2.18 AGRICULTURAL ORIGINS AND SOCIAL IMPLICATIONS IN SOUTH AMERICA

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One of the most important developments in the existence of human society was the shift from a subsistence economy based primarily on terrestrial or maritime foraging to one based primarily on plant and animal food production. This profound transition in human ways of life occurred independently in at least seven or eight regions of the world, namely, the eastern United States, Mesoamerica, South America, the Near East, China, New Guinea, probably mainland Southeast Asia and possibly India (for recent updates of the evidence, see Barker 2006; Zeder *et al.* 2006; Cohen 2009; and Price & Bar-Yosef 2011). In most of these places, including South America, the transition occurred shortly after the Pleistocene ended. Within a few centuries to millennia of the first domestication of plants, people began living in sedentary communities that derived a significant portion of their diet from agriculture. With the dispersal of agriculture to other parts of the world, such communities developed in new regions, although the processes of their establishment varied. Where agriculture spread through colonisation, a sedentary way of life usually appeared immediately, but where agriculture was adopted by local hunters and gatherers, there was often a gradual reliance on crops. Nonetheless, almost everywhere crops appeared, eventually important subsequent demographic, economic, social and technological changes in society took place.

This sequence of developments cannot be placed within any simple framework of the "emergence of cultural complexity", a rising trajectory punctuated by points when signs of early food production, social inequality, centralisation, large-scale ritual and economic intensification all come together (Sassaman 2008). Instead, institutions and conditions of the Neolithic in the Old World and the Formative in the New World – sedentism, an economy based on domesticates, the expanded social role of material culture, rising population levels, among others – proved mutually reinforcing. They created a coherent way of life and newly defined and integrated spaces which tended to exclude alternatives, and which made a return to loosely structured, mobile, low-density forager groups an unlikely event in many places.

It is instructive to consider the scholarly thinking on the beginnings of agriculture and its long-term consequences for social and economic transformations within specific continental and regional settings. This is the intent of this chapter for the continent of South America. Thorough reviews by a number of South American palaeoethnobotanists, botanists and archaeologists have been published on the prehistory and related aspects of agriculture in various regions of the continent (see Hastorf 1999, 2006, 2007; Iriarte 2007; Oliver 2008; Pearsall 2003, 2008; Piperno & Pearsall 1998; Piperno 2011a, 2011b; Clement 2006; Clement *et al.* 2010). It is clear that plant food production emerged and took hold during the first three thousand years of the Holocene. This is about the same time as in other major regions of the world, such as the Near East and China. South America is a large continent with many diverse ecological zones, and its numerous and vibrant prehistoric cultures contributed a veritable wealth of cultivated and domesticated plants to the Americas and, after Europeans arrived, beyond. Many, such as manioc, sweet potato, yams, peanuts, various squashes, pehibaye palm, white potato, common and lima beans, quinoa, chile peppers, cotton, coca, tobacco and others continue today to be major staple foods, condiments, industrial plants and stimulants (Table 2.18.1). Two other premier plants, tomato and cacao (chocolate), were native to South America but were probably domesticated in Mexico, based on current data from the Prehistoric Period and where they were being cultivated when Europeans arrived.

As agriculture developed and spread, rich and unique agricultural systems were invented by advanced societies in different parts of the continent that brilliantly exploited the productive capacity of native landscapes, and often fundamentally transformed them (*e.g.*, Denevan 2001; Glaser & Woods 2004; Erickson 2000, 2008; Heckenberger *et al.* 2008; Mann 2008). This especially occurred during the final four thousand to three thousand years of the Pre-Columbian Era, when domesticated plants had dispersed widely, agricultural populations were numerous and social systems were becoming more complex. In a chapter such as this one, we cannot hope to adequately cover this long and diverse scope of Pre-Columbian agriculture. For the most part, we focus on Preceramic and early Formative periods, from about eleven thousand to four thousand calendar years ago. During the first few thousand years of this timeframe, food production emerged and became established in a number of regions of South America (see the discussion later). By the end of it, agriculture was the dominant subsistence mode over substantial areas of the continent.

TABLE 2.18.1. Cultivated and domesticated plants of South America.

Root Crops

Plant	Common Name	Dates and Places of Earliest Appearances
Calathea allouia	Leren	Lairén Aguadulce Shelter, central Pacific Panama, by 8600 BP Peña Roja, Colombian Amazon, 9000 BP Las Vegas, southwestern Ecuador, 11,060–10,220 BP
Dioscorea trifida	Yam	Aguadulce Shelter, Panama, 5700 BP
Maranta arundinacea	Arrowroot	Aguadulce Shelter, Panama, by 8600 BP Western Panama rock shelters, 7400 BP Valdivia, southwestern Ecuador sites, 6500 BP
Manihot esculenta	Manioc tapioca	Zaña Valley, Peru, c. 8500 BP Aguadulce Shelter, Panama, 7600 BP Abejas, Colombian Amazon, by 5700 BP Valdivia, southwestern Ecuador sites, 5100 BP
Ipomoea batatas	Sweet potato	Coastal Peru, 4500 BP
Xanthosoma sagittifolium	Malanga	Cocoyam
Canna edulis	Achira	Valdivia sites, southwestern Ecuador, 5000 BP
Solanum tuberosum	White potato	Tres Ventanas, Peru, 7600 BP Coastal Peru, 4500 BP
Ullucus tuberosus	Ulluco	
Oxalis tuberose	Oca	Coastal Peru, 4500 BP
Lepidium meyenii	Maca	
Pachyrrhizus ahipa, Pachyrrhizus tuberosus	Jícama	Coastal Peru, 5400 BP
Tropaeolum tuberosum	Mashua	
Arracacia xanthorrhiza	Arracacha	

Seed Crops

Plant	Common Name	Dates and Places of Earliest Appearances
Amaranthus caudatus	Amaranth	
Arachis hypogaea	Peanut	Cultivated *Arachis* sp. hulls occur in the Zaña Valley, Peru at 8600 BP Remains identified as *A. hypogaea* occur in coastal Peru at 4500 BP
Canavalia plagiosperma	Jackbean	Valdivia Sites, Ecuador, 5100 BP
Chenopodium quinoa	Quinoa	Cultivated quinoa-like seeds occur in the Zaña Valley, Peru by 8000 BP Remains positively identified as *Chenopodium quinoa* occur at Chiripa, Bolivia at 3500 BP
Chenopodium pallidicaule	Kañawa, cañihua	
Cucurbita ficifolia	Squash	Paloma, coastal Peru, 5800 BP
Cucurbita maxima	Squash	Coastal Peru, 4500 BP
Cucurbita moschata	Squash	Zaña Valley, Peru, 10,300 BP Aguadulce Shelter, Panama, by 8600 BP
Phaseolus lunatus	Lima bean	Chilca I, coastal Peru, 6400 BP; cultivated *Phaseolus* sp. from Zaña Valley, Peru at 9000 BP may be lima bean
Phaseolus vulgaris	Common bean	Guiterrero Cave, Peru, 5000 BP

