Chapter 2
Global Applicability of Landscape Evolution

Beyond the Asia-Pacific context of this book with focus on the Mariana Islands, studies of landscape evolution can be applied in any region and time period, as well as accommodating a diverse range of information about what landscapes are and how they have changed through time. The issues of studying an ethnohistorically defined landscape as it is experienced today are substantially different from the issues of studying the cultural interface with the environment during the Last Glacial Maximum about 24,000–18,000 B.C. Studies of the last 1000 years of dynamic coastlines work with many of the same principles yet at different scales of the last 10,000 years or 100,000 years of changing sea level and effects on coastal ecologies. Landscapes certainly are configured differently, experienced individually, and have undergone unique transformations in coastal zones, inland mountains, river valleys, and other settings.

Each region presents its own concerns about landscape evolution, so brief accounts of coastal China, California, and the Hawaiian Islands here serve as a prelude to illustrate the research approach in longer and shorter time scales and with qualitatively different datasets. Research in coastal China can address transitions from hunter-gatherer to sedentary agriculturalist modes of landscape experience, over a long time scale including *Homo erectus* ancestors, drowning of the former Pleistocene coastlines after the Last Glacial Maximum, and origins of some of the world's oldest complex societies. Landscape studies in California similarly must contend with conditions of remarkably different coastlines and associated ecological zones during the Pleistocene more than 10,000 years ago, in this case during the ancient migrations of people into the North American Continent, followed by a series of changing conditions during the Holocene leading to the historically known patterns of hunter-gatherer land use. The Hawaiian Islands offer an opportunity to examine a richly textured ethnohistoric perspective of a unique landscape system in comparison to geoarchaeological and other material records of how this system has evolved over the last 1000 years.

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Coastal China

Archaeology in China has proceeded at a rapid pace over the last two decades; yet, a landscape approach has not yet been formally applied except in a few cases. Detailed culture history sequences have been formulated from thousands of site excavations. The amount of information is so vast that scholars may feel lost in a sea of names of archaeological cultures, periods, phases, and areas spanning hundreds of thousands of years and more than 9 million km^2 of diverse terrain. The time range incorporates several thousands of years of *Homo sapiens* presence and much longer if considering evidence of *Homo erectus*, while the geographic scope includes staggering diversity of wet tropical lowlands, river valleys, grassland steppes, desert plateau, and dry and freezing high-altitude mountains.

Focusing just on the coastal region of China, today's coastline extends over more than 14,000 km of linear distance (Fig. 2.1). Coastal China includes zones of humid tropical, subtropical, and temperate climates with variable landforms of sandy beaches, alluvial coastal plains, deeply incised river drainages, broad river deltas, rocky bluffs, colluvial slopes, and steep mountainsides. Additionally, more than 6000 offshore islands contribute to the coastal landscape. All of these settings contain evidence of human occupation at least over the last few thousands of years and often much longer, crossing multiple periods of changing natural-cultural landscape contexts.

The physical shoreline and associated ecological zones have undergone substantial transformations during periods of higher and lower sea level. These alterations were driven primarily by change in global climate and the amount of ocean water trapped in ice sheets, but additional contributing factors included the effects of slope erosion and re-deposition into coastal lowlands and the changing river courses and amounts of alluvial sediment over time. Other considerations involve the roles of human groups, whether intentionally or not, in altering sedimentation rates through forest-clearing, crop cultivation, and other activities. Furthermore as shown in archaeological records, people have caused impacts on the compositions of plant and animal communities and even on geological mineral deposits differentially in some cases more than others, effectively reconfiguring the ecological balance of their inhabited landscapes.

Although ever-changing in a long-term perspective, China's coastal zones consistently have supported some of the world's densest populations. Reasons for the long-term reliability and intensity of coastal habitation are not difficult to imagine and in fact much the same as for any coastal zone, beginning with essential access to fresh water in streams, rivers, and seeps. Coastal communities benefit from the reliability of shellfish and seaweeds in intertidal and shallow sub-tidal zones, fisheries positioned safely near the shore, and naturally healthy plant growth close to the water table and especially near stream and river drainages. These same settings offer good prospects for hunting or trapping animals attracted to the water sources and vegetation. Moreover, the ocean water could facilitate transport of people and supplies. Later developments of sea-crossing vessels expanded the abilities of deep-sea fishing, broadened trade and commerce, and magnified the potential for long-distance migrations.

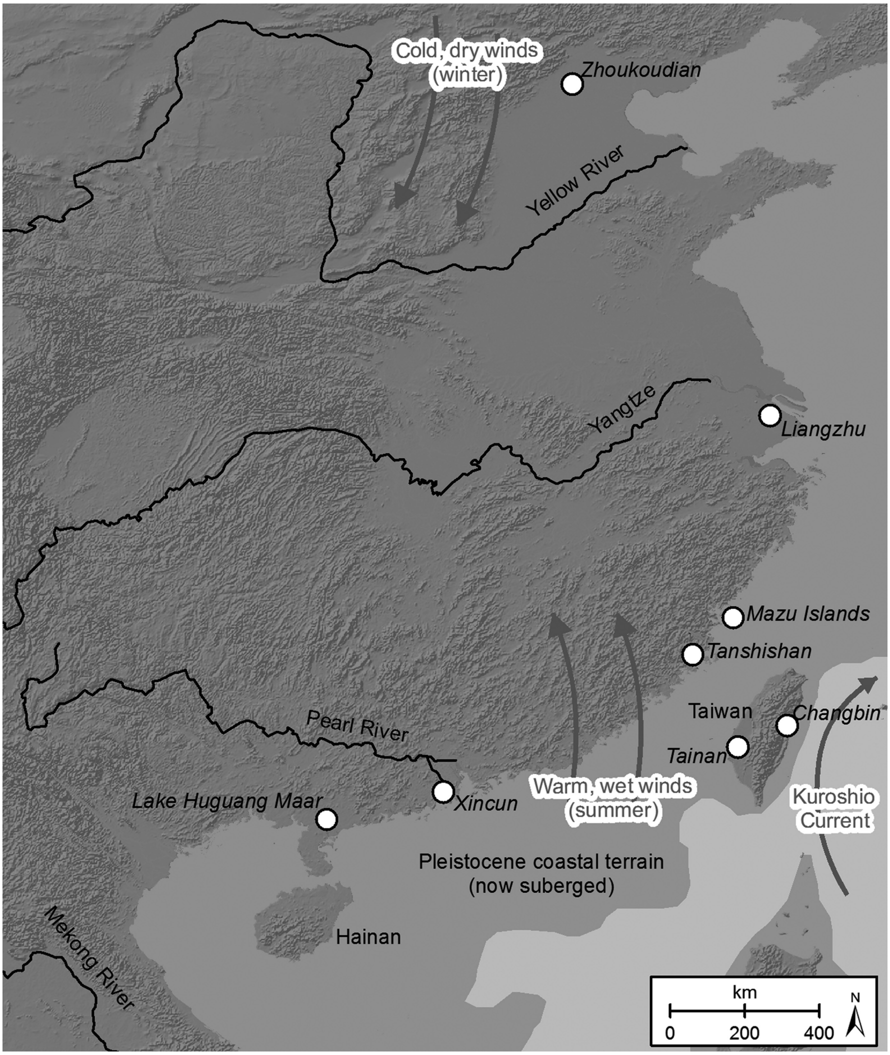

Fig. 2.1 Coastal China, showing major landscape features and sites mentioned in the text

Coasts arguably have been essential for the evolution of the human species and global dispersals of populations, and coastal China evidently played a key role in these events. This region is among the longest-inhabited places on earth, supporting populations of ancient human ancestors such as *Homo erectus*, famously found at Zhoukoudian near Beijing and dated in the range of 700,000–400,000 years old (Shen et al. 2009), while additional fossils of *Homo erectus* have been found on the seafloor of the Taiwan Strait that would have comprised a lowland terrain at the time (Chang et al. 2015). Remains of anatomically moderns humans or *Homo sapiens* have been found beneath and pre-dating a geological layer that could be as much as 100,000 years old at Zhiren in southern China (Liu et al. 2012), closely following the estimated date of first human dispersals and genetic diversification from an African homeland (Soares et al. 2012). Even when accepting a younger age of perhaps 60,000 years for *Homo sapiens* in China, the arrival of our species in Australia by 40,000 years ago (Hiscock 2008) and eventual migrations into the American continents by 14,000 years ago (Anderson and Bissett 2015) cannot be explained without first acknowledging that people must have been living already in other regions such as in coastal China.

