K., and Amy E. Gusick. 2011. Submerged prehistory in the Americas. In *Submerged prehistory*. Jonathan Benjamin, Clive Bonall, Catriona Pickard, and Anders Fischer, eds. Pp. 145–157. Oxford: Oxbow.

Galipaud, Jean-Christophe, Rebecca Kinaston, Siân Halcrow, Aimee Foster, Nathaniel Harris, Truman Simanjuntak, Jonathan Javelle, and Hallie Buckley. 2016. The Pain Haka burial ground on Flores: Indonesian evidence for a shared Neolithic belief system in Southeast Asia. *Antiquity* 90(354):1505–1521. [J-CG]

Gillis, J. R. 2014. Not continents in miniature: islands as ecotones. *Island Studies Journal* 9(1):155–166. [PDN]

Gosden, Chris, and Lesley Head. 1994. Landscape: a usefully ambiguous concept. *Archaeology in Oceania* 29:113–116. [QM]

Gosden, Chris, and John Webb. 1994. The creation of a Papua New Guinean landscape: archaeological and geomorphological evidence. *Journal of Field Archaeology* 21:29–51. [GRS]

Grier, Colin, Bill Angelbeck, and Eric McLay. 2017. Terraforming and monumentality as long-term social practice in the Salish Sea region of the northwest coast of North America. *Hunter Gatherer Research* 3(1):107–132. [QM]

Hoffmann, Tanja, Natasha Lyons, Debbie Miller, Alejandra Diaz, Amy Homan, Stephanie Huddlestan, and Roma Leon. 2016. Engineered feature used to enhance gardening at a 3800-year-old site on the Pacific Northwest coast. *Science Advances* 2(12):e1601282. [QM]

Hsieh, Menglong, and Pingmei Liew. 2010. A new version of Holocene tectonic uplift rates along the HuaTung coast of eastern Taiwan. *Bulletin of the Central Geological Survey, MOEA* 23:165–199. [In Chinese.]

Hsieh, Meng-long, Ping-mei Liew, and Ming-yang Hsu. 2004. Holocene tectonic uplift on the Hua-tung coast, eastern Taiwan. *Quaternary International* 115–116:47–70.

Huang, Shih-chiang. 1991. Some issues about the prehistoric culture of the east coast. *Field Arhchaeology of Taiwan* 2:1–30. [In Chinese.]

Hung, Hsiao-chun. 2005. Neolithic interaction between Taiwan and northern Luzon: the pottery and jade evidence from the Cagayan Valley. *Journal of Austronesian Studies* 1:109–133.

———. 2008. Migration and cultural interaction in southern coastal China, Taiwan and the northern Philippines, 3000 BC to AD 100: the early history of Austronesian-speaking populations. Doctoral dissertation, Department of Archaeology and Natural History, Australian National University, Canberra.

Hung, Hsiao-chun, and Mike T. Carson. 2014. Foragers, fishers and farmers: origins of the Taiwan Neolithic. *Antiquity* 88:1115–1131.

Hung, Hsiao-chun, Mike T. Carson, Peter Bellwood, Frediliza Z. Campos, Philip J. Piper, Eusebio Dizon, Mary Jane Louise A. Bolunia, Marc Oxenham, and Zhang Chi. 2011. The first settlement of Remote Oceania: the Philippines to the Marianas. *Antiquity* 85:909–926.

Hung, Hsiao-chun, Zhang Chi, Hirofumi Matsumura, and Li Zhen. 2017. Neolithic transition in Guangxi: a long development of hunting-gathering society in southern China. In *Bio-anthropological studies of early Holocene hunter-gatherer sites at Huiyaotian and Liyupo in Guangxi, China*. Monograph 47. Hirofumi Matsumura, Hsiao-chun Hung, Li Zhen, and Kenichi Shinoda, eds. Pp. 205–228. Tokyo: National Museum of Nature and Science.