Tree Crops

Anacardium occidentale	Cashew	
Ananas comosus	Pineapple	
Annona cherimola	Cherimoya	
Annona muricata	Guanabana, soursop	Coastal Peru, 4500 BP

continued

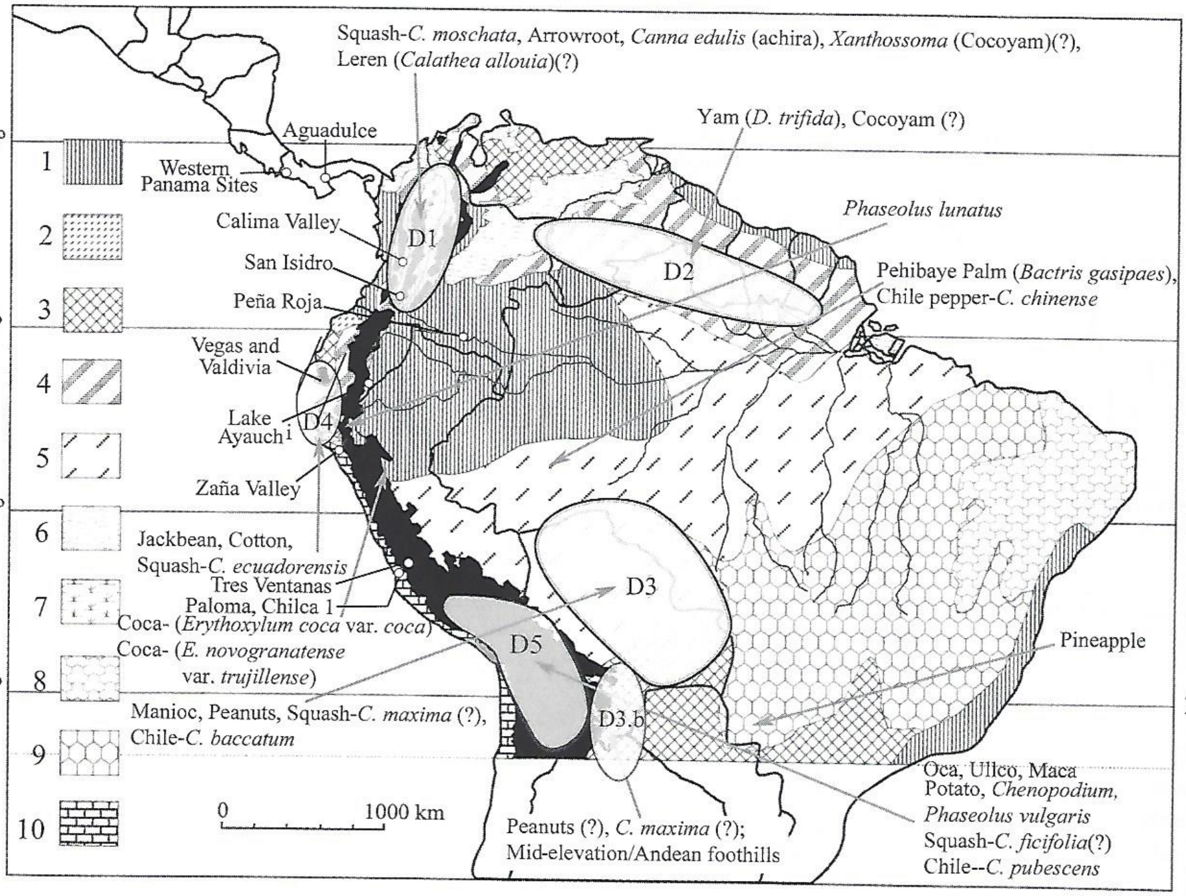
TABLE 2.18.1. Continued

Plant	Common Name	Dates and Places of Earliest Appearances
Tree Crops		
Bactris gasipaes	Pehibaye palm	
Bertholletia excelsa	Brazil nut	
Bunchosia armeniaca	Ciruela de Fraile	Coastal Peru, 4500 BP
Carica papaya	Papaya	
Elaeis oleifera	American oil palm	
Inga edulis	Ice cream bean	
Inga feullei	Pacay	Zaña Valley, Peru, 9000 BP
Lucuma obovata	Caimito	Coastal Peru, 4500 BP
Persea Americana	Avocado	San Isidro, Upper Cauca Valley, Colombia, 10,500 BP
Psidium guajava	Guava	Paloma, coastal Peru, 6000 BP
Industrial Plants		
Gossypium barbadense	Cotton	Zaña Valley, Peru, **6200** BP
Condiments and Stimulants		
Bixa orellana	Annona, Achiote (Primarily used as dye)	
Capsicum baccatum	Ají pepper	Cultivated chile pepper starches are found in ceramics and on stone tools from the Aguadulce Shelter, Panama and Valdivia Sites, Ecuador dating from c. 5600 to 4600 BP. They have not definitively been identified to species and may represent more than one species. Remains positively identified as this species occur on the coast of Peru by 4500 BP.
Capsicum chinense	Habeñero pepper	See previous note. Remains positively identified as this species occur on the coast of Peru at c. 3800 BP.
Capsicum frutescens	Tabasco pepper	See previous note for *C. baccatum*.
Capsicum pubescens	Rocoto pepper	Starch grains from this species occur at a site in highland Peru at c. 3700 BP.
Erythroxylum coca	Coca	
Erythroxylum novogranatense	Coca	Zaña Valley, Peru, **7950** BP
Genipa Americana	Jagua (used as dye)	
Nicotiana tabacum	Tobacco	

Notes: Plants without ages are currently not documented with archaeobotanical data until after 3500 BP and/or are mentioned in early European accounts. Evidence predating 3500 BP is likely to be found for some of them.
Dates printed in bold indicate that the C14 determinations were made directly on the plant remains.

For purposes of structuring the following discussion, we follow Hastorf (2006) and Pearsall (2008) in focusing on three major environmental zones: the moist tropical lowlands (encompassing especially northern South America and Amazonia), the Andean highlands, and arid Peruvian coast (Maps 2.18.1 and 2.18.2). Portions of these broad regions currently provide the most, and most complete, archaeological data on early agriculture and its dispersals, or, as with the southwestern periphery of Amazonia, were probably origin areas for major crops such as manioc, peanuts and chile peppers, even though empirical archaeological data are presently lacking. We will also consider the evidence from the Panamanian land-bridge. It appears that plant food production began there about 8600–8000 years ago with the appearance of a number of crops that originated in lowland northern South America. All dates in the chapter are expressed in calibrated radiocarbon years. We note that our definition of cultivation refers to the preparation of plots specified for plant propagation and repeated planting and harvesting in such plots. A cultivated plant or cultivar refers to those that are planted and harvested, regardless of their domesticated status. Domesticated species are those that have been genetically altered through artificial selection such that phenotypic characteristics distinguish them from wild progenitors.

MAP 2.18.1. Location map of Formative Period sites in South America mentioned in the text. Modern vegetation zone guide: 1. Tropical evergreen forest (TEF); 2. Tropical semi-evergreen forest (TSEF); 3. Tropical deciduous forest (TDF); 4. Mixtures of TEF, TSEF and TDF; 5. Mainly semi-evergreen forest and drier types of evergreen forest; 6. Savannah; 7. Thorn scrub; 8. Caatinga; 9. Cerrado; 10. Desert. Black areas indicate mountain zones above 1500 m asl. (Modified from Lavallée 2000.)