China's coastal ecologies of the last glacial period of the Pleistocene, approximately 110,000 through 12,000 years ago, today are drowned beneath more than 100 m of ocean water that has risen due to the melting of polar ice sheets. The approximate shapes of ancient coastlines can be mapped by tracing the depths of the seafloor relative to the global sea-level history, refined through location-specific accountability of geotectonic movements, river discharge patterns, and geological cores showing depths of sedimentary deposits of different ages. Other landscape indictors such as pollen records and faunal remains so far have not been obtained directly from the submerged Pleistocene landforms, but general information is available from today's on-land areas where deep sedimentary coring is possible, especially in the bottoms of lakes and swamps, such as at Lake Huguang Maar where sedimentary records reveal the fluctuating climate conditions of the last 16,000 years (Yancheva et al. 2007) and preserved pollen of the vegetation communities that have changed over the last 13,000 years (Wang et al. 2007).

Even during the most extreme cold period of the Last Glacial Maximum at 24,000–18,000 B.C., most of coastal China was an ice-free zone without ice sheets, permafrost, or polar deserts. Along thousands of km of coastline, people would have encountered more arid and cooler conditions than seen today, but overall the setting was encouraging for finding edible plants and animals as well as reliable sources of water. The same qualities that made the coast attractive for living in general also facilitated mobility of people from one resource area to another and potentially supporting cross-regional migrations.

A particularly informative glimpse into the China's late Pleistocene coastal landscape comes from a set of caves in the Changbin Township on the eastern coast of Taiwan, occupied as early as 25,000 B.C. (Tsang et al. 2009, 2011), at a time when the island of Taiwan was connected to mainland China and the east-facing coastline was positioned just outside these caves. The mountain range of eastern Taiwan happens to have risen dramatically among the world's most rapidly uplifting geological formations, measured at nearly 1 cm per year at its southern end and 5–7 mm per year in the northern end associated with the caves in the Changbin Township (Liew et al. 1993). The ancient living floors of those caves now at 150–170 m elevation would have been scarcely above sea level at 25,000 B.C. (Figs. 2.2 and 2.3). Outside the eastward-facing coastal caves, a steep rocky slope descended to the tides and a broad expanse of coastal resources.

Named after the Changbin Township, archaeological materials in these caves locally are described as the Changbinian Culture (Sung 1969), regarded as a generic term for hunter-gatherer groups who lived in Taiwan for several thousands of years

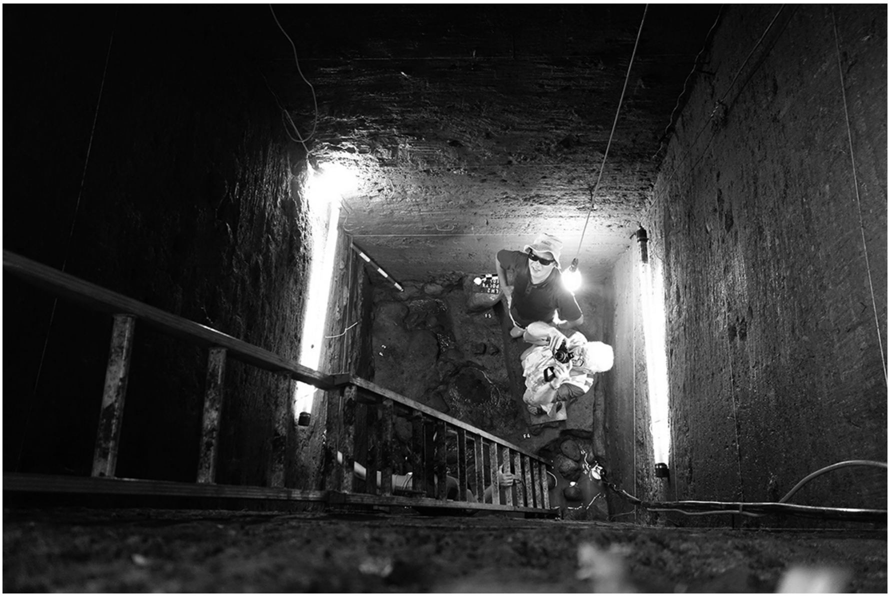

Fig. 2.2 Deep excavation at one of the Changbinian Cave Sites in eastern Taiwan, September 2014, with Dr. Tsang Cheng-hwa (wearing *dark glasses*) and Dr. Peter Bellwood (holding camera)

prior to the horizon of pottery-bearing sites about 4000 B.C. Tsang et al. (2009, 2011) documented a stone-tool industry of chipped pebbles and cobbles, as well as several small stone flakes. The larger chipped stone stools likely were used for general-purpose tasks, perhaps for chopping through wood, meat, and bone. The small flakes likely were used for finer cutting and slicing tasks. Extremely few animal bone fragments and shells confirm the expectation of coastal foraging, but the poor preservation of material disallows more precise statements.

The coastal zone must have been the major attraction of reliable natural resources for the people engaged in a hunter-gatherer economy at 25,000 B.C., but the limited faunal and botanical records do not yet provide a clear definition of those ancient resources. The ocean water itself may have been somewhat warm due to the passage of the Kuroshio Current bringing generally warmer tropical water from the western-central Pacific, but it may not have been warm enough to support growth of coral reefs prior to the post-glacial conditions of the Holocene. So far, the oldest dated corals embedded in uplifted terrain of eastern Taiwan have produced results of about 4000 B.C. (Chen et al. 1991; Liew et al. 1993). The Pleistocene coastal ecology still needs to be addressed, for example through studying the kinds of shellfish that are preserved even in small numbers in the cave deposits and embedded in the uplifted land mass.

After 10,000–9000 B.C., coastal China underwent massive transformation due to the melting of polar ice sheets and glaciers, when low-lying terrain throughout the world became flooded under more than 100 m of rising oceans. People necessarily adjusted to these changing circumstances, along with new opportunities of plant

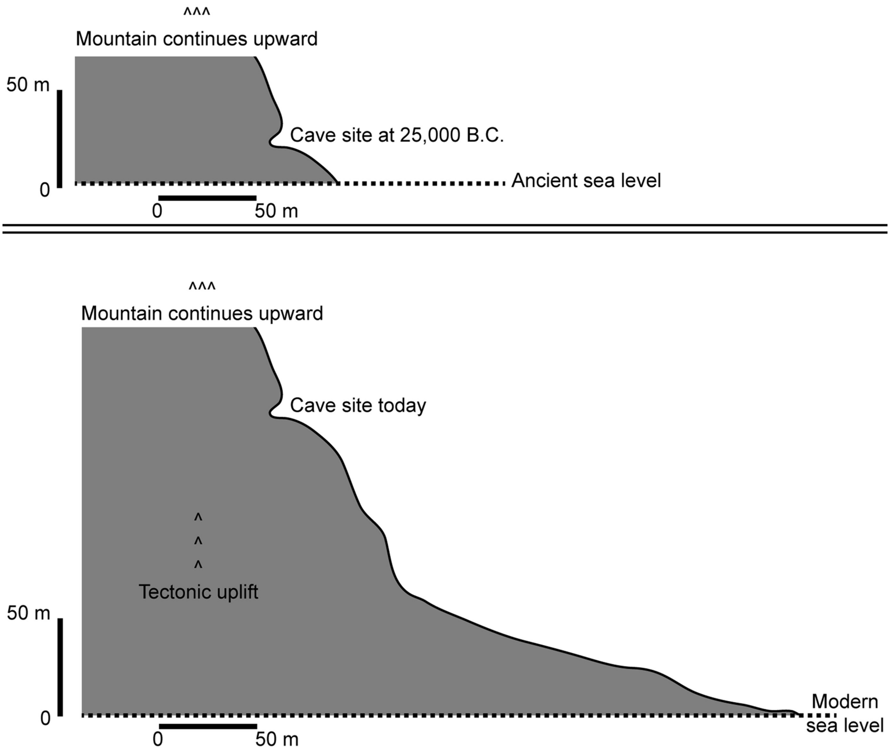

Fig. 2.3 Schematic section view of Chanbginian cave site occupation, view to north, based on information from Tsang et al. (2009; 2011)

growth and different ecological niches of the warmer Holocene conditions. The East Asian monsoon weather patterns have been steady throughout the Holocene: summer winds from the south bring warm moist air and rain, and then winter winds from the north bring cold and dry air. These predictable conditions definitely have influenced the human interface with the landscape, not only in practical terms of growing rice and other crops but also in terms of organising annual activities suitable for each season and developing a long-term relationship with the natural world. Although people were manipulating rice, millet, and other plants in China prior to 10,000 B.C. (Zhang and Hung 2008, 2010), the key turning point in developing a formally domesticated crop-dependent agricultural system began after 7000 B.C. (Fuller et al. 2009; Liu et al. 2007; Zhang and Hung 2013) and very clearly within a context of the overall stability and predictability of the Holocene.