Hung, Hsiao-chun, Y. Iizuka, P. Bellwood, K. D. Nguyen, B. Bellina, P. Silapanth, E. Dizon, R. Santiago, I. Datan, and J. H. Manton. 2007. Ancient jades map 3000 years of prehistoric exchange in Southeast Asia. *Proceedings of the National Academy of Sciences* 104:19745–19750.

Institute of Archaeology of the Chinese Academy of Social Sciences, Fujian Provincial Museum, and Mingxi County Museum. 2017. Excavation report of Cave 4 of the Nanshan Site in Mingxi County, Fujian Province. *Archaeology* 10:3–22. [In Chinese.]

Jinam, T. A., M. E. Phipps, F. Aghakhanian, P. P. Majumder, F. Datar, M. Stoneking, H. Sawai, et al. 2017. Discerning the origins of the Negritos, first Sundaland people: deep divergence and archaic admixture. *Genome Biology and Evolution* 9(8):2013–2022. [PDN]

Kaifu, Y., M. Fujita, M. Yoneda, and S. Yamasaki. 2015. Pleistocene seafaring and colonization of the Ryuku Islands, southwestern Japan. In *Emergence and diversity of modern human behavior in Paleolithic Asia*. Y. Kaifu, M. Izuho, T. Goebel, H. Sato, and A. Ono, eds. Pp. 344–361. College Station: Texas A&M Press. [IB]

Kawahata, H., M. Matsuoka, A. Togami, N. Harada, M. Murayama, Y. Yokoyama, Y. Miyairi, H. Matsuzaki, and Y. Tanaka. 2017. Climatic change and its influence on human society in western Japan during the Holocene. *Quaternary International* 440:102–117. [PDN]

Kirch, P. V. 2001. Three Lapita villages: excavations at Talepakemalai (ECA), Etakosarai (ECB), and Etapakengaroasa (EHB), Eloaua and Emananus Islands. In *Lapita and its transformations in Near Oceania: archaeological investigations in the Mussau Islands, Papua New Guinea, 1985–88*. P. V. Kirch, ed. Pp. 68–145. Contributions of the Archaeological Research Facility 59. Berkeley: University of California. [GRS]

Kusuma, P., M. P. Cox, D. Pierron, H. Razafindrazaka, N. Brucato, L. Tonasso, H. L. Suryadi, T. Letellier, H. Sudoyo, and F. X. Ricaut. 2015. Mitochondrial DNA and the Y chromosome suggest the settlement of Madagascar by Indonesian sea nomad populations. *BMC Genomics* 16:191. [PDN]

Laland, Kevin N., and Michael J. O'Brien. 2010. Niche construction theory and archaeology. *Journal of Archaeological Method and Theory* 17:303–322.

Leary, J. 2009. Perceptions of and responses to the Holocene flooding of the North Sea lowlands. *Oxford Journal of Archaeology* 28:227–237. [QM]

Lee, Kunxiu, and Meizhen Yeh. 1995. Excavations at Fushan in 1994. *Newsletter of the National Museum of Prehistory* 5:33–94. [In Chinese.]

———. 2001. *History of Taitung County: the prehistory*. Taidong: Taidong County Government. [In Chinese.]

Lepofsky, Dana, Nicole F. Smith, Nathan Cardinal, John Harper, Elroy (Gitla) White, Randy Bouchard, Dorothy I. D. Kennedy, et al. 2015. Ancient shellfish mariculture on the northwest coast of North America. *American Antiquity* 80(2):236–259. [QM]

Lien, Chao-mei. 2008. *Studies on the stratified mortuary data of Peinan (Beinan) in Neolithi Taiwan*. Taipei: National Taiwan University Press. [In Chinese.]

Lien, Chao-mei, and Wen-hsun Sung. 1986. *Analytical studies of stratification and the cultural remaisn from habitation levels: Excavation data from the Beinan site*. Taipei: Department of Anthropology, National Taiwan University. [In Chinese.]

Liew, P. M., P. A. Pirazzoli, M. L. Hsieh, M. Arnold, J. P. Barusseau, M. Fontugne, and P. Giresse. 1993. Holocene tectonic uplift deduced from elevated shorelines, eastern coastal range of Taiwan. *Tectonophysics* 222:55–68.