MAP 2.18.2. Postulated domestication areas for various crops in South America. The ovals in D1–D5 designate areas where it appears that a number of important crops may have originated. Open circles are some archaeological sites where early crop remains are present (see Table 2.18.1). See Piperno (2011a, 2011b) for all of the sources used in the figure. Modern vegetation zone guide: 1. Tropical evergreen forest; 2. Tropical semi-evergreen forest; 3. Tropical deciduous forest; 4. Savannah; 5. Low scrub/grass/desert; 6. Mostly cactus scrub and desert. Black areas indicate mountain zones above 1500 m asl. (Modified from Piperno 2006a.)

The Plants and Where They Came From

Table 2.18.1 contains a list of plants that were brought into cultivation and/or domesticated in South America during the Pre-Columbian Era. We should stress that the list is not complete, as it does not include a number of trees and other crops known or thought to have been cultivated at some point before European arrival (for examples from Amazonia, see Clement 2006; Clement *et al.* 2010; see also Piperno & Pearsall 1998: 157 and Table 2.18.1 for information on tree crops). Map 2.18.2 displays known or postulated areas of domestication for some of the crops in Table 2.18.1, based on current molecular, archaeological and botanical/ecological evidence. Harlan (1971) believed that the large number of plant species domesticated in South America, together with the considerable geographic scales and diverse ecological contexts involved, made it unlikely that the continent supported a "centre" or contiguous core area of agriculture. He posited that, in contrast to other regions of the world such as Mexico and Southwest Asia, South America should be considered a "non-centre"; in other words, it was difficult to recognise a circumscribed zone where agriculture began and out of which it spread. It is evident now that Harlan's non-centre idea for South America hit close to the mark. Origins of different crop species were spatially diffuse, were spread from the northern to the southern parts of the continent, west and east of the Andes, mostly in seasonal types of tropical forests for major lowland root and seed crops, but also in lowland wet forests and midelevation, moist forest habitats, from the northern to the southern Andes mountain ranges for the high-elevation seeds and tubers (Map 2.18.2). Moreover, techniques and tools used in farming varied widely (see the discussion later), and it is inherently unlikely that regionally distinctive forms (*e.g.*, black earth modifications of lowland Amazonia) arrived via diffusion from elsewhere. It should also be noted that few important lowland crops appear to have originated from within the core of the Amazon Basin, and several are from outside of it, indicating that the use of single geographic descriptors such as "Amazonia" for lowland crop origins (*e.g.*, Diamond 2002; Richerson, Boyd & Bettinger 2001) should cease.

In some cases, designations of the circled and other localities on Map 2.18.2 as origin areas for particular crops should be treated as hypotheses that require testing with additional molecular and archaeological data. For example, more precise origin-area localities will eventually be revealed for lowland crops that are probable northern South American domesticates, such as *C. moschata* squash, yam (*Dioscorea trifida*), leren (*Calathea allouia*), and cocoyam (*Xanthossoma sagittifolium*, the New World analogue to taro). Similarly, a definitive geographic source for several Andean tubers such as oca and ulluco has yet to be revealed. There is agreement, however, that their origins will be found in the southern Andes of Peru or Bolivia. We should note that not all scholars would agree with the geographic locales for all crops highlighted in Map 2.18.2. For example, Clement *et al.* (2010) believe that the pineapple is almost certainly native to northeastern, not southern, South America (the D2 area in Map 2.18.2), and they and others feel that the Brazilian cerrado should be seriously considered as a source area for the cocoyam, which we have placed in northern South America. We believe current data better support the scenarios given in Map 2.18.2, bearing in mind that future research may cause revisions.

Importantly, wild ancestors of lowland tropical crops such as manioc, yam, *C. moschata* squash, arrowroot, leren, cocoyam and others appear to be native to seasonally dry tropical forest. As in Central America (Piperno & Pearsall 1998; Piperno 2011a, 2011b), these areas were very significant in agricultural origins. Some important crops such as the pehibaye palm and other tree fruits and chile peppers were native to the wetter evergreen forests of Amazonia and elsewhere, but these forests do not appear to have contributed many important food plants.

Another important point is that an increasing array of powerful molecular data derived from living crop representatives and their wild progenitors indicates single domestications for most species studied so far, including those for which one versus multiple domestications were long debated. They include manioc, the pehibaye palm, cotton, *Cucurbita moschata* squash, peanuts and the white potato. We suspect that single domestications will prove to be more the rule than the exception when molecular data are available for other crop species. Of course, knowing that crop plants were domesticated once in a fairly localised area does not necessarily lead to a conclusion that food production was independently developed there. It is possible that the spread of a crop(s) into new regions inspired receiving cultures to grow their native plants. On the other hand, crop improvements (*e.g.*, to nutritional quality or seed/tuber/fruit size, *etc.*) and other types of changes such as those culturally pleasing to prehistoric cultivators undoubtedly took place in many instances after crop dispersals.

How many truly independent developments of agriculture were there? Given the large distances separating lowland northern and southern South American domestication zones and the fact that a number of plants native to each of these areas were apparently taken under cultivation and domesticated before about 7600 BP, it is difficult to see how northern and southern lowland regions do not form at least two to three independent areas of food production (*e.g.*, oval nos. D1, D3 and D4 in Map 2.18.2). Archaeological and genetic data are fewer for Andean domestication, and it is unclear whether there is temporal priority or sameness when the northern and the southern highlands are compared. The relationship, if any, between agricultural origins in the humid lowlands and the high Andes similarly cannot be properly assessed at this time. Present data provide evidence for a number of lowland crops millennia earlier than highland examples. However, because highland data are fewer than lowland examples, considerably more research is needed on these points.

The First Farmers in South America

The earliest evidence for plant food production and domestication can be traced to the beginning of the Holocene and the following two to three thousand years in parts of lowland Ecuador, northern Peru, the Colombian Amazon and lower montane regions of the Cauca Valley in Colombia, and adjoining Panamanian land-bridge (Map 2.18.2). Here, semipermanent and, less frequently, permanent settlements appeared along the Pacific coast or in interior locations near secondary water courses and seasonal streams, whose small stretches of alluvium were probably used for planting gardens (Dickau, Ranere & Cooke 2007; Mora 2003; Gnecco & Aceituno 2006; Piperno *et al.* 2000; Piperno 2006b, 2011a, 2011b; Piperno & Stothert 2003; Stothert, Piperno & Andres 2003; Dillehay, Bonavia & Kaulicke 2004; Dillehay *et al.* 2007). The vegetation of all of these areas was humid tropical forest with the exception of the Vegas (Ecuador) sites, located at an ecotone between forest and scrub vegetation. The interior sites are typically rock shelters and/or limited clusters of small, open-air occupations less than one hectare in size. Settlement organisation was similar to modern, tropical hamlets and hamlet clusters where one to a few nuclear families compose the residential community. The first cultivated and domesticated plants included important seed crops, such as *Cucurbita moschata* squash and peanuts (*Arachis* sp.); lesser known and now casually used root crops including arrowroot (*Maranta arundincea*) and lleren (*Calathea allouia*); root crops that would become major staple foods, such as manioc (*Manihot esculenta*); and tree crops, including avocados (*Persea* sp) and pacay (*Inga feuillea*). It is clear now that early lowland farming was primarily neither root nor seed based, as was previously thought.