The earliest sedentary landscape systems in China had developed most strongly not in the coastal region but rather farther inland along river valleys and terraces, in close association with the land-use patterns and annual predictability of rice and millet agriculture. By 6000 B.C., sedentary farming economies were spreading along the major river valleys such as the Yangtze and Yellow River that provided the most suitable landforms and reliable water sources. Similar kinds of landforms did not exist at that time in coastal zones, where instead the available terrain for horizontally expansive agriculture was far less than was already being used in the inland river valley terraces. Archaeological evidence reveals a chronology of gradual expansion of the geographic range of sedentary agriculturalists over the course of some millennia. By 5000–4000 B.C., farming communities were established at the coasts associated with some but not all of the major river valleys, while many coastal zones continued to support groups engaged in mixed hunting, gathering, and fishing economies (Liu and Chen 2012:169–212). Until about 3000 B.C., hunter-gatherer groups continued to inhabit most of the southeast coast (Zhang and Hung 2012).

From 6000 to 3000 B.C., coastal communities in southeast China developed a very different kind of sedentary landscape than had emerged among their inland neighbours of land-dependent rice-farming villagers. These coastal groups lived in small settlements and relied primarily on mixed foraging and fishing over broad catchment areas. At the Xincun Site near the inland side of the Pearl River Delta, occupied at 3350 through 2470 B.C., preserved palaeobotanical remains have yielded no evidence of domesticated rice or millet, but rather the plant foods are represented in starches and phytoliths of sago palms, banana, Job's tear, acorns, and other taxa (Yang et al. 2013) indicative of low labour-input subsistence economies of foraging, managed forests, and perhaps limited horticulture. Coastal settlements at this time mostly covered less than 10,000 m^2, although a few exceeded 20,000 m^2, in comparison to their contemporary rice-farming villages along the middle Yangtze River averaging 20,000–30,000 m^2 (Zhang and Hung 2008).

By 6000 B.C., the same warming conditions that encouraged rice-farming along the river valleys had resulted in global rise of sea level reaching approximately its modern level, directly affecting China's coastal landscapes. The lifestyle of coastal people at that time evidently involved sea crossings to several small offshore islands (Fig. 2.4), such as in the Mazu Islands where people created mounds of shells and other debris from mixed foraging and fishing (Chen 2013). People were buried in these mounds in Liang Island or Liangdao (*dao* = "island") as early as 6000 B.C. according to direct radiocarbon dating of the human bones (Ko et al. 2014).

Coastlines in China and elsewhere have been affected by a number of minor sea-level fluctuations during the last few thousand years. These later fluctuations have been generally 2 m or less, indeed minor compared to the post-glacial sea-level rise of more than 100 m but nonetheless bringing significant effects to low-lying coastal zones. The net effects on coastal landforms and ecologies are even greater when accounting for increased rates of slope erosion within the last few thousand years.

A highstand of sea level occurred approximately at 3000 through 1000 B.C., about 1.5–2.5 m higher than the present level and in most cases prior to the accumulations of sediments composing the lowland plains and terraces that now characterise much of coastal China (Zong 2004; Zong et al. 2009). Large expanses of alluvial plains and flat tablelands simply did not exist in low-elevation areas near sea level, so that the coastal settings did not include the same opportunities for agricultural land-use patterns that have been possible only more recently. As rice and millet farming gained more popularity in coastal areas after 3000 B.C., the rate of slope erosion increased and began to

Fig. 2.4 View of ancient shell midden site dated at 6000 B.C., on ridge of Liangdao, Mazu Islands

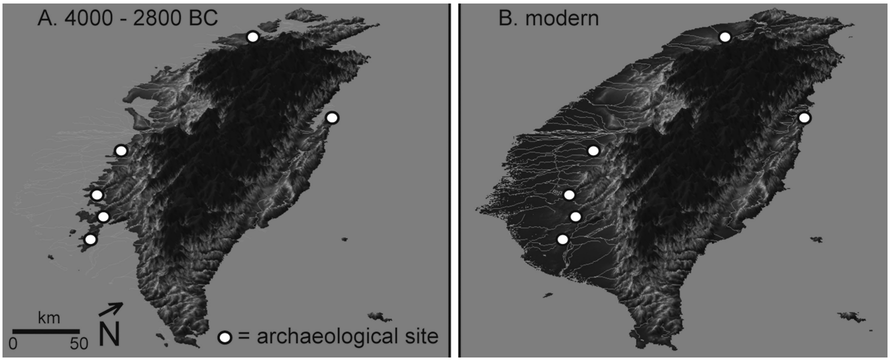

Fig. 2.5 Early Neolithic (4000–2800 B.C.) versus modern landscape of Taiwan. Palaeoterrain model is modified from Carson and Hung (2014)

generate thicker alluvial and colluvial sediments in lowlands of coastal zones and riverside terraces. Due to a higher sea level at that time, however, the lowland sedimentary accumulations in some cases had settled beneath water levels, only later exposed as dry landform surfaces after a period of sea-level drawdown following 1000 B.C.

The western coast of Taiwan offers one example of the landscapes changing with sea level, alluvial deposition, and placement of human settlements that occurred not only there but also along several coastal areas of mainland China (Fig. 2.5). Prior to 3000 B.C., residential sites were situated on low hills and ridges overlooking coastal waters (Hung and Carson 2014). After alluvial sediments began to accumulate, likely due to increased slope erosion prompted by forest-clearing, residential sites began to develop in the newly forming coastal plain, but these sites of 2800 B.C. such as at the Tainan Science Park now are buried under 5–7 m of more recent alluvial sediments and stranded more than 20 km inland from today's coastline of western Taiwan (Tsang 2005). Later, alluvial deposits continued to accumulate over the abandoned site, and a drawdown of sea level after 1000 B.C. magnified the extent of the alluvial plain exposed above sea level (Chen et al. 2004). These combined factors created a substantially different coastal landscape today than had been inhabited at 2800 B.C. and even more dramatically different from the landscape prior to 3000 B.C.

On a larger scale than can be seen in Taiwan, the mouths of major rivers in China present broad deltas and adjacent marshlands, at 3000 B.C. covering much more extensive zones than experienced today. The Yangtze Delta was a centre of one of China's classic early complex societies known as the Liangzhu Culture at 3300–2200 B.C. (Liu and Chen 2012:240), renowned for the production of ornately carved jade artworks, beautifully polished discs, finely made pottery wares, cemeteries with elaborate grave offerings and associated religious rites, and extensive stone-work structural remains of formalised village complexes (Qin 2013). The Liangzhu Culture emerged at a time when people populated a low-elevation coastal strip between the river delta and an extensive marshland (Stanley et al. 1999), and much of the habitation complex involved tall stonework structures with living surfaces elevated above the threats of floods (Fig. 2.6). Most impressively, the structures within the walled city of Maojiaoshan covered 290 ha, larger than the Forbidden City in Beijing, regarded as the capital city of the Liangzhu Kingdom.

By 2200 B.C., the Liangzhu residential sites were abandoned apparently all at once, suggestive of a major catastrophe. Among the hypothesised reasons, a failure of the rice-farming complex must be considered, likely related to the brief but sharp aridity that caused collapse of several farming economies all across Asia, known as the "4200 ybp Event" (Yasuda 2008). Following a severe drought and lowered water table, the dry soils along riverbanks and hill slopes became more vulnerable to erosion, so the return of heavy rains brought massive lowland sedimentation in areas such as the Yangtze Delta. Given the drought followed by sediment-filled flooding and landslides, the once thriving Liangzhu Culture was no longer sustainable (Xu et al. 2011; Zhang et al. 2004, 2005). Following later episodes of lowland sedimentation and coastal progradation, today's large expanse of contiguous terrace land around the Yangtze Delta supports an entirely different land-use pattern near modern-day Shanghai.

Approximately at the same time of the Liangzhu Culture at the Yangtze Delta, sedentary landscape systems developed all along coastal China, for example as seen in the Tanshishan Culture in the Fuzhou Basin of the Fujian Province. At approximately 3000–2300 B.C., communities of the Tanshishan Culture lived on low hills and promontories along an estuary that reached nearly 80 km farther inland from today's shoreline (Rolett et al. 2011). The inhabited landscape of that time accommodated small groups scattered on the available landforms, in a much more watery world than later would be the case after 1000 B.C. when a drawdown of sea level and increase of sedimentation created broad coastal plains and extensive river terraces.