Liew, Ping-mei, and Shu-Yue Huang. 1994. A 5000-year pollen record from Chitsai Lake, central Taiwan. *Terrestrial, Atospheric and Oceanic Sciences* 5:411–419.

Madsen, David B. 2015. A framework for the initial occupation of the Americas. *PaleoAmerica* 1:217–250.

Maeda, Y., F. Siringan, A. Omura, R. Berdin, Y. Hosono, S. Atsumi, and T. Nakamura. 2004. Higher-than-present Holocene mean sea levels in Olocos, Palawn and Samar, Philippines. *Quaternary International* 115:15–26.

Mathews, Darcy, and Nancy J. Turner. 2017. Ocean cultures: northwest coast ecosystems and indigenous management systems. In *Conservation for the Anthropocene ocean: interdisciplinary science in support of nature and people*. P. S. Levin and M. R. Poe, eds. Pp. 169–206. New York: Academic Press. [QM]

McLaren, Duncan, Daryl Fedje, Murray B. Hay, Quentin Mackie, Ian J. Walker, Dan H. Shugar, Jordan B. R. Eamer, Olav B. Lian, and Christina Neudorf. 2014. A post-glacial sea level hinge on the central Pacific coast of Canada. *Quaternary Science Reviews* 97:148–169. [QM]

Meltzer, D. J. 2009. *First peoples in a New World: colonizing Ice Age America*. Berkeley: University of California Press. [IB]

Nunn, Patrick D. 1999. *Environmental change in the Pacific Basin: chronologies, causes, consequences*. New York: Wiley. [PDN]

———. 2007*a*. *Climate, environment and society in the Pacific during the last millennium*. Amsterdam: Elsevier. [PDN]

———. 2007*b*. Holocene sea-level change and human response in Pacific Islands. *Earth and Environmental Science* 98:117–125.

———. 2013. The end of the Pacific? effects of sea level rise on Pacific Island livelihoods. *Singapore Journal of Tropical Geography* 34:143–171.

———. 2016. Sea levels, shorelines and settlements on Pacific reef islands. *Archaeology in Oceania* 51(2):91–98. [PDN]

Nunn, Patrick D., and Mike T. Carson. 2015. Collapses of island scoieties from environmental forcing: does history hold lessons for the future? *Global Environment* 8:110–133.

Nunn, Patrick D., and Tony Ahikau Heorake. 2009. Understanding the place properly: palaeogeography of selected Lapita sites in the western tropical Pacific Islands and its implications. In *Lapita: ancestors and descendants*. Peter J. Sheppard, Tim Thomas, and Glenn Summerhayes, eds. Pp. 235–254. Auckland: New Zealand Archaeological Association.

Odling-Smee, F. John, Kevin N. Laland, and Marcus W. Feldman. 2003. *Niche construction*. Monographs in Population Biology 37. Princeton, NJ: Princeton University Press.

Ogawa, Hidefumi. 2005. Typological chronology of pottery assemblages from the Lal-lo shell middens in northern Luzon, Philippines. *Journal of Southeast Asian Archeology* 25:1–30.

Palmer, E. 2007. Out of Sunda? provenance of the Jōmon Japanese. *Nichibunken Japan Review* 19:47–75. [PDN]

Peterson, Warren E. 1974. Summary repot of two archaeological sites from northern-eastern Luzon. *Archaeology and Physical Anthropology in Oceania* 9:26–35.

Piper, Philip J., Hsiao-chun Hung, Frediliza J. Campos, Peter Bellwood, and Rey Santiago. 2009. A 4000-year-old introduction of domestic pigs into the Philippine Archipelago: implications for understanding routes of human migration through Island Souheast Asia. *Antiquity* 83:687–695.