In the high Andes, a number of settlements dating to the Terminal Pleistocene and Early Holocene have been investigated, but although a variety of plants were utilised, no clear evidence for food production has emerged from these sites (Aldenderfer 2008). Based on present evidence, food production and domestication of crops such as the lima bean and white potato occurred before 6400 and 4500 BP, respectively, judging from the dates of their appearance on the coast of Peru (Table 2.18.1). At Tres Ventanas Cave, highland Peru (Map 2.18.1), primitive forms of white potato have been directly dated to about 7600 BP (Hawkes 1990). It appears that Hawkes

(1990), on the basis of an unpublished examination by another investigator, considers them to be cultivars. Further description of them would be welcome. Ullucu and oca also occur in early deposits at both Tres Ventanas and Guiterrero Cave, but to our knowledge they have not been directly dated, and assessments of their status as wild or domesticated taxa are not available. Recent data from the lower western slopes of the Andes in northern Peru point to *Phaseolus* consumption at 8600 BP (Piperno & Dillehay 2008). The sites are outside the zones of wild lima and common bean distribution, indicating that the beans were cultivated. For a number of reasons, these starch grains isolated from human teeth are more likely to be lima rather than common beans, but a definitive identification with regard to either a species designation or a domesticated status was not possible. Domesticated *Chenopodium quinoa* is present at Chiripa, Bolivia, by 3500 BP (Bruno & Whitehead 2003). Other data relating to early Andean domestication are minimal. More evidence, including from plant microfossil studies, is needed to better document the chronology of agricultural emergence there.

During the mid-8th millennium BP, the first signs of major crop movements northwards from their area(s) of origin in southern South American can be seen. Peanuts moved into the Zaña Valley of northern Peru by 8500 BP. Manioc also occurs there by about 8500 BP, and the plant is present in central Panama at about 7600 BP. Pollen evidence from the Colombian Amazon indicates manioc arrived there before 5800 BP. It is possible that peanuts and manioc moved north together from a common area of origin (Map 2.18.2). Chile peppers were well-dispersed from their source areas in western Amazonia by 5600 to 4600 BP (Perry *et al.* 2007). A large corpus of data indicates that maize was dispersed into lower Central America by 7600 BP and had moved into the inter-Andean valleys of Colombia by 7000 BP. Recent evidence documents its domestication by 8700 BP in the central Balsas region of Mexico (Piperno *et al.* 2009; Ranere *et al.* 2009). Therefore, both north-to-south and south-to-north crop transfers were occurring early on.

Current evidence reveals that household communities developed during the Early Holocene in southwestern coastal Ecuador and northern Peru as part of a long unbroken archaeological sequence starting during the Terminal Pleistocene. One of the earliest settlements so far discovered in South America is Las Vegas in coastal Ecuador, a pit house community dating to 11,000–7800 BP (Stothert 1985; Stothert, Piperno & Andres 2003). In the Zaña Valley, northern Peru, located on the lower western slopes of the Andes, occupations between 10,000 and 7600 BP were small, circular houses located 200 to 400 m apart with stone foundations and stone-lined storage pits (Fig. 2.18.1). By 7000 to 6000 BP, horticultural and maritime household communities were present on the Peruvian and northern Chilean coasts (*e.g.*, at Paloma and Chilca I).

There has been much discussion among scholars about whether the earliest cultivars were food items or utilitarian plants. The answer is both, but that most early crops documented were taken under cultivation and domesticated for dietary purposes. For example, leren and arrowroot tubers, manioc roots and avocado fruits are not utilitarian items, they are eaten. Another ubiquitous early crop, *C. moschata* squash, was routinely consumed, underwent early artificial selection for different traits related to fruit edibility and thus was not primarily used as a little-modified nondietary plant (*e.g.*, Piperno & Dillehay 2008; Piperno 2006b). It can be a difficult task to reconstruct how much of the diet was derived from cultivated or domesticated plants, particularly for earlier periods before sedentary village life and pottery use appear. Nonetheless, there are substantial indications from a variety of evidence that, by 7600 BP, crop plants constituted important elements of diets in several regions. For one thing, significant and reliable sources of carbohydrates such as leren and arrowroot are ubiquitous components of earliest crop plant assemblages, and they, along with *C. moschata* squash, often appear together, indicating initial cultivation of a diversity of crops. An additional line of data comes from starch grains recovered directly from the plaque of human teeth. More than 70% of the starch grains recovered from the teeth of nine different Zaña Valley individuals dating to 8800 to 7700 BP were from four crops: *Phaseolus*, *C. moschata*, peanuts, and *Inga feuillea* (Piperno & Dillehay 2008). In the Zaña area, small-scale irrigation systems emerged by 7000 BP (Dillehay, Eling & Rossen 2005) and, in central Panama, landscape clearance resulting from slash-and-burn cultivation is documented by pollen, phytolith and charcoal records from lake sediment cores beginning at 7600 BP. In that region, a variety of domesticated plants including arrowroot, leren, manioc and *C. moschata* squash are present at the same time or earlier at nearby archaeological sites; all arrived from South America. Thus, agricultural intensification had clearly occurred in a number of regions by 7000 BP.

These people and others appear to have been committed farmers who were practicing agriculture at a horticultural level, probably in house gardens or small plots near their houses. While still integrating planting with collecting and hunting, they had taken important steps along the path to full-scale agriculture during the c. 10,000 to 7600 BP period. The appearance of large sedentary and nucleated villages, which postdates 6000 BP throughout the Americas, should no longer

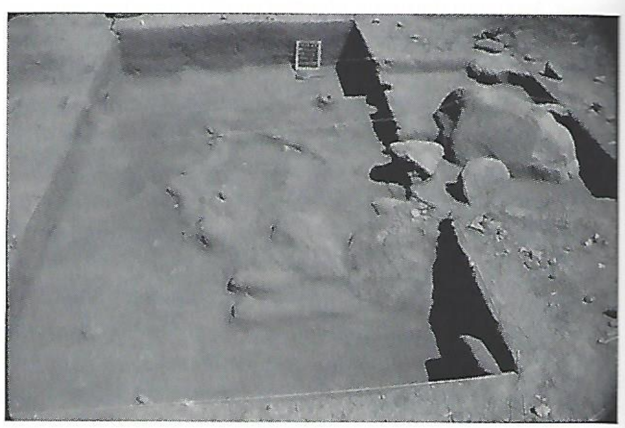


FIGURE 2.18.1. General view of a Las Pircas stone-lined hut foundation dating to the middle Preceramic Period. (Photo by Jack Rossen.)

be considered a necessary backdrop for the occurrence or recognition of effective and productive agriculture in the New World. Even today, it is easy to find examples of tropical cultures who practice small-scale horticulture while hunting and fishing, and derive many of their calories from cultivated and domesticated foodstuffs (*e.g.*, Piperno & Pearsall 1998; Gurven *et al.* 2010).