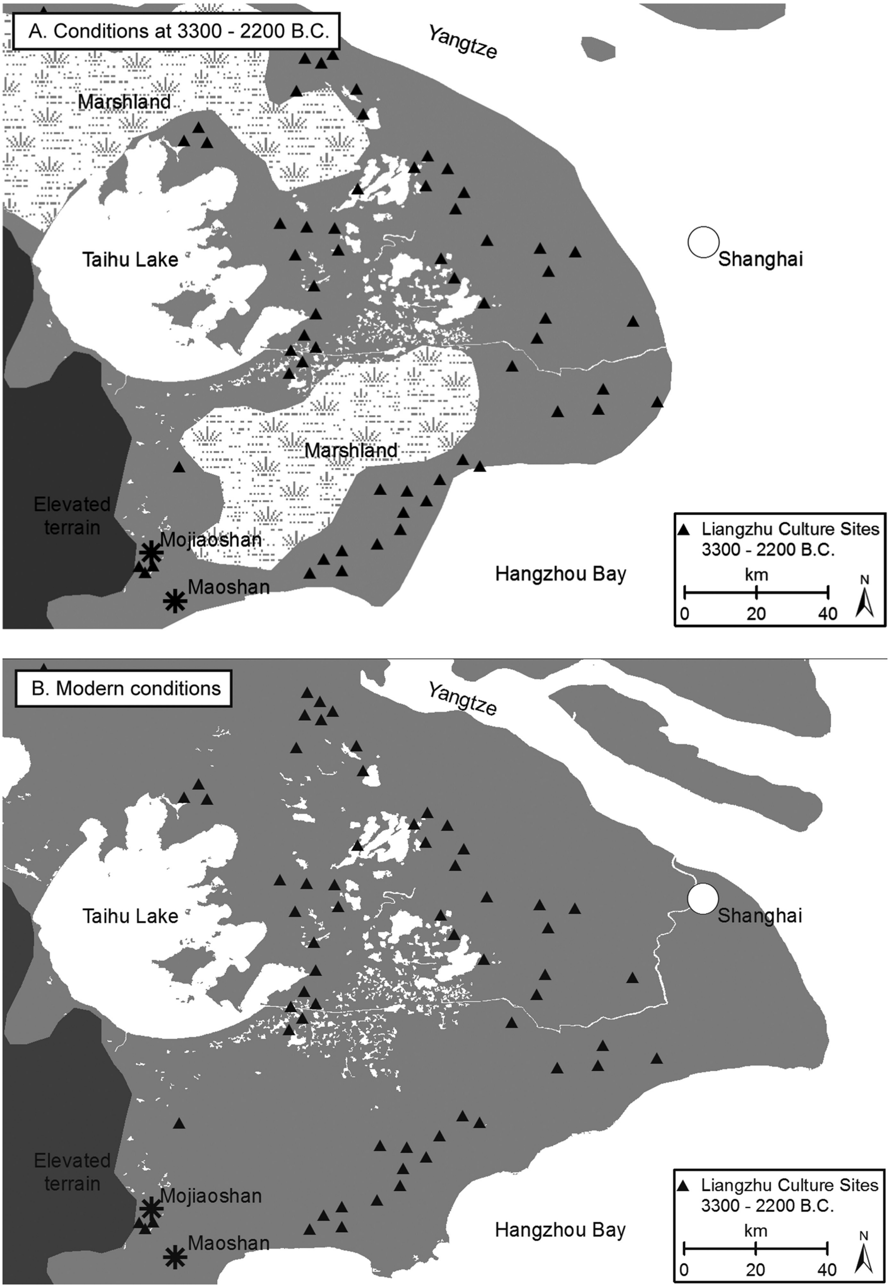

Fig. 2.6 Landscape of the Liangzhu Culture Period, 3300–2200 B.C., as compared to the modern setting. Information follows Stanley et al. (1999), Qin (2013), Xu et al. (2011), and Zhang et al. (2004, 2005)

By the time of the Han Dynasty expansion and imperial regime at 206 B.C.–A.D. 220, China's coastal landforms and ecologies were very much similar to today's conditions. Dense population centres relied for successive generations on widespread rice-farming, but coastal life of course continued to involve use of the sea and related resources. Written records allow vastly more detailed understanding of the natural-cultural landscape, although the Han writers clearly were biased when writing about the conquest of indigenous populations. In southeast coastal China, Han records describe the people of the Yue State or Bai Yue ("Hundred Yue") as barbarians with tattoos who lived in bamboo groves without proper villages (Brindley 2015). The Yue were rebellious from time to time, and eventually they were forced to retreat into marginal inland hills outside their preferred coastal zones and outside the primary concern of Han and later Empires.

This greatly condensed review leaves no doubt about the dynamism of China's coastal landscapes, constantly undergoing change in multiple factors at different but concurrent paces. Archaeological records reveal how groups of people engaged in certain modes of life and traditions of how to interact with their landscapes for periods of time, but eventually the inhabited landscape transformed to such an extent that qualitatively different lifestyles were needed. Archaeologists can refer to the landscape systems of Changbinian hunter-gatherers using caves along the eastern coast of Taiwan at 25,000 B.C., coastal-marine foragers ranging through a watery world of estuaries and offshore islands at 6000–3000 B.C., a thriving complex society emerging on the edge of the Yangzte Delta at Liangzhu about 3300 B.C. yet unsustainable by 2200 B.C., and historical developments of intensive agricultural land-use patterns since the Han Dynasty of 206 B.C.–A.D. 220. Many other examples could be added in a more thorough review not attempted here, and of course a number of minor fluctuations could be discussed within each identifiable time period that did not always cause deep restructuring episodes as highlighted for the landscape system overall.

California

Landscape evolution in California (Fig. 2.7) involves issues of first human migration into the American Continents, long-term development of hunter-gatherer economies in varied ecological niches and patchworks, emergence of complex social structures among semi-sedentary groups, and contributions of history and ethnography in building a sense of place in a landscape. As is the case for the Americas generally, the beginning of human presence is unclear but at least as early as 10,000 B.C. during the last centuries of the Pleistocene, so the origins of an inhabited landscape are not yet understood along the coasts that now are submerged beneath the Pacific Ocean. In today's more accessible terrain, post-glacial Holocene sites have yielded information about how established populations adjusted to their changing environmental settings over the last several thousands of years. People evidently sustained hunter-gatherer economies and lifestyles, despite the demands of dense residential communities and complicated social, economic, and political systems as documented at the time of European written histories in the A.D. 1500s.

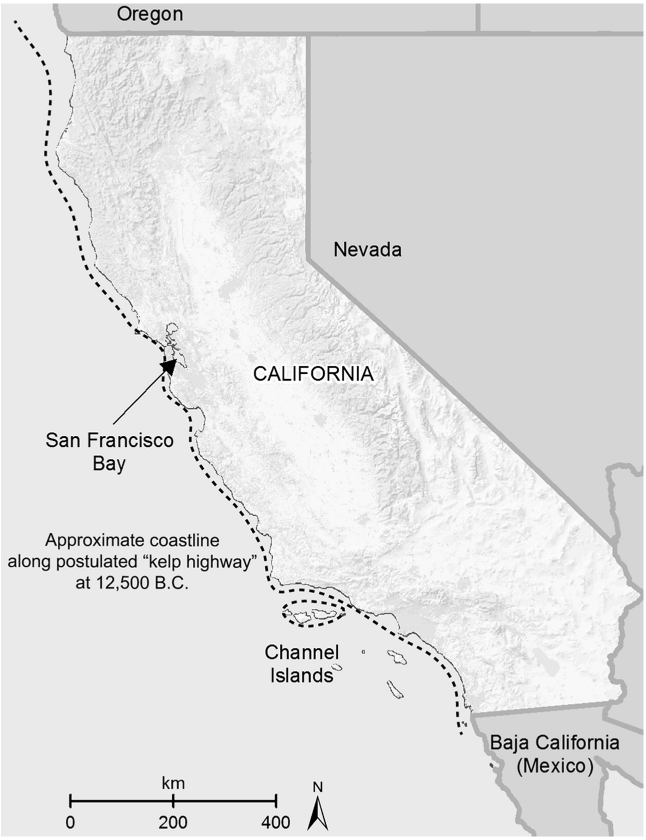

Fig. 2.7 California landscape today, with approximation of Pleistocene shoreline

Historical and modern traditions convey a strong sense of place in the landscape as it is experienced today, with elements of both long-term continuity and disjuncture when considering more than 12,000 years of an inhabited landscape.