Potter, B. A., J. D. Reuther, V. T. Holliday, C. E. Holmes, D. S. Miller, and N. Schmuck. 2017. Early colonization of Beringia and northern North America: chronology, routes and adaptive strategies. *Quaternary International* 444:36–55. [IB]

Reimer, Paula J., Edouard Bard, Alex Bayliss, J. Warren Beck, Paul G. Blackwell, Christopher Bronk Ramsey, Caitlin E. Buck, et al. 2013. INTCAL13 and MARINE13 radiocarbon age calibration curves 0–50,000 years cal BP. *Radiocarbon* 55:1869–1887.

Rolett, B. V., Z. Zheng, and Y. Yue. 2011. Holocene sea-level change and the emergence of Neolithic seafaring in the Fuzhou Basin (Fujian, China). *Quaternary Science Reviews* 30(7–8):788–797. [PDN]

Ross, Malcom. 2005. The Batanic languages in relation to the early history of the Malayo-Polynesian subgroup of Autronesian. *Journal of Austronesian Studies* 1:1–24.

Shugar, D., I. Walker, O. Lian, J. Eamer, C. Neudorf, D. McLaren, and D. Fedje. 2014. Post-glacial sea-level change along the Pacific coast of North America. *Quaternary Science Reviews* 97:170–192. [QM]

Skoglund, Pontus, Cosimo Posth, Kendra Sirak, Matthew Spriggs, Frederique Valentin, Stuart Bedford, Geoffrey R. Clark, et al. 2016. Genomic insights into the peopling of the Southwest Pacific. *Nature* 538(7626):510–513. [J-CG]

Smith, Bruce D. 2015. A comparison of niche construction theory and diet breadth models as explanatory frameworks for the initial domestication of plants and animals. *Journal of Archaeological Research* 23:215–262.

Snow, Bryan E., Richard Shutler Jr., D. E. Nelson, J. S. Vogel, and J. R. Southon. 1986. Evidence of early rice cultivation in the Philippines. *Philippine Quarterly of Culture and Society* 14:3–11.

Spriggs, Matthew. 1988. The changing face of Lapita: transformation of a design. In *Lapita design, form and composition: proceedings of the Lapita Design Workshop*. M. Spriggs, ed. Pp. 83–122. Canberra: Australian National University. [J-CG]

———. 2007. The Neolithic and Austronesian expansion within Island Southeast Asia and into the Pacific. In *From Southeast Asia to the Pacific: archaeological perspectives on the Austronesian expansion and the Lapita cultural complex*. Scarlett Chiu and Christophe Sand, eds. Pp. 104–140. Taipei: Center for Archaeological Studies, Research Center for Humanities and Social Sciences, Academia Sinica.

———. 2011. Archaeology and the Austronesian expansion: where are we now? *Antiquity* 85(328):510–528. [J-CG]

Summerhayes, G. R. 2018. An Austronesian presence in the Sakishima Islands—an archaeological update. *Japan Review*. https://nichibun.repo.nii.ac.jp/?action=repository_action_common_download&item_id=6892&item_no=1&attribute_id=20&file_no=1. [GRS]

Summerhayes, G. R., and A. J. Anderson. 2009. An Austronesian presence in southern Japan: early occupation in the Yaeyama Islands. *Bulletin of the Indo-Pacific Prehistory Association* 29:76–91. [GRS]

Summerhayes, G. R., M. Leavesley, and A. Fairbairn. 2009. Impact of human colonisation on the landscape—a view from the western Pacific. *Pacific Science* 63(4):725–745. [GRS]

Summerhayes, G. R., K. Szabo, M. Leavesley, and D. Gaffney. Forthcoming. Kamgot at the lagoon's edge: site position and resource use. In *Debating Lapita: chronology, society and subsistence*. S. Bedford and M. Spriggs, eds. Canberra: Terra Australis. [GRS]

Tanaka, Kazuhiko, and Alfredo B. Orogo. 2000. The archaeological excavation at the Pamittan site. *Journal of Environmental Studies* 8:113–141.

Terrell, John Edward, Terry L. Hunt, and Chris Gosden. 1997. The dimensions of social life in the Pacific: human diversity and the myth of the primitive isolate. *Current Anthropology* 38:155–195.

