



1994

# Methodological Considerations in the Study of Ancient Andean Field Systems

Clark L. Erickson

*University of Pennsylvania*, [cerickso@sas.upenn.edu](mailto:cerickso@sas.upenn.edu)

Follow this and additional works at: [http://repository.upenn.edu/anthro\\_papers](http://repository.upenn.edu/anthro_papers)

 Part of the [Anthropology Commons](#)

---

## Recommended Citation (OVERRIDE)

Erickson, C. L. (1994). Methodological considerations in the study of ancient Andean field systems. In K. Gleason & N. Miller (Eds.), *The archaeology of garden and field* (pp. 111-15). Philadelphia: The University of Pennsylvania Press.

This paper is posted at ScholarlyCommons. [http://repository.upenn.edu/anthro\\_papers/13](http://repository.upenn.edu/anthro_papers/13)  
For more information, please contact [libraryrepository@pobox.upenn.edu](mailto:libraryrepository@pobox.upenn.edu).

---

# Methodological Considerations in the Study of Ancient Andean Field Systems

## **Disciplines**

Anthropology | Social and Behavioral Sciences

# The Archaeology of Garden and Field

edited by Naomi F. Miller and  
Kathryn L. Gleason



University of Pennsylvania Press  
Philadelphia

1994

## Chapter 6 Methodological Considerations in the Study of Ancient Andean Field Systems

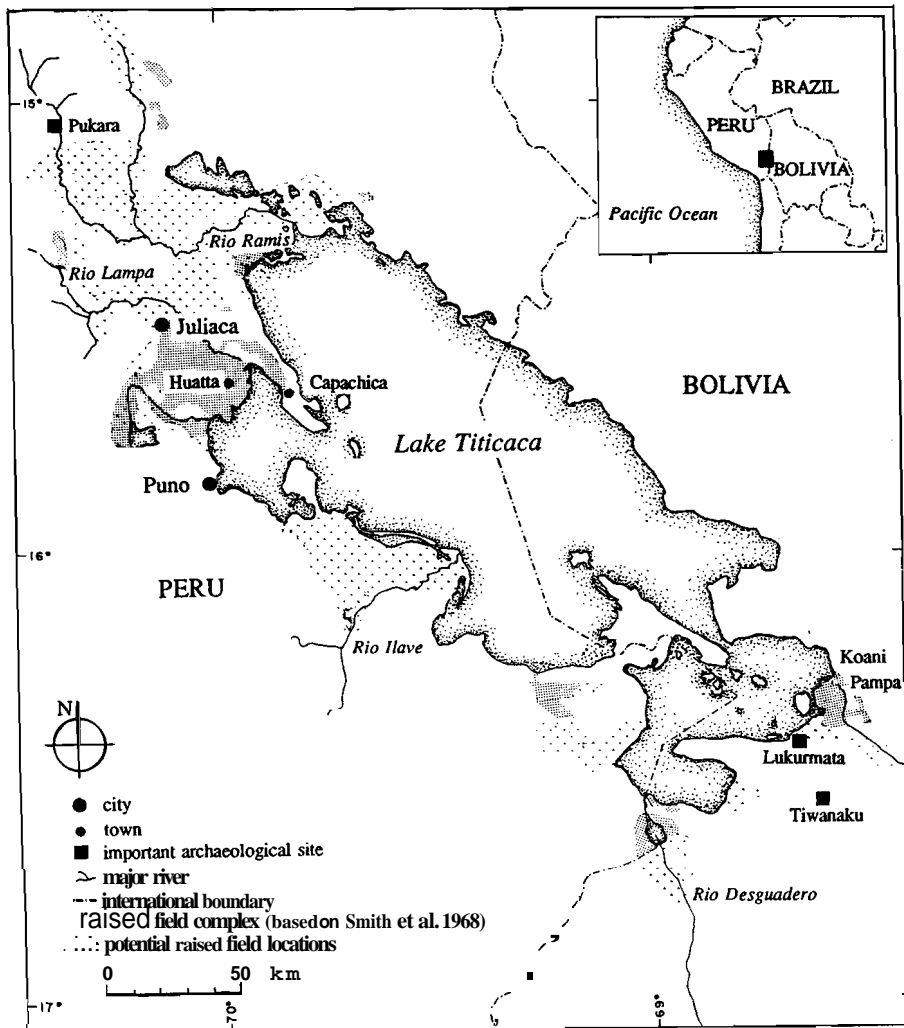
---

Clark L. Erickson

Raised field agriculture is a pre-Hispanic intensive crop production system used in the Andean region of highland Peru and Bolivia around the Lake Titicaca Basin (Figure 6.1). The system combines the use of large raised earthen planting platforms with complex networks of intervening canals and ditches. These features are evidence of massive earthmoving and landscape modification covering an area of over 82,000 ha of seasonally waterlogged land surface.