California's landscape today is very much a product of historical events. Most Californians are aware that their modern cities developed in the places around the Spanish missions and along the roads that connected them, but these developments in turn had been based largely on wherever the Spanish missionaries could find suitable land for their settlements and observed existing aggregations of indigenous tribes to recruit into the mission projects. As a result of these procedures, whether intentionally or not, California's historical population centres reflected indigenous views of the most productive and favourable landscapes, although these reflections became increasingly warped over time.

Early European explorers approached California from the south and along the coast, gradually gaining knowledge of the navigable waters, shapes of terrain, types of resources, and distributions of local populations. These oldest written accounts capture a sense of how people explore and learn about a landscape, in this case however with the understanding that the landscape in question already had been inhabited and intimately known by local residents for several millennia. More than 12,000 years previously, the first Californians must have approached the landscape from an opposite direction of the Spanish missionary experience, moving from the Bering Strait in the north and continuing southward along a Pleistocene coastline that no longer is visible today beneath the Pacific Ocean.

The archival records are invaluable for learning about the California landscape at a critical historical juncture, but unfortunately the locations and details often are vague and mysterious. Maps and charts were precious government secrets during the 1500s and 1600s, sometimes destroyed before falling into enemy hands or else containing deliberately misleading information, unique codes, or simply left frustratingly sparse so as to avoid a written record in the first place. The limits of documentary evidence have not stopped bold claims and occasional hoaxes of discovering the places witnessed by Hernán Cortés in the 1530s, Francisco de Ulloa in 1539, Juan Rodríguez Cabrillo in 1542, Francis Drake in 1579, Pedro de Unamuno in 1587, Sebastian Cermeño in 1595, and Sebastien Vizcaíno in 1602. The missions were established over the course of more than 100 years, beginning in Baja California with Misión de Nuestra Señora de Loreta Conchó in 1697 and incrementally expanding as far northward as the north end of San Francisco Bay with Misión San Francisco Solano in 1823. While the missionary expansion still was underway, the Adams-Onis Treaty of 1819 limited Spanish territorial claims at the 42nd Parallel, still in effect today as the boundary between the U.S. States of Oregon and California.

When pealing back the veneer of post-colonial European land-use and indigenous population decline, the native Californian landscape is revealed as among the most densely inhabited regions of North America. Hunter-gatherers lived in sedentary or semi-sedentary communities, collected and stored massive quantities of acorns and other foods, practiced controlled burning and other manipulations of their environment, used standardised shell beads as a form of monetary currency, and maintained complex social and political systems (Arnold 1992, 2001, 2012). These groups occupied every one of the diverse inhabitable regions of California, with equally diverse ethnolinguistic groups accounting for "approximately 20 % of all the languages articulated in North America" (Lightfoot and Parrish 2009:7).

The diversity of the California landscape has been instrumental in supporting the long-term residence of dense populations. Rather than relying too much on a narrow range of foods, people could shift their focus from one resource to another in the event of prolonged drought or other circumstances that occur regularly in California. In addition to the repeated droughts, periodic el Niño events create warm ocean waters with cascading effects in the marine food chain. In this context, both land-based and sea-based subsistence economies developed with the ability and perhaps even a cultural expectation of shifting and reconfiguring according to ever-changing conditions. As long as people were ready to adjust their routines periodically, then ample resources could be available.

Controlled burning evidently comprised another key component of maintaining diversity in the California landscape. Through managing the timing and spatial parameters of burning events, the mosaic of habitats included patches of vegetation of variable ages and compositions as they recovered differentially from the fires. Through weed-pulling and other activities, people could continue to manipulate the development of the fired landscape. Furthermore, fresh young grass may have attracted antelopes and other animals, while the natural habitats of birds, rodents, and other wildlife were variably disrupted or enhanced.

Pyrodiversity through managed burning must be recognised differently from slash-and-burn horticulture. Superficially, both approaches are based on the same principles of allowing the burned organic material to release nutrients into the soil and thus increase plant-growing productivity. The most obvious difference is that horticulturalists would then proceed to plant domesticated crops, whereas the native Californian tribes evidently did not cultivate the domesticated versions of maize, beans, and squash as known in other regions. Moreover, people did not engage in purposeful narrowing of the plant species diversity, instead promoting as much diversity as possible.

The origins and long-term functioning of California's pyrodiversity continue be investigated, but evidence such as charcoal flecking in soil profiles so far suggests managed burning for at least the last 1000 years (Cuthrell et al. 2012). This time range allows fair correlation with ethnohistorically attested Californian tribes and their landscape traditions, although a much older chronological sequence may be expected in this region. The practices of pyrodiversity most likely developed in the context of taking advantage of California's natural biodiversity and adjusting the focus of hunting-gathering regimes in times of droughts and other challenges. Now after some centuries of strict laws against burning, modern California's annual wildfires can be disastrous, and a landscape of fully functional pyrodiversity is difficult to imagine except in the most general terms.

Among the most critical obstacles against researching the long time scale of California's landscape evolution is the fact that the oldest human presence in the region is not yet clarified. Without knowing the context of the first human–environment relations, the available chronological sequence is incomplete and refers only to periods when people already were engaged within a landscape system that necessarily had been inherited and modified over the course of several generations and perhaps for some thousands of years. Based on the limited evidence available, people had migrated into the Americas through the Bering Strait region prior to 12,000 B.C. and perhaps much earlier, then proceeded to occupy ecological niches in a Late Pleistocene landscape that later would transform profoundly with post-glacial warming of the Holocene, increasing resident population levels, and adaptations to the changing environment (Madsen 2015). Despite lingering debates, most researchers accept this general chronological outline, yet the fact remains that the earliest periods of human–environment interactions and dynamics are missing from the Californian archaeological record and indeed missing from most of the Americas.

Throughout the American Continents, the first few millennia of human settlement are notoriously ambiguous in archaeological records, definitely pointing to a human presence prior to 10,000 B.C. but so far lacking a consensus about exactly how much earlier and under what circumstances people migrated through ice-free zones. Fluted stone points of the Clovis cultural tradition are known from more than 1000 sites in North through Central America, dated at least as old as 11,000 B.C. (Miller et al.

2013), but people must have migrated into the Americas earlier in order to create the tent-like structures of a small community campsite at Monte Verde in Chile of South America around 12,500 B.C. (Dillehay et al. 2008). The Monte Verde site now is situated nearly 60 km inland from the Pacific Ocean shoreline of Chile, but it would have been about 90 km inland when the site was occupied prior to the post-glacial flooding of coastal lowland terrain (Dickinson 2011). In those now-flooded coastal lowlands of the Late Pleistocene landscape, ancient archaeological sites of the first Americans likely existed but have not yet been discovered in today's submerged contexts.

The missing millennia of the first Americans very well could be due to the submergence of Pleistocene coastal sites beneath today's oceans on both the Pacific and Atlantic coasts. In particular, the western coast of North America would have been the most accessible migration route for people coming from the Bering Strait and Alaska, although archaeologists so far have not attempted to find submerged sites there. Even without tangible evidence, Jon Erlandson and colleagues formulated a compelling argument that people had migrated along ice-free coastal zones, following the productive habitats of kelp forests and related coastal-marine ecologies of a "kelp highway" along the Pacific coast of North America (Erlandson et al. 2007). More specifically, the first Americans following such a migration route would have been coastal foragers, adapted to the Pleistocene shorelines and estuaries of the far north Pacific Rim, extending their ways of life into the American Continent along the Pacific coast (Madsen 2015). As attractive as this argument may be, it cannot be proven or disproven until archaeologists can develop a realistic way to survey in the submerged continental shelves. Potentially, the post-glacial flooding already has displaced or destroyed the material traces of these ancient sites, so an underwater survey could be pointless. On the other hand, fossils of *Homo erectus* have been recovered from today's seafloor of the Taiwan Strait (Chang et al. 2015), so a number of archaeological sites indeed may be awaiting discovery on the drowned continental shelves of North America. Extremely few archaeologists have attempted to search for these kinds of sites (Faught 2004; Faught and Gusick 2011), and so far no such attempt has been reported for coastal California.