Ecological Contexts of Early Farming

We briefly consider the existing environmental and ecological conditions shortly before the emergence of food production and during its initial development and spread. The degree to which the Pleistocene-Holocene environmental transitions influenced people's decisions to initiate plant cultivation is still actively debated among scholars. However, few, we think, would disagree that changing availabilities of plant and animal resources would have impacted people's subsistence choices and settlement strategies. A large body of information indicates that both highland and lowland regions of South America experienced very significant temperature, precipitation, floristic and faunal changes as the Pleistocene ended and the Holocene began. In additional, the Holocene climate was far from stable. Detailed reviews of this information can be found in Baker *et al.* (2001), Seltzer *et al.* (2002), Piperno and Pearsall (1998), Piperno (2006a), Bush, Gosling and Colinvaux (2007), Bush, Hanselman and Hooghiemstra (2007), Léon (2007) and Sandweiss and Richardson (2008). Many records are relevant to the ecological circumstances of sites where early food production and its subsequent dispersals are indicated. Map 2.18.1 displays modern vegetational formations in South America that can be compared with the descriptions of late glacial and Early Holocene vegetation that follow.

In summary, by the time the Pleistocene ended twelve thousand to eleven thousand years ago, the lowlands and highlands had warmed by 4 to 7 ° C compared with late glacial conditions. Precipitation also increased significantly in many lowland localities studied, although the interior of the Amazon Basin probably was not as dry as its southwestern and eastern peripheries during the Late Pleistocene, when it primarily remained forested. Highland Andean precipitation during the Pleistocene varied along a north-to-south axis, with locations from about 11° S latitude southwards experiencing wetter conditions than today's, and locations to the north, such as in Colombia, having drier conditions. Highland precipitation trends during deglaciation were the opposite of these (*e.g.*, increasing precipitation in northern sites and decreasing rainfall in more southern localities). Late-glacial warming was more punctuated in the northern Andes, which, like in the lowlands, experienced a 4° temperature rise and marked precipitation increase when the Pleistocene ended. The major end-of-Pleistocene vegetational responses were (1) retreat of tree lines and montane forest elements into higher elevations where they occur today, (2) expansion of seasonally dry tropical forest into areas that supported open land types of vegetation (savannah and thorny scrub types) during the Pleistocene (vegetation zones 3 and parts of 4 and 5 on Map 2.18.2), and (3) the coalescence of floristic elements of evergreen forest into their modern associations (zones 1 and large parts of 5 in Map 2.18.1). In some areas, the Early Holocene may have been even warmer and wetter than the following millennia. In many areas of the tropical lowlands studied, forests with floristic and structural elements closely comparable to those seen today were present by about 9600 BP. In coastal Peru and Chile, the late glacial period appears to have been cool and arid, followed by a somewhat wetter Early Holocene.

Regardless of how one views the importance to food production origins of these environmental transitions, it is clear that major vegetational and faunal shifts occurred in the lowlands immediately before the emergence of plant cultivation. These transitions involved significant losses of open-land vegetation and its unique flora (*e.g.*, many succulents and legumes) and large game animals, together with expansion of tropical forests of different types with their dramatically different subsistence resources. Further discussion of what these transitions may have meant can be found in Piperno (2006a, Piperno 2011b). Although more stable than the latter stages of the Pleistocene, the Holocene was far from being one unvarying climatic period. Between 8000 and 4000 years ago, many parts of the continent were affected by drier and warmer conditions. They probably provided favourable and more widespread ecological contexts for the initiation and spread of slash-and-burn agriculture. Strong but infrequent El Niños began in coastal Peru at 5800 BP, and around 3000 BP the ENSO's periodicity and strength became like those of today (Sandweiss & Richardson 2008). The transition at 5800 BP can be associated with the appearance of a variety of introduced crop plants and the establishment/expansion of farming communities and, slightly later, with monumental temple construction on the Peruvian coast, while the 3000 BP change correlates with the end of the Formative Period and less use of the temples (Piperno & Pearsall 1998; Sandweiss & Richardson 2008).

The Beginning of the Formative and Other Important Later Developments

The preceding discussion illustrates that food production in South America did not originate in the context of large or fairly large permanent and nucleated villages using pottery, situated in major river valleys and with fully or nearly so agricultural economies. These developments, conventionally called the Formative Period, came a few millennia later. The earliest evidence for the Formative comes from the Valdivia Culture of southwest Ecuador and dates to 5500 BP (*e.g.*, Pearsall 2003; Raymond 2008; Zarillo *et al.* 2008). After the emergence of Valdivia, a Formative way of life developed unevenly across lowland northwestern South America and adjacent Isthmian areas, and it lagged behind in highland areas (Raymond 2008). Sedentary ways of life with large population aggregations and advanced agricultural systems are documented in Amazonia and eastern lowland South America as a whole beginning about 3000 BP (Neves & Petersen 2006). In the Colombian Amazon, smaller-scale but permanent communities growing maize and manioc were present by about 5000 BP (Mora *et al.* 1991).

By the close of the 5th millennium BP, domestic forms of squash, manioc, maize, chile peppers, beans and other plants were disseminated throughout much of the Neotropics and the northern half of the Andes, and along the Pacific coastal corridor. These cultivars were probably transmitted across an ever-expanding web of social and economic interaction through diffusion routes that are not yet well understood, but that probably in part involved the tropical lowlands east of the Andes along with the coasts of Ecuador and Peru. This growing field of interaction during the late Preceramic and Formative periods may also be attributed in part to the domestication of animals in the central or south-central Andes probably dating sometime between the 6th and 5th millennia BP: principally camelids (*e.g.*, llama, vicuña, alpaca) and the mobile wealth associated with them (Mengoni Gonalons & Yacobaccio 2006; Stahl 2008). Domesticated herds must have transformed the scale and pace of human interaction, transgressing the temporal and spatial conventions that regulated the flow of objects, including crops, and ideas between people (Bonavia 2009).

The exceptionally informative record of macrobotanical plant remains on the arid Peruvian coast contributes a wealth of insights into crop plant usage and its meanings over the past few thousand years. For example, the region experienced a "fibre revolution" during the 5th and 4th millennia BP when it shifted from chiefly cultivating wild reeds to cotton to produce fishing nets and textiles. This development may have led to qualitative transformations in land-working and land-holding relationships in some coastal areas, yielding prime agricultural land from food crop cultivation for additional cotton cultivation and utilising more marginal or adjacent lands. Rather than agricultural intensification, this process may have involved what McCorriston (1997) has termed "agricultural expansification" in Mesopotamia, which refers to a geographic spread rather than intensified production resulting from technological innovation or increased production. Ultimately, such a shift may have fostered the development of permanent agricultural settlements such as Caral, Caballito, Aspero, El Paraiso and many others in the heart of the political economy of north and north-central coastal Peru, culminating in the attachment of people to larger tracks of fertile lands (Moseley 1975; Quilter 1991; Shady & Leyva 2003; Haas & Creamer 2006).