The methods for studying raised field agriculture discussed in this paper were employed by the Raised Field Agricultural Project, a long term (over 7 years) multidisciplinary study of ancient Andean agriculture. The research focused on the determination of original raised field morphology, origins and evolution of the system, carrying capacity and population dynamics, field functions, and crops cultivated. Key research problems included an assessment of the labor input necessary for construction and maintenance and a study of the field productivity and potential carrying capacity. This information was used to evaluate the efficiency of raised field farming in comparison to other past and present systems. The project also included an applied dimension, in that raised field technology was reintroduced to several communities and actively included the participation of local farmers in the agricultural experiments and fieldwork.

Archaeological techniques including analysis of aerial photographs, trenching, chronology development based on stratigraphic, ceramic thermoluminescence and radiocarbon dating, flotation and pollen analysis, settlement analysis and experimental archaeology established a basic outline of the extinct agricultural system. Agricultural experimentation created new possibilities for understanding the pro-



6.1. Locations of known and potential raised field remains in the Lake Titicaca Basin (after Smith et al. 1968)

ductive and social aspects of the ancient agricultural system. Finally, the data provided by these techniques form the basis for the design and implementation of an experimental program of raised field construction and use within the context of indigenous farming communities in the Lake Titicaca Basin.

## Raised Field Agriculture in the Andean Landscape

The Andean landscape is truly anthropogenic. Where any agriculture was possible, the natural land features have been totally transformed into cultural features by prehistoric farmers. The remains of these human transformations, such as terraces, raised fields, sunken fields, reservoirs, irrigation canals, aqueducts, channelized rivers, and roadways, are abundant throughout the Central Andean Highlands of Peru and Bolivia (Burga and de la Torre 1986; Denevan 1980; Denevan et al. 1987; Erickson 1992). Ironically, much of this once productive landscape now lies abandoned and much of the traditional technological knowledge base and resources have been lost. These prehistoric remains of agricultural systems can tell us a great deal about the people who made them. Even more important is how this knowledge can potentially be used in solving contemporary problems in rural development.

Raised fields are large, artificially elevated planting platforms. The excavation of soil to create adjacent platforms creates "canals," "swales," or "ditches" (Denevan and Turner 1974; Erickson 1985, 1986, 1988a, 1988b, 1992). Evidence of these fields has been found throughout the Americas in Colombia, Ecuador, Peru, Bolivia, Venezuela, Surinam, Guatemala, Belize, Mexico, Florida, Wisconsin, and Michigan (Denevan 1970, 1982; Parsons and Denevan 1967).<sup>1</sup> In the Lake Titicaca region, raised fields are highly variable in form and size. Most common forms are long straight linear platforms arranged in "bundles" of five to seven fields (for some of the field forms, see Figure 6.2). Commonly, fields range from 4 to 10 m wide, 10 to 100 m long and 1 m in elevation (see Erickson 1986, 1988a; Lennon 1982, 1983; Smith et al. 1968 for commonly used classifications). Remains of raised fields are estimated to cover at least 82,000 ha of the extensive flat plains (pampas) around Lake Titicaca (Smith et al. 1968), although this figure is probably very conservative (Erickson 1988a).

All prehistoric raised fields in the Lake Titicaca Basin of Peru and Bolivia are abandoned.\* Archaeological evidence indicates that this probably happened before the arrival of the Spanish, and no early historical records mention the field systems (Erickson 1988a). Because

1. Raised fields are found throughout much of the tropical and some of the temperate zones of both the New World and the Old World (e.g., Denevan 1982; Denevan and Turner 1974; Farrington 1985).