Just within the last few years, researchers have begun to consider seriously how to conceptualise of the submerged Late Pleistocene landscapes of the American coasts (Anderson and Bissett 2015; Clark et al. 2014). Prior to 10,000 B.C., the Late Pleistocene coast of California extended farther westward than can be observed today, comprising a few thousands of sq km of land with several internally variable zones. The approximate shape of the Late Pleistocene coastal terrain can be mapped according to the sea-level history plotted against the depths of the now submerged continental shelf, further refined according to localised effects of California's complicated tectonic movements and other factors. Interdisciplinary studies are beginning to reveal the diversity of ancient landforms now preserved in relict features on the seafloor, consisting of a mosaic of coastal plains, variable sandy and rocky shores, hilly lowlands, and river drainage systems (Masters and Aiello 2007). Beyond identifying the physical shapes of coastal palaeolandforms, supplementary datasets from soil profiles, preserved pollen, and assorted climate indicators provide a fuller understanding of the ancient environment (West et al. 2007).

In the absence of knowing about the potentially submerged offshore sites, California's on-land archaeological record begins more than 2000 years after people already had been living in the Americas. One site has been dated about 10,000 B.C. at Daisy Cave in San Miguel of the Channel Islands (Connolly et al. 1995), and at least a few others may be close to this age. Most of the known archaeological record post-dates approximately 8000 B.C. (Rick et al. 2005), when the Pleistocene–Holocene transitions were underway and creating a significantly transformed landscape. These same later-dated records inherently cannot provide information about initial niche-targeting, adaptations to locally available conditions, or human response to earliest periods of environmental change.

Regardless of what happened during California's archaeologically missing millennia prior to 10,000 B.C., later sites reveal considerable details of how people related with their ecosystems and developed complex landscape systems. Especially in coastal sites with good preservation of faunal remains and other materials in datable contexts, long-term sequences provide invaluable information about human–environment dynamics (Braje 2010). These kinds of records tend to emphasise the impacts of people on the environment, such as over-harvesting of certain shellfish communities, depopulation of birds and other animals, and burning of natural vegetation. Although often overlooked in archaeological records, the natural change in climate, sea level, and coastal ecology certainly affected many of the food resources and food webs, in conjunction with the well documented human-caused impacts and variable cycles of learning how to manage the dynamic conditions.

While the Californian archaeological record offers one of the world's most informative examples of long-term human–environment relations, it nonetheless must be recognised as not yet providing sufficient evidence from the earliest periods of the inhabited landscape. The unbalanced record disallows a complete view of the influences of people and the natural environment on one another, potentially contributing to a number of unfortunate misunderstandings. Most scholars acknowledge that processes of landscape evolution already had been enacted since perhaps 14,000–12,000 B.C. and with significant transformations prior to the available evidence beginning after 10,000 B.C. and more abundantly after 8000 B.C., yet more research will be necessary to clarify those "missing millennia" for a fuller comprehension of California's long-term landscape evolution.

Hawaiian Islands

Among the most intensively studied islands in the Pacific, the Hawaiian Archipelago (Fig. 2.8) presents a worthwhile but in many ways cautionary reference before considering the archaeological landscape of the Mariana Islands. Although well established in the academic literature over several decades of scholarship, for example seen in Kirch's (1985) synthesis and a more recent overview by Bayman and Dye (2013), Hawaiian archaeology should not be mistaken as representative of the Pacific Islands. The Hawaiian and Mariana Islands could hardly be more different in their natural and cultural histories. The Marianas case of this book offers a

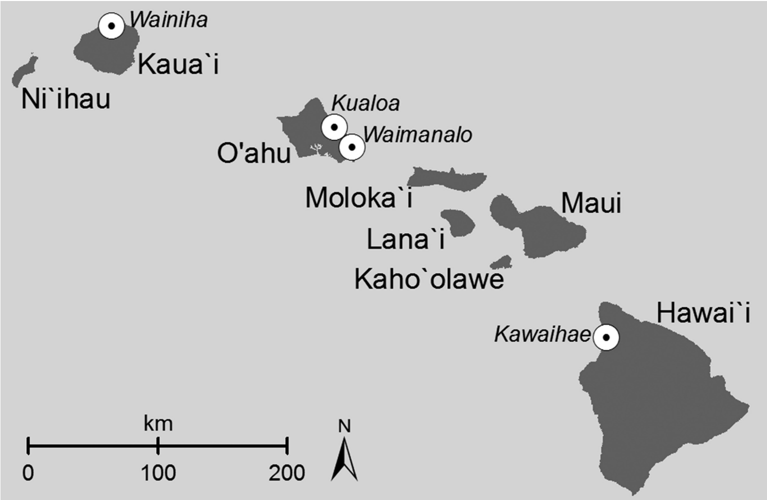

Fig. 2.8 Hawaiian Islands, showing sites mentioned in the text

considerably stronger illustration of long-term landscape evolution than is possible in the Hawaiian Islands, yet the Hawaiian record is instructive in its own right when its limitations are acknowledged.

The Hawaiian environment serves well as model system of natural ecological and social-ecological operations in a functional sense (Vitousek et al. 2010), but Hawaiian archaeology must contend with at least four serious problems. Firstly, the Hawaiian Archipelago comprises the most isolated set of islands in the world, with unique plant and animal species and an accordingly unique culturally inhabited landscape, by its own definition not representative as a model of anything else in the world. Secondly, the brief archaeological chronology since A.D. 1000 disallows accountability for truly long-term change in complex systems. Thirdly, a default research emphasis on the most recent centuries of the ethnohistoric record and surface-visible site ruins has ignored the possibility of chronological change even within the brief frame of 1000 years, while instead the overall picture of Hawaiian archaeology has been synchronic within an unbalanced view of just the few centuries closest to A.D. 1800. Fourth, the contributions of an exquisite Hawaiian ethnohistory are essential for interpreting the later-aged archaeological contexts, but their full potential has been missed when scholars fail to engage in critical review of the sources and multiple layers of interpretation.

Due to the remoteness of these islands, they were among the last in the Pacific to be settled by Polynesian seafaring groups around A.D. 1000 and then again among the last ever known by European explorers with Captain James Cook's arrival at Kaua'i in 1778. By the time of Polynesian settlement about A.D. 1000, nearly every island group of the Pacific already had been occupied, so that the entirety of Hawaiian cultural landscape evolution occurred during a context of an extensively inhabited sea of islands. Additionally, the late settlement date allows firm association of the Hawaiian language, oral traditions, and material culture with a slightly older homeland in

Central East Polynesia encompassing the islands today known as French Polynesia. Of further interest, the extensive written records since 1778 have captured a lively sense of native Hawaiian cultural history.

The temporal scope of an inhabited Hawaiian landscape within only about 1000 years lacks the major transformations of climate, sea level, and other factors as seen in other regions, but this shallow chronology supports potential integration of ethnohistoric traditions with the archaeological material record. The orthodox approach in Hawaiian archaeology has served as an extension of ethnohistory, wherein no archaeological study can be complete without first considering the multitude of place names, stories associated with those place names, genealogies of the historically known ruling chiefs, and other traditions that are alive and well in the Hawaiian Islands. When archaeologists routinely survey for surface-visible ruins without considering older contexts unrelated to the modern surface, then inevitably they produce results that date to the surface-related occupations in the range of A.D. 1400 through 1800 and can be related easily with a familiar ethnohistoric context. Very few subsurface layers have been found that refer to the earlier settlement period of A.D. 1000 through 1400, and oddly enough no investigation yet has attempted expressly to find the oldest sites, leading to repeated examples of later-aged archaeological sites undifferentiated from ethnohistoric contexts.

The shallow time depth of Hawaiian archaeology extends through just a few minor fluctuations in natural environmental transformations, thus creating a false notion that the natural environment did not influence cultural behaviours. Without a record of substantially changing environmental conditions, the major transformations in the Hawaiian landscape logically are attributed to human agency. Nobody would doubt the skills of people in mastering their environment, and indeed the Hawaiian archaeological record reveals profound human-caused impacts on native forests, bird populations, and slope erosion–deposition patterns (Athens et al. 2002). The role of environmental influence on people, however, has not been considered seriously in Hawaiian archaeology except indirectly in terms of noting how people made the best use of their available ecological zones and manipulated them into economically and politically profitable landscapes. These issues tend to be expressed in terms of synchronic ecological functioning as known in the 1700s through 1900s, not accounting for chronological concerns of adapting to ecological niches and changing conditions over extended periods of time.