Initially in the central Andes and slightly later in the eastern tropical lowlands, agricultural villages and monumental construction occurred in selected productive habitats (*e.g.*, usually temperate to Neotropical climates with fertile soils and predictable water supply), which set the stage for social hierarchy, centralised political leadership, villages and towns and religious centres. In the Andes, rather than accumulating personal wealth for individual competition and prestige during the late Preceramic and Formative periods (c. 5000–3000 BP), communities channelled their efforts towards the construction of large-scale public projects often centred on religious ideology probably involving ancestor worship and competition and cooperation between residential kin groups (*e.g.*, Burger 1992; Zeidler 1998; Dillehay, Bonavia & Kaulicke 2004). Similar but later and less elaborate social and economic transformations were taking place in the eastern tropical lowlands (Lathrap, Collier & Chandra 1975; Heckenberger, Petersen & Neves 1999; Iriarte *et al.* 2004).

As mentioned at the outset, some of the richest and most distinctive developments in South American agriculture are manifested by forms of landscape modification undertaken by highland and lowland societies, mainly during the past 3000 years of the prehistoric era. They are well studied and described, and include Amazonian dark earth (ADE; Fig. 2.18.2), artificially raised and drained fields (Fig. 2.18.3), irrigated fields, terraces, sunken gardens and, most recently, sustainable "garden cities" and "geoglyphs" (the last category not positively associated with agriculture as yet) (Denevan 2001; Glaser & Woods 2004; Erickson 2000, 2006, 2008; Heckenberger *et al.* 2008; Mann 2008). Capable of providing continuous high yields and requiring high labour inputs and the organisation of labour, they are found over areas of lowland Amazonia, Ecuador, coastal Peru, Venezuela, the Guianas, Colombia, Bolivia, southern Brazil, south-central Chile and the high Andes. The transformations were often so massive in scope and scale that the term "domestication of landscape" is commonly applied. Various kinds of technological developments accompanied the use of these landforms, such as the Andean foot plough, short-handled hoes and clod breakers (Denevan 2001).

Along with these "human built landscapes", naturally formed levees or *varzeas* suitable for seasonal food production were in abundance along the Amazon River and other major tributaries in the tropical lowlands, and were surely used by early farmers (Denevan 2001). Human impacts on the environment also produced negative consequences, such as deforestation and soil degradation under slash-and-burn methods of cultivation, and the reduction of protective vegetation cover caused by overgrazing of wild and domesticated camelids, causing a higher rate of denudation (*e.g.*, Bonavia 2009). In the case of coastal Peru and northern Chile, with its irrigation systems developed during the Formative Period, it is likely that overintensification led to salinity problems which ultimately reduced crop yields (Moseley 1992).

Social Impact of a Farming Way of Life

Important changes in social and economic organisation took place in the Andes from 9000 to 6000 BP. It is likely that, as more hunter-gatherer peoples experimented with cultivated plants and became increasingly reliant on them, they became

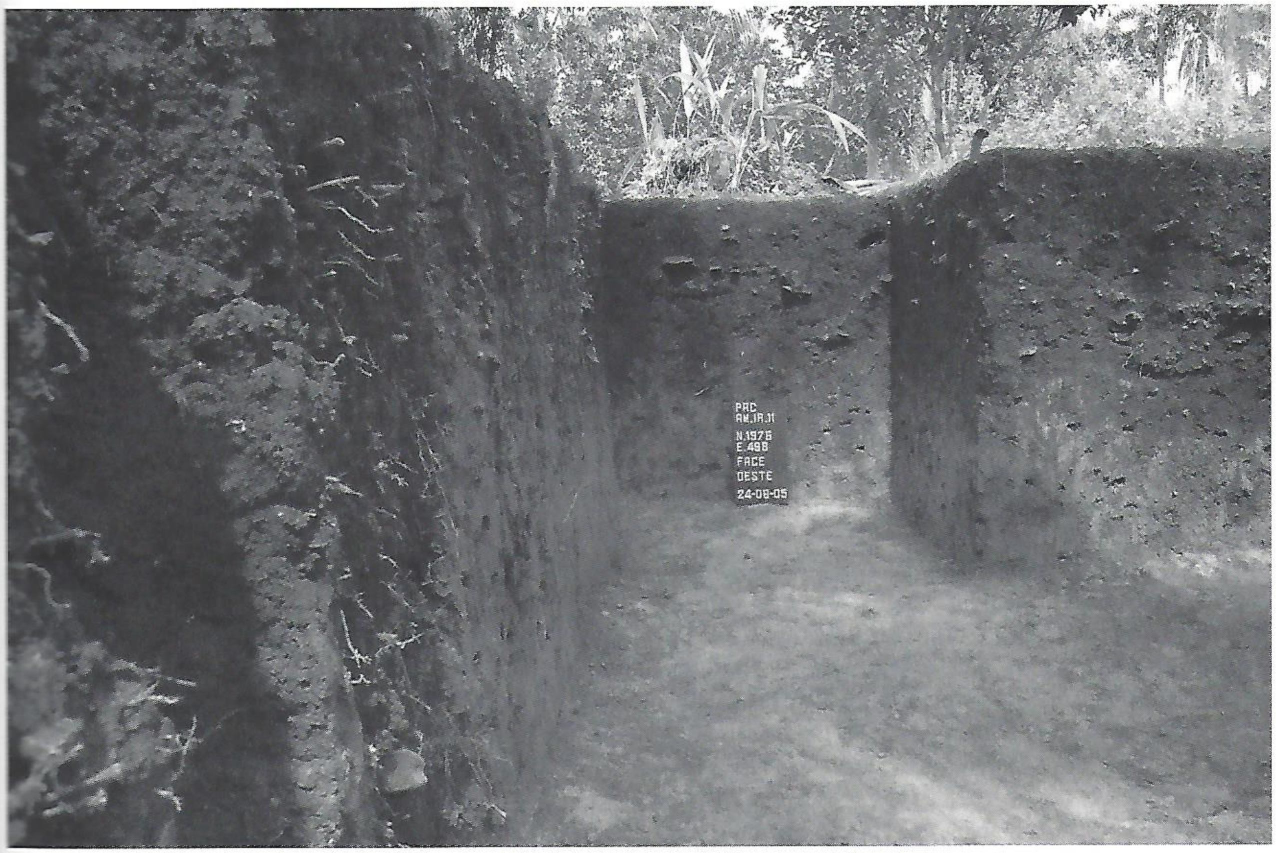


FIGURE 2.18.2. Dark earth layer produced by human occupation at a tropical lowland site in Brazil. (Courtesy Manuel Arroyo-Kalin.)

FIGURE 2.18.3. Raised agricultural fields and other modified land forms (arrows) in the Budi region of south-central Chile, dating to the late ceramic period. (Photo by T. Dillehay.)

more sedentary in order to attend to their plants during the growing and harvesting seasons. Increased sedentism probably then fostered greater elaboration in treatment of the dead and their role in defining permanent ancestral territories, as we witness during the Middle Holocene Period in Peru and northern Chile (Rossen 1991; Dillehay *et al.* 2003; Dillehay, Bonavia & Kaulicke 2004; Arriaza *et al.* 2008; Quilter *et al.* 1991). As several scholars have noted for the Andean region (Arriaza *et al.* 2008; Santoro *et al.* 2005; Raymond 1998), ritual expressions of territoriality and ancestral ties to land are linked to increased sedentism and food production. This situation is less clear in the tropical lowlands. Slash-and-burn systems of agriculture that emerged between 7600 and 6000 BP and continued for at least the next 3000 years in Panama and parts of lowland tropical South America (*e.g.*, Ayauchi in eastern Ecuador, the Colombian Amazon, and probably in eastern Amazonia) would not be expected in and of themselves to help fuel social stratification and complexity nor result in materially impressive forms of social elaborations. Slash-and-burn agriculture was probably associated then, as it still is now, with a social organisation characterised by household autonomy in decision making and relatively small settlements that shifted every few years. As the title of a recent article stresses, it is important to remember that "domestication alone does not lead to inequality" (Gurven *et al.* 2010).