2. Large "lazy beds" for potatoes are used in the Lake Titicaca Basin and these are considered by some to be a small form of raised fields. I find that size of canal and platform is critical in the functioning of a true raised field and that most, if not all, of the currently used beds are not of sufficient size to be classified as true raised fields (Erickson 1988a).

of the lack of written records referring to raised field farming or local ethnographic analogy, the only direct means by which to investigate prehistoric raised field farming in the Lake Titicaca Basin were through the application of archaeological techniques and raised field experimentation.

### The Archaeological Study of Raised Field Systems

The Lake Titicaca raised fields were first investigated by geographers in the late 1960s (Smith et al. 1968) and later by an archaeologist in the late 1970s (Lennon 1982, 1983). The research on which this paper is based was done between 1981 and 1986. A similar program of excavation and experimentation has recently begun in highland Bolivia (Kolata 1989). In 1981, the Raised Field Agricultural Project began a detailed multidisciplinary investigation in the northern Lake Titicaca Basin, where the largest known block of prehistoric raised fields (some 56,000 ha) is located. Results of this project have been presented in various publications and monographs (Brinkmeier 1985; Erickson 1985, 1986, 1987, 1988a, 1988b, 1989, 1992, 1993; Erickson and Brinkmeier 1990, 1993; Erickson and Candler 1989; Garaycochea 1986a, 1986b).<sup>3</sup>

The archaeological techniques employed in this study provide information regarding the original morphology, chronology, crops cultivated, and site formation processes of raised field agriculture. These data are then used to reconstruct the fields accurately for agronomic experimentation to address field function, crop productivity, labor investment and organization, and sustainability.

### Aerial Photographic Analysis

The raised fields of the Lake Titicaca Basin were first discovered in the 1960s through the use of aerial photographs, despite having been walked over by scholars for over a hundred years (Smith et al. 1968). Most fields and canals in the Lake Titicaca Basin can easily be dis-

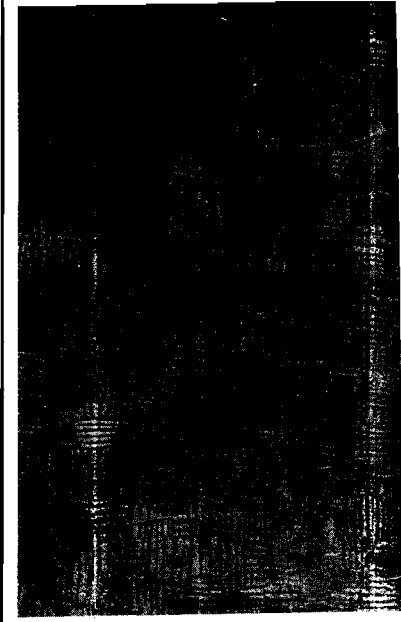
3. There is an extensive bibliography on the subject of archaeological techniques employed for the study of raised fields (including Bray et al. 1987; Broadbent 1987; Culbert et al. 1991; Eidt 1984; Evenari et al. 1971; Farrington 1983; Freidel and Scarborough 1982; Gliessman et al. 1985; Golson 1977; Graffam 1990; Hammond et al. 1987; Knapp and Ryder 1983; Kolata and Graffam 1989; Kus 1972; Moore 1988; Moseley 1983; Muse and Quintero 1987; Orloff 1988; Orloff et al. 1985; Parsons et al. 1985; Pohl 1989; Puleston 1976, 1977a, 1978; Siemens 1989; Stemper 1987; Turner and Harrison 1983b; Zucchi and Denevan 1979). These techniques have also been employed in studies of terracing (e.g., Malpass 1987) and irrigation (e.g., Farrington 1983; Moseley 1983).

cerned in aerial photographs because of contrasting vegetation and soil conditions and because of the lack of dense ground cover (see Figures 6.2, 6.3, 6.4, 6.5). Aerial photograph interpretation proved very useful in locating and mapping field patterns, their areal distribution (Erickson 1988a; Kolata 1986; Lennon 1982, 1983; Smith et al. 1968), and associated archaeological occupation sites (Erickson 1988a, in prep. a). The aerial photographic record is also very useful in guiding the experimental reconstruction of raised fields discussed below.