Perhaps the most significant environmental change within the last 1000 years involved the overall stable, wet, and warm conditions of the Little Climatic Optimum (LCO) at A.D. 1000 through 1300, followed by the unstable, cool, and punctuated stormy conditions of the Little Ice Age (LIA) at A.D. 1300 through 1850 (Nunn et al. 2007). The effects of the LCO–LIA transition are not yet well understood in the Hawaiian record, because the vast majority of the available evidence post-dates A.D. 1400 and therefore is missing the relevant information about how people adapted to the changing conditions prior to this time. Nonetheless, in the few areas with records spanning this time range, at least some difference is detected around A.D. 1300–1400 in the placement of habitation zones, reliance of different kinds of crops, and overall patterns of settlement and land use. Moreover, the emergence of intensive agricultural field complexes, artificial fish ponds, and complex political economies entirely post-dated A.D. 1400 (Carson 2006). Oral traditions and chiefly genealogies point to the A.D. 1400s as the beginning of increased competition of warring chiefs (Cordy 2000), indicative of environmental and social stress.

The trends before and after A.D. 1300 are consistent with the transition from LIA to LCO conditions, but the same outcomes could have been due to population growth following island settlement about A.D. 1000 and reaching a critical threshold by A.D. 1400. This population growth would have been encouraged by the overall favourable conditions of the LCO at A.D. 1000 through 1300, followed by crisis during the extended unfavourable conditions of the LIA that no longer could support the population that had expanded and thrived during prior centuries. The picture is far from clear in the Hawaiian archaeological record, still rather sparse in the range of A.D. 1000 through 1400.

A chronological view of landscape evolution has been under-appreciated in Hawaiian archaeology, while instead a synchronic view of landscape ecology has figured prominently in the last several decades of research. At the time of European records in the late 1700s, the traditional land-use system involved partitioning of each island into a set of pie-slice units known as *ahupua'a*. Each *ahupua'a* contained a series of ecological zones from the interior upland mountain to the sea, often following the natural shapes of stream-cut valleys, so that people living in each ecological zone could maximise the locally specific resources and trade with one another. The zonation was especially clear in steep-sloped terrain with dramatic rain gradients increasing by elevation, wherein each elevation range was most suitable for a different mode of crop growth or other land-use pattern. The *ahupua'a* were more than practical organisations for allocation of resources among the local residents, and in fact the name *ahupua'a* literally means "pig altar" in reference to the tribute of food (and especially pigs) given at the community's altar near the coast for the ruling chiefs to collect.

Each *ahupua'a* is filled with named places and stories of literal and mythological events, and almost every Hawaiian archaeological site can be associated with these traditions. The naming in itself may be viewed as a cultural rendering of the natural world into an inhabited landscape, prompting questions of how and when this rendering occurred. Upon further thought, the place names and traditions as known in the late 1700s conceivably overprinted older traditions, especially when knowing that warring chiefs imposed their own ideals and propaganda when they consumed other lands and even entire islands.

The wonderfully informative Hawaiian ethnohistoric context must have developed over a period of time of changing natural and cultural history of the inhabited landscape, yet this chronological dimension has been under-represented in Hawaiian archaeology. Partly, the focus on the more recent past is due to the sparse knowledge of sites dating to the earliest settlement period of A.D. 1000 through 1400, although external scholars may wonder why Hawaiian archaeologists have not searched more vigorously for the oldest sites in their neatly contained island model systems. The situation has been exacerbated by a status quo methodology of surveying for surface-visible stonework ruins of house foundations, agricultural fields, and religious monuments that invariably date only to the more recent periods of occupation.

Admittedly, the rather brief Hawaiian chronology of approximately 1000 years does not include very much opportunity for preserving subsurface cultural layers hidden from surface survey, but these ancient subsurface layers do of course exist. In coastal plain landforms, depositional units of beach sands and slope-eroded sediments can accumulate 1 m or thicker, covering ancient habitation layers and obscuring their original contexts. These older buried sites logically cannot be identified through the standardised surveys of surface-visible stonework features.

Instead of finding the oldest Hawaiian sites and learning about their original contexts, proxy information has been obtained from palaeoenvironmental archives unrelated to actual archaeological sites. The proxies include preserved botanical remains in lake-bottom and swamp-bottom sediments indicative of forest-clearing by the first human contact in the islands, bones of rats that must have arrived with the first ocean-crossing settlers, and bones of birds that became extinct due to human impacts, all pointing to an age of about A.D. 1000 (Athens et al. 2002). By default, the dating of first human arrival has relied on inferential statistical modelling of the very few available radiocarbon dates from the known early sites in conjunction with the palaeoenvironmental proxies (Dye 2015), effectively refining the most probable dating but surely less desirable than obtaining substantive information directly from the early habitation sites. The reliance on proxies and statistical modelling has made the best of a poor situation with limited evidence, instead of the preferred strategy of finding and examining the actual substantive site records as has been accomplished in the Mariana Islands and elsewhere.

Despite the noted problems in developing a chronologically informed view of Hawaiian landscape evolution, at least three studies have provided long-term records with secure dating and accountability for changing natural and cultural contexts. In Kawaihae of leeward (west) Hawai‘i Island, geoarchaeological investigation reveals a sequence of changing cultural use of a transforming coastal environment since A.D. 1200–1400, much different from the ethnohistorically defined cultural landscape of the Kamehameha Dynasty's royal residence during the late 1700s through early 1800s (Carson 2012). In Kualoa of windward (northeast) O‘ahu, mythological traditions distinguish at least two periods of different environmental and social contexts, coordinated with geomorphological evidence and an archaeological record extending as old as A.D. 1040–1280 (Carson and Athens 2007). In Wainiha of northern Kaua‘i, the sequence of settlement and land use since A.D. 1030–1400 involves changing roles of coastal occupation, as well as low labour-input tree crop arboriculture versus intensive irrigated taro farming, attested in archaeological and oral historical records (Carson 2003, 2004). Other relevant examples exist but are not covered in detail here, such as a reconstruction of the meandering Waimanalo Stream and beach deposits associated with shifting placements of habitations at and around the Bellows Dune Site of O‘ahu (Peterson 2005), providing an excellent substantive framework although the dating and context of an apparent early habitation at A.D. 1000–1200 are unclear (Tuggle and Spriggs 2000).

A study at a coastal portion of Kawaihae provides a five-part chronology from A.D. 1200 to –1400 through the present (Fig. 2.9), noting change in the physical landforms, vegetation communities, cultural use of the available setting, and associated

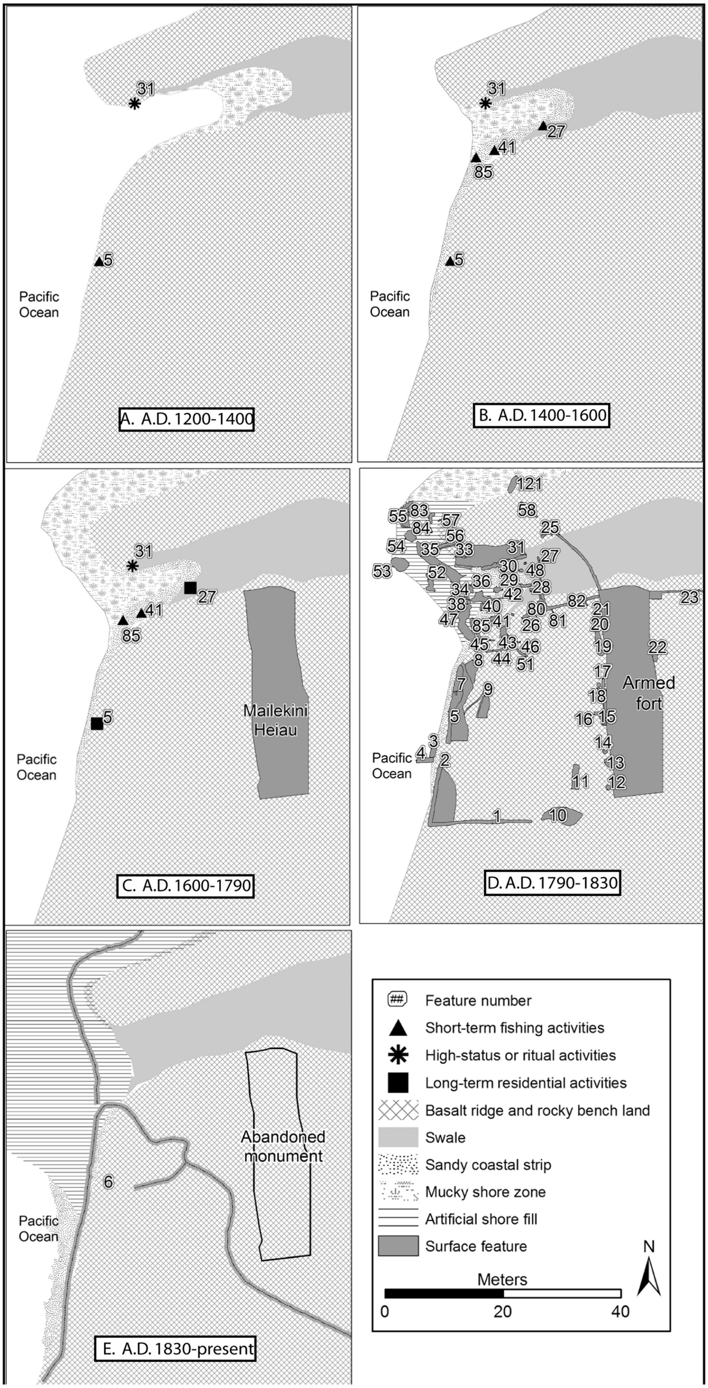

Fig. 2.9 Landscape evolution at Kawaihae, following Carson (2012)