Dramatic changes in economic and social organisation are particularly evident around 8000 to 7500 BP in the Nanchoc Valley of northern Peru. Prior to this period the Las Pircas people were foraging but also cultivating squash, pacay, quinoa, beans, peanuts and other crops in small garden plots situated next to scattered household communities. Between 7500 and 7000 BP a major shift occurred from cultivation and broad spectrum foraging to a more intensive farming economy based on a variety of food, medicinal and industrial crops, including the above species as well as coca, cotton, probably manioc and others. Accompanying this change was the appearance of irrigation canals, communal rituals at small-scale public mounds and more aggregated and larger household communities (Dillehay, Netherly & Rossen 1989; Dillehay *et al.* 2007; Piperno & Dillehay 2008). There is considerable evidence for greater reliance on domesticated plants and/or animals in several other areas of the central Andes as well (Hastorf 1999; Pearsall 2008). Most communities were probably inhabited for at least several months of the year, or all year round. Permanent settlements were also established along the coastal plains of Peru, combining agriculture with the exploitation of marine resources, probably using nets and simple boats. Existing patterns of exchange may also have been transposed and adapted to new settings, and by the 6th and 5th millennia BP this coastal form of Preceramic life was widely replicated along the shorelines and into the interior valleys of the whole of Peru, and later all the way down to central Chile. Late Preceramic agricultural villages such as La Paloma, Huaca Prieta, Salinas de Cao, Chilca, Bandurria, Caral (Fig. 2.18.4) and others were characterised by new interrelated organisational trends: more restricted social networks for sharing and consumption, and more formalised mechanisms for community-wide integration. Similar transformations were taking place in the highlands of Peru and Bolivia, especially around Lake Titicaca Basin, where agro-pastoral economies focused on potatoes and other tubers and on camelid wool and meat were thriving (Aldenderfer 2004; Bonavia 2009; Núñez 2006). During both the late Preceramic and early Formative periods (6500–4000 BP), ideology and religion appear to have been focused on group or communal activities.

New patterns of social behaviour requiring more community-wide interaction must also have emerged regarding the division of labour, processing, storage and exchange patterns. The presence of rituals at public mounds, agricultural fields and probably irrigation canals in the Nanchoc Valley by at least 7000 BP indicates interhousehold or communal labour projects. Such intracommunity changes reflect the growing significance of ritual activities in structuring interhousehold relationships, an increased emphasis on both resources and the ability of some sort of leadership structure, even if informal and situational, to organise community-wide labour activities. Similar developments were taking place in southwest Ecuador, where the Valdivia Culture (c. 6000–4200 BP) developed large circular agricultural villages comprising oval houses and ritual structures, a pattern later witnessed in many areas of the eastern tropical lowlands (Heckenberger, Petersen & Neves 1999; Meggers, Evans & Estrada 1965; Neves & Petersen 2006; Raymond 2008). This was a fundamental reorganisation of social life, and certainly at those sites where intense harvesting was important, it must have been tied to the annual cycle of seasonality, changing human perceptions of the environment, and the social implications of living in larger, more permanent communities.

The cultural structuring of space – in this case agricultural infrastructure and newly defined domestic space – was a way of creating physical historic embodiments of beliefs about the nature of the social group, and its origin and identity (*cf.* Kaulicke 1997; Zeidler 1998). Among the most striking features of the middle and late Preceramic periods of the central Andes was the transformation of "the architectural landscape" – the building of canals, agricultural fields and terraces, gardens,

FIGURE 2.18.4. View of a late Preceramic mound at the Caral Site, located on the north-central coast of Peru. (Photo by T. Dillehay.)

mounds and storage facilities. These communal landscape projects required organized labour in the form of corporate groups presumably overseen by a part-time steward or leader (Moseley 1975; Feldman 1980). Corporate labour and incipient leadership are key elements in setting the stage for more complex political and organisational transformations, which occurred later in many parts of the northern and central Andes and subsequently in the eastern lowlands.

Throughout the 4th millennium BP both coastal and highland Formative Andean societies continued to be influenced, albeit in different ways, by developments farther to the north and east in the tropical lowlands of Colombia, Ecuador, Peru and Bolivia (Raymond 2008; Burger 1992). This period of change witnessed the cultural and perhaps religious unification of the central Andes and its progressive differentiation from neighbouring societies in the northern and south-central Andes. Acceleration of change in coastal and highland societies during the early centuries of the 3rd millennium BP, the cultural uniformity of the central Andes came to an end. This growing disparity followed related developments in crop cultivation and camelid husbandry. In consequence, human occupation gravitated towards nodal points along the coastal floodplains and highland valleys, where large-scale irrigation developed. It may be at this juncture that farming began to play a more decisive role in central Andean developments providing opportunities for long-term occupation at key points of contact between the coastal valleys and their highland neighbours.

Settlement nucleation on the scale found at large Formative sites in many parts of the Andes is assumed to have involved intensive agriculture (and/or agro-pastoralism in the northern to south-central Andes). One precondition for intensification must have been an increased detail for overproduction, and this probably both happened in response to and required new forms of social relationships. This must also have underlain the simultaneous development of even more aggregated and larger settlements and a food-producing economy and various intensifications such as plough agriculture, expanded storage capacity and agro-pastoralism throughout many parts of the Andes.

Within these changing patterns of production, consumption and interaction, the development of material culture in South America proceeded along lines established in previous millennia. Within the increasingly fluid arena of interaction in the late Preceramic and early Formative periods, older and less flexible media of display such as ceramics and textiles underwent more marked elaboration and standardisation. By at least 5000 BP, pottery decorated with simple linear or geometric designs is found over an unprecedented area, reaching from Colombia and Ecuador to Peru and the Amazon Basin. Its production is symptomatic of the intensification of village industries throughout the northern and central Andes, where the reconfiguration of domestic space and life is apparent in the spread of oval to rectangular houses and more agglutinated villages. In the eastern lowland basin as well as northern South America, the invention of pottery also indicates that methods of food acquisition and preparation were diversifying. After 1500 BP, thicker-walled pottery was found in a context with cultivated corn, beans and other crops at several sites in the northern and central Andes (Pearsall 2008). In terms of spatial and temporal distribution, pottery appears integral to the spectrum of social and technobiological transformations that accompanied the beginnings of farming. Not known is the specific relationship of pottery to this process. Was it in some way fundamental to the adoption and spread of domesticates, or merely a technological addition to a self-sustaining process of economic innovation and diffusion?