Throughout the raised field system in the pampas are isolated and clustered occupation mounds (Figure 6.4). Most of these mounds are unoccupied, although some have permanent and seasonal residences of families who use the pampa for pasture. We know from excavation and surface collections that the occupation of most of these mounds is multicomponent and continuous. One of the advantages of working in the Lake Titicaca Basin is that prehistoric occupation sites of raised field farmers are easy to locate with stereo pairs of aerial photographs. The slight topographic relief (0.5 to 1.0 m in elevation) of these mounds stands out against the relatively flat lake plain surface. Even the smallest individual house mounds can usually be distinguished (Figure 6.4). Many mounds are also surrounded by water during the rainy season when the pampa is inundated.

The patterns of field shape, size, and orientation provide many kinds of information on the organization of raised field farming. In spite of the great degree of variation, most raised field blocks were carefully designed to the point of approaching a form of standardization. Discrete rectangular or square "bundles" of five to ten parallel fields are very common (Erickson 1988a; Lennon 1983) (Figures 6.2, 6.4, 6.5). Many of these are bordered by canals or earthen embankments. These appear to have been family or extended family holdings (land that could be worked and maintained by a group of five or more people). These in turn are nestled within larger blocks of fields defined by large straight canals which radiate outward from certain points (usually higher ground). These larger units probably represent *ayllus* or the local Andean land holding units. These, in turn, combine at a higher level unit, the local community or *llacta* (Figure 6.5). Since we know that most of the fields visible on the surface in the Huatta area date to the Late Intermediate Period and thus are probably contemporary, the differences between field patterns in larger areal extent may reflect ethnic differences and social boundaries.

Farmer aesthetics and basic cognitive structures may also be represented in the formal patterning of the earthworks. The majority of raised fields in the Lake Titicaca Basin are oriented to the cardinal directions. The most common type of general patterning, the



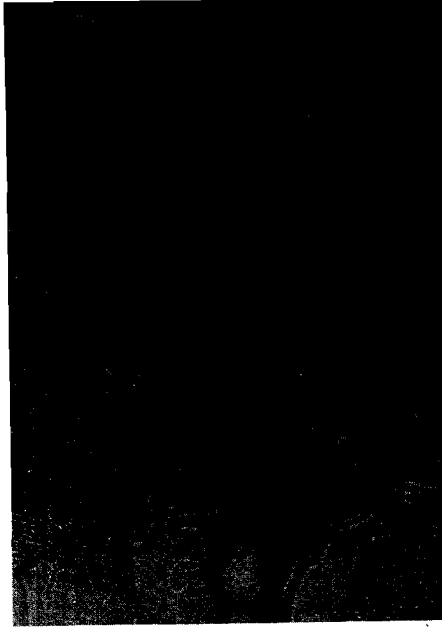
A.



B.