ethnohistoric traditions (Carson 2012). This sequence could not have been known through the orthodox approach of examining surface-visible ruins related with ethnohistories. In this case, the surface ruins and monuments refer to the royal residence of the Kamehameha Dynasty and the birthplace of the historically known Hawaiian Kingdom, where Kamehameha's rival Keoua was killed and sacrificed in the late 1700s, where early European visitors reported dutifully to pay respects to Kamehameha and later his son Liholiho during the formative years of the kingdom through the early 1800s, and where the visible features of the landscape are strongly imbued even today with traditions of the royal residence. The ethnohistoric landscape at Kawaihae offers an effective example of how political elites can formalise public notions of power and authority into material monuments, overprinting older features of the landscape with their own creations and propaganda, further enforced through re-naming of places and installation of new oral traditions at the expense of older memories of the landscape. Prior to being known as the royal residence called Pelekane, this place may have been known as Kikiakoi or another name unclearly remembered today, and the traditions of a religious complex of Mailekini have been lost after the temple was converted into an armed fort by Kamehameha and his entourage.

Looking beyond the surface-visible ruins and historical propaganda at Kawaihae, geoarchaeological study recovered evidence of a chronological sequence of the changing landscape. Initial cultural use of the area at A.D. 1200–1400 entailed two small habitations on opposite sides of a narrow inlet, followed by gradual infilling of the inlet with slope-eroded sediments and enlargement of a low-lying coastal plain landform. In later centuries, people occupied increasingly numerous and larger portions of the available terrain, and they engaged in diverse types of activities such as ordinary habitation, high-status occupation, and religious performance. The royal residence constituted only one portion of the sequence that overlaid and masked much of what had happened previously, and in turn the royal residence eventually was transformed with later developments in the modern era.

Unlike the politically driven ethnohistory at Kawaihae, oral traditions of the landscape at Kualoa are grounded more in mythology and have endured through periodic impositions of different ruling regimes (Carson and Athens 2007). Traditions refer to the slaying of a dragon-like creature whose body was thrown down and thus created the local mountainous terrain of Kualoa, literally meaning "the long back" as in the backbone and body of the dragon. The dragon's tail is said to be a small offshore islet of Mokoliʻi, literally meaning "little lizard". These traditions explain the physical landforms while symbolically accounting for a change in social and religious context alluded in other vaguely remembered tales of ancient temples and religious orders that no longer existed in later periods. Before becoming known as Kualoa, the older place name is remembered as Paliku, literally meaning "upright cliff" and referring to the steep mountainside that once bordered the ocean, later transformed by the accumulation of a broad coastal plain within which archaeological deposits have been identified in different stages of the coastal formation (Fig. 2.10). In addition to the mythologically based elements, apparently factual accounts in oral histories mention periodic tidal waves or *tsunami*, with counterparts in the sedimentary profiles showing surge deposits and interruptions of the cultural occupations.

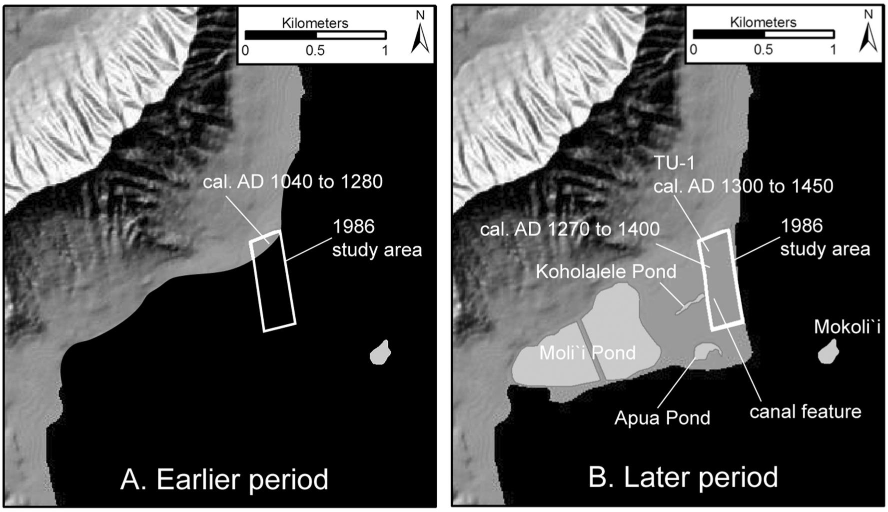

Fig. 2.10 Landscape evolution at Kualoa, modified from Carson and Athens (2007)

One more example of Hawaiian landscape evolution comes from Wainiha in the "separate kingdom" of Kaua'i (Carson 2003, 2004), where cultural traditions proudly underscore the spirit of independence and uniqueness apart from the other islands, in this case with intriguing congruence between the cultural traditions and archaeological evidence. The stream-cut valley of Wainiha, like others in the Halele'a District along the north of Kaua'i, is replete with irrigated terraces for growing taro and exemplary of the economic basis of complex chiefdoms (Earle 1978), yet the extensive transformation of the valley into a taro-producing landscape entirely post-dated A.D. 1400 (Carson 2006). Beneath the constructions of taro fields, remnants of older cultural layers refer to a qualitatively different and less intensive form of land use with scattered charcoal flecking, occasional hearth features, and little or no investment in long-lasting stonework architecture seen in the later periods. The only archaeologically detectable residential occupation prior to A.D. 1400 was close to the beach in the range of A.D. 1030–1400 (Carson 2004), at a time when the interior valley supported low-intensity land use pre-dating the taro fields. The creation of larger-sized and longer-lasting stonework complexes throughout Wainiha post-dated A.D. 1400 and marked the beginning of a significantly different land-use pattern, population demography, and social context.

The archaeological sequence at Wainiha accords well with tales of the banana-eating *Mu* people of this particular part of Kaua'i but not known elsewhere in the Hawaiian Islands, said to be the older inhabitants prior to the more recent ethnohistoric contexts. These traditions reflect memories of "times when (or places where) bananas and other tree crops were more important in a local diet and landscape that otherwise came to be dominated by taro and other root crops" (Carson 2003:100). Furthermore, Kaua'i is known for its unique forms of stone food-pounder artefacts with stirrup-like shapes and other characteristics (McElroy 2004), not seen in other of the Hawaiian Islands and thus suggesting a different use than taro-pounding documented extensively in the Hawaiian record outside Kaua'i. Indeed, throughout the Hawaiian homeland region of Central East Polynesia, food pounders were (and still are) used for making breadfruit paste, and the paste known as *poi* refers to breadfruit in all of these islands except in Hawaii where it refers to taro paste today.

Although still needing more attentive research, Hawaiian landscape evolution highlights the potential contributions of cultural traditions and ethnohistory that can be combined with geomorphology and archaeology. In the few examples reviewed here, substantive evidence informs about chronological change in the physical shape and configuration of the landscape, cultural adaptation and use of the changing settings, and variation in cultural traditions over the last several centuries. This approach contrasts against the orthodox manner of looking at surface stonework ruins and interpreting them through the face values of ethnohistories. Within the limits of a short chronology, the Hawaiian landscape sequence so far includes at least two components before and after A.D. 1400, and new investigations eventually will refine this outline.

Mariana Islands

The next chapters build a detailed account of landscape evolution as seen in the Mariana Islands over a sequence of 3500 years, drawing on diverse lines of evidence in natural and cultural historical records. The time scale in this case is less than in the preceding examples of coastal China and California that span the Pleistocene–Holocene transition, but it is sufficient to account for significant change in climate, sea level, coastal morphology, and several other factors. Moreover, the Marianas chronology is rather refined in periods of a few centuries each, and all of those periods provide substantial physical evidence of the natural and cultural landscape. The Marianas case includes limited input from cultural traditions as compared to the exceptional case of Hawaiian ethnohistory, most directly relevant in later-aged periods.

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