In the central Andes, the 4th millennium BP also witnessed the development of complex metallurgical techniques around the sources of native copper in highland Peru and Chile. The exotic composition of copper objects found at several Late Formative highland sites in Peru (Burger 1992) indicates that metals circulated on a large scale along major waterways. Early forms of village bureaucracy probably allowed copper tools and domestic products to be removed from everyday routines of consumption and exchange, and mobilised in the acquisition of commodities (*e.g.*, metals, colourful spondylus shells from coastal Ecuador, precious stones from Colombia) that could not be locally produced, and may only occasionally have been available. The expanding trade of these and other exotics accompanied more differentiated, if not ranked, social structures characterised by permanent leaders and more formal occupational roles, social identities and emblematic corporate labour groups (Moseley 1975).

Labour and Social Means of Food Production

Even for the late Preceramic, Formative, and subsequent economies of South America, a most basic challenge of agricultural food production and later its intensification must have been to recruit labour to sustain the operation, whether on the scale of the earlier individual household garden or the later communal agricultural field. Without marked means of cooperation or coercion, with production in many ways technologically rudimentary and with communal production and redistribution supplementing rather than substituting for basic domestic production of subsistence, there must have been little to strengthen people's dependence upon community leaders to the point at which compliance surpassed the bounds of obvious mutual advantage and developed into economic dependence (*sensu* Arnold 1996). Such factors probably made change self-limiting and inequality largely ideological rather than purely social or economic. It is thus unsurprising that the clearest case for social inequality in the late Preceramic and Formative periods of South America, particularly in the Andes, was primarily founded on the control of communal ritual practice rather than upon individualised economic difference (Patterson 1999; Burger 1992; Dillehay, Bonavia & Kaulicke 2004): if differential access to resources existed, it may have been submerged through an extended participatory ritualism conceptually open to all to some degree. Elsewhere, crop production and intensification depended on enlisting labour, probably through voluntary mutual association, most likely ties such as kinship binding similar persons together, and fission and movement as ways of resisting potential hierarchy.

The issue of social stratification and inequality is important here. There is only limited mortuary evidence indicating individual social differentiation during the late Preceramic and Formative periods, such as grave-goods, and differential access to preferred resources, and this has led some researchers to propose egalitarian societies that lacked formalised social or political hierarchies (Burger 1992; Quilter 1991; Dillehay, Bonavia & Kaulicke 2004). The complexities of large communities probably included enhanced roles for community leaders and possibly even elites, although admittedly there is little supporting archaeological evidence and the existence of leaders is largely inferential. In terms of the central processes through which people generally defined social relations, there is also little sign of competition for individual prestige in the sense proposed for later urban societies in the central Andes. There is evidence that large-scale ritual was an important part of normal social reproduction (*cf.* Moore 1996). The main locus of action in which people probably experienced the world and their place in it meaningfully was in carrying out the many activities of daily life. In this sense, the economy was more than a means of providing subsistence and shelter. It created people and their identities; it provided the means through which individual bodies were enabled, differentiated, endowed with biographical histories and related to groups. Thus, whether based primarily on agriculture, animal husbandry or agro-pastoralism, late Preceramic and Formative economies were also social reproduction. In short, at present the evidence is not ample enough to determine whether the social structure of these cultural periods can be called economically stratified though they were certainly socially differentiated, if not ranked and occasionally stratified in the central Andes. The current evidence is not sufficient to address these issues in other parts of the continent.

In the Andes and in parts of the eastern lowlands, late Preceramic and Formative public or communal structures also have some social significance, simply due to labour investments required in their construction, if nothing else. Large-scale monumental buildings probably functioned in several social spheres, both at inter- and intragroup levels. Prominent and long-lived structures, as at Huaca Prieta, Aspero, Salinas de Chao and others on the coast of Peru during the late Preceramic Period, could have served as markers that existed both before and after an individual's lifetime, providing a longer historical chain. This was quite different from smaller settlements, and the shared iconography at many late Preceramic and early Formative Period sites (c. 5000–4000 BP) on the north-central coast of Peru (Burger 1992) hints that these sites could have served as dominant settlements with power over other communities. Another possibility is that the regional ceremonial centre was constructed to honour certain key ancestors and deities (such as male and female founding ancestors) who were important to a multicommunity social group such as a lineage. Since there are few traces of residential life at the sites, people from surrounding areas may have had access to these centres for periodic ceremonies.

In sum, there is little convincing evidence for the accumulation of individual or household wealth or material capital (such as mortuary differentiation, architectural differentiation or social distinctions based on house form and size) or political centralisation (such as two- or three-tiered settlement hierarchies, craft specialisation) during the late Preceramic and Formative periods in the Andes and even much less so in the eastern tropical lowlands. The same is true for aspects of ideological control except for large-scale ritual architecture at later Formative sites like Chavín de Huantar in the Peruvian highlands, for instance. We see the long-distance circulation of some exotic materials and possibly prestige goods. Both late Preceramic and Formative societies were thus characterised by economies developed largely for the construction of public places rather than the widespread circulation of prestige goods for individual political and economic stratification. However, emerging social inequality may have been linked to the ability of ambitious or charismatic individuals backed by their community branch members to gain control of food surpluses that they used to attract followers and labour by sponsoring feasts in public contexts, including funerals (*sensu* Dietler 2001). Hence, these societies were more likely heterarchical based on defining persons and activities in terms of qualitative differences.

Conclusions

The accumulated archaeobotanical, palaeoecological, molecular and other data on agricultural origins and dispersals in South America reviewed here and by others cited earlier reveal several clear patterns of development. First, the production of a number of tropical food crops of various types (roots, seeds and trees) is evident in a number of regions beginning during the first two to three thousand years of the Holocene. Second, the evidence indicates that early tropical food production during the c. 10,000–7500 BP period was often undertaken by people who were committed to practicing farming; that is, they were systematically growing a number of crops for food and deriving a substantial number of dietary calories from crop plants. Third, the advent of food production was associated with a significant decrease in mobility from previous transient foraging ways of life; the term "mobile foragers" applied to early farmers is likely to be inappropriate. Fourth, slash-and-burn systems of agriculture emerged in a number of regions during the 7500 to 6000 BP period. A classic Formative way of life is apparent with the beginning of the Valdivia cultural period in southwestern Ecuador at about 5500 BP, but it developed unevenly in other regions, perhaps due to the stability and success of slash-and-burn cultivation and other earlier farming practices characterised by smaller and more autonomous household communities. To reiterate what has been discussed earlier, an absence of large, nucleated, and sedentary villages using pottery prior to 5500 BP does not indicate an absence of effective and productive farming systems.

Patterns of early development in the high Andes are less clear at this time, and substantially more data are needed. Present evidence suggests the cultivation of the white potato perhaps by 7500 BP and of other crops native to the Andean mountain chain by a few thousand years later in time. Finally, to explain the development and spread of an agricultural way of life in South America, we should look not only to climatic and environmental changes, but also to demographic expansion and to the assimilation of hunters and gatherers into farming communities. Another possibility would see some hunter-gatherers, perhaps already practicing delayed-return economies in favourable (coastal?) areas, adopting farming themselves. While the environment will have determined what resources were available for exploitation and production, it would have been the social system that determined how these resources were used and distributed, and any study of the processes involved in the transition to farming needs to take into account both aspects in tandem in different environmental and social settings.

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