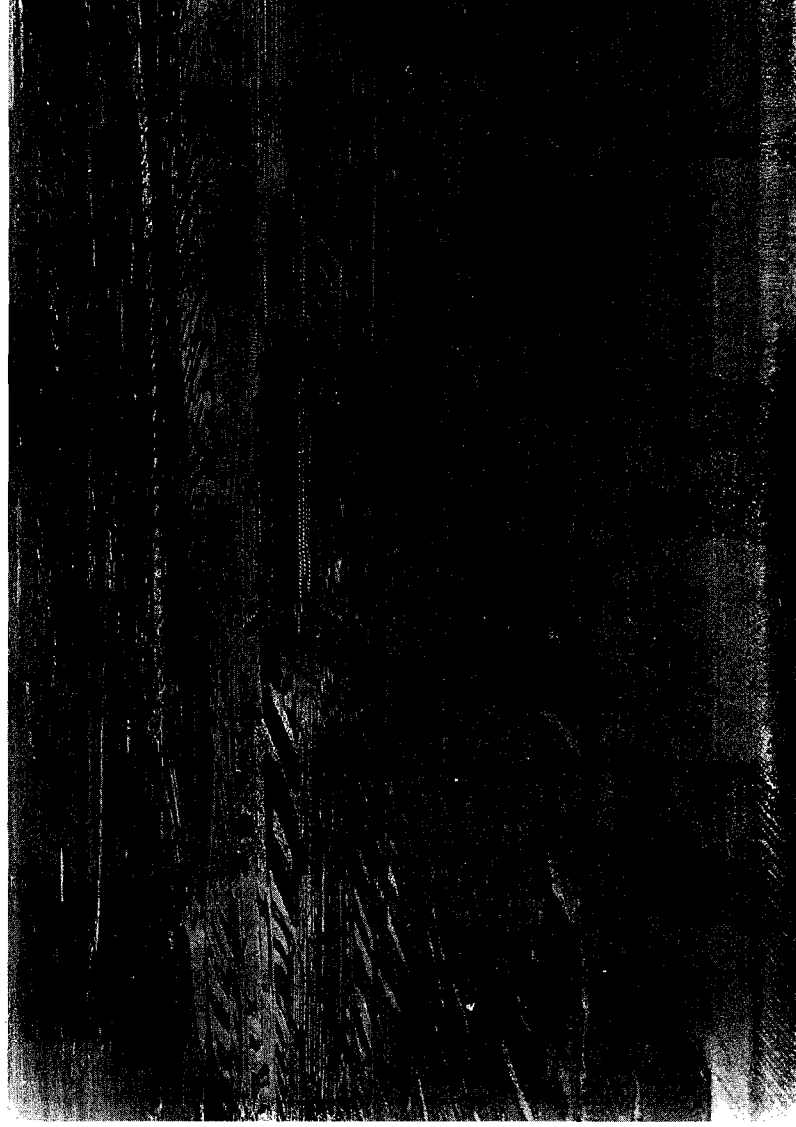


C.



D.

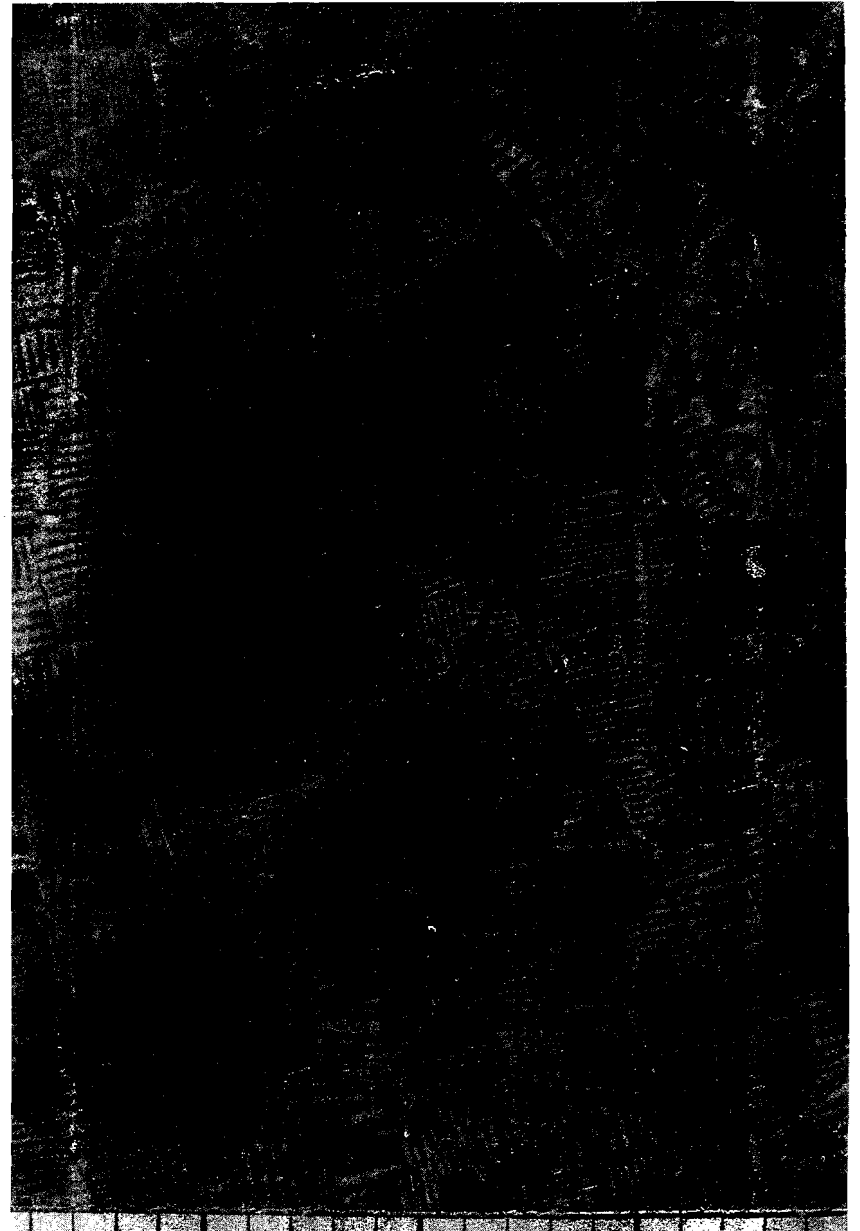
6.2. Variations in the forms of raised fields in the Huatta area of Peru.