Terrell, John Edward, and Robert L. Welsch. 1997. Lapita and the temporal geography of prehistory. *Antiquity* 71:548–572.

Thiel, Barbara. 1988. Austronesian origins and expansion: the Philippine archaeological data. *Asian Perspetives* 28:119–129.

Trant, Andrew J., Wiebe Nijland, Kira M. Hoffman, Darcy L. Mathews, Duncan McLaren, Trisalyn A. Nelson, and Brian M. S Starzomski. 2016. Intertidal resource use over millennia enhances forest productivity. *Nature Communications* 7:12491. [QM]

Tsang, Cheng-hwa. 2005. Recent discoveries at the Tapenkeng Culture sites in Taiwan: implications for the problem of Austronesian origins. In *The peopling of East Asia: putting together archaeology, linguistics and genetics*. Laurent Sagart, Roger Blench, and Alicia Sanchez-Mazas, eds. Pp. 63–73. London: Routledge Curzon.

Tsang, Chen-hwa, Kuang-ti Li, Tze-fu Hsu, Tuan-ching Tsai, Po-hsuan Fang, and Yue-le Caroline Hsing. 2017. Broomcorn and fox-tail millet were cultivated in Taiwan about 5000 years ago. *Botanical Studies* 58:3. doi:10.1186/s40529-016-0158-2.

Tsang, Cheng-hwa, Rey Santiago, and Hsiao-chun Hung. 2002. Report on archaeological exploration in northern Luzon, Philippines, 1996–2002: annual report for the program of Asian and Pacific study. Taipei: Academia Sinica. [In Chinese.]

Wang, X., X. Sun, P. Wang, and K. Stattegger. 2009. Vegetation on the Sunda Shelf, South China Sea, during the Last Glacial Maximum. *Palaeogeography, Palaeoclimatology, Palaeoecology* 278(1–4):88–97. [PDN]

Wang, Z., Q. Zhan, H. Long, Y. Saito, X. Gao, X. Wu, L. Li, and Y. Zhao. 2013. Early to mid-Holocene rapid sea-level rise and coastal response on the southern Yangtze delta plain, China. *Journal of Quaternary Science* 28(7):659–672. [PDN]

Weiberg, E., I. Unkel, K. Kouli, K. Holmgren, P. Avramidis, A. Bonnier, F. Dibble, et al. 2016. The socio-environmental history of the Peloponnese during the Holocene: towards an integrated understanding of the past. *Quaternary Science Reviews* 136:40–65. [PDN]

Wilson, Lucy. 2011. The role of geoarchaeology in extending our perspective. In *Human interactions with the geosphere: the geoarchaeological perspective*. Special Publication 352. Lucy Wilson, ed. Pp. 1–9. London: Geological Society of London.

Wu, I-lin, and Laurent Deschodt. 2012. A spatial analysis of Neolithic sites on east Taiwan and related issues. *Journal of Austronesian Studies* 3:44–70.

Yang, Hsiaochin, and Wanshan Chen. 2013. The coastline development of the southern part of the Coastal Range in eastern Taiwan since the last glacial epoch and its relation with the distribution of archaeological sites. *Lingnan Archaeological Research* 13:89–94. [In Chinese.]

Yasuda, Yosinori. 2008. Climate change and the origin and development of rice cultivation in the Yangtze River Basin, China. *Ambio* 37:502–506.

Yoneda, Minoru, Hikaru Uno, Yasuyuki Shibata, Ryo Suzuki, Yuichiro Kumamoto, Kunio Yoshida, Takenori Sasaki, Atsushi Suzuki, and Hodaka Kawahata. 2007. Radiocarbon marine reservoir ages in the western Pacific estimated by pre-bomb molluscan shells. *Nuclear Instruments and Methods in Physics Research B* 259:432–437.

Zong, Yongqiang. 2004. Mid-Holocene sea-level highstand along the southeast coast of China. *Quaternary International* 117:55–67.