6.3. Prehispanic raised fields in Viscachani Pampa, Huatta. The darker fields in the center are reconstructed raised fields, part of the experimental program.



6.4. Raised field platforms (light colored strips) and prehispanic occupation mounds (upper right and lower left) in the shallows of Lake Titicaca.



6.5. Highly patterned raised fields in Viscachani Pampa. The long dark linear features are large canals which divide up the blocks of raised fields into larger units.

"checkerboard" form (Smith et al. 1968) clearly has structural similarities to textile patterning (Erickson in prep. b), something that has been argued for by archaeologists working with pre-Hispanic Andean architectural patterning. While it is expected that some aspects of the form of raised fields were specific to their function and efficiency, the majority of decisions regarding patterning of fields probably was culturally based. In several locations, whimsical or cultural metaphors appear to have been expressed in the visible spatial patterning (complex spirals, circles, and other possible shapes).

### Trenching

The trenching of earthworks and architectural features has been a very useful tool in archaeology throughout its history (see Yentsch and Kratzer, this volume). Excavation trenches provide long stratigraphic profiles of complex features which allow the definition of construction stages and internal chronology, original morphology and extent of cultural disturbance of the original land surface, and the effects of natural and cultural site formation processes during use and after abandonment. In the case of the raised fields of the Lake Titicaca Basin, the topographic features are heavily eroded and sometimes buried. Sediments have filled the once deep canals and the field platform surfaces have been planed off by wind and water erosion, human disturbances through agricultural and pastoral activities, road building, urbanization, and sod removal for construction. In this context, surface remains will only provide a limited amount of information and thus excavation of deep trenches is necessary.

In order to determine original morphology, numerous trenches were excavated within raised field complexes. The most effective placement of a trench is *perpendicular* to the principal axis of a block of fields and canals (Figures 6.6, 6.7, 6.8, 6.9). The ideal length of a trench extends from the center of one raised field surface to the center of the adjacent raised field surface across the intervening canal (see Figure 6.6). Long trench excavations are much more efficient than small test units or soil coring for raised field investigation. Small units that do not span the distance between raised field and canal do not provide adequate information for the interpretation of the complex stratigraphy. The changes which occur over a short horizontal and vertical distance within raised fields would be missed or misinterpreted without the long profile perspective provided by trenches. On exceptionally large fields, trenches were excavated from canal center to adjacent field center and the unexcavated half extrapolated from



6.6. Excavation of Unit A at Viscachani Pampa, Huatta. The trench extends from the center of one raised field across a canal to the center of field.





6.7. Excavations of trenches in raised fields.

the known strata. The trenches were 1 or 2 m wide to allow sufficient space and light for mapping profiles and to detect complex horizontal stratigraphy. Trenches were excavated to a depth below the boundary between subsoil and cultural levels (normally between 1 and 2 m below the present pampa surface; see Figure 6.8).

In trenches with very complex stratigraphy, a second 1 m wide trench was excavated alongside the original one (Figure 6.6). This excavation used the first profile as a guide, so that each cultural stratum



6.8. Unit NOPQ at the site of Pancha showing portions of two small wavelength Phase I raised field platforms under larger wavelength Phase II raised fields (visible at the surface). The meter scale is at the center of the Phase II canal.



6.9. Mapping of the stratigraphic profiles in Unit A at the site of Jucchata, Huatta.

of the second trench could be "peeled back." This technique permitted very precise control of micro-strata and permitted accurate recording and recovery of in situ artifacts useful in dating and interpreting field function.

The canal stratigraphy and canal boundaries are clearest because they were originally cut into the lighter-colored B and C Horizons and later were filled with dark organic sediments, leaving a sharp stratigraphic contrast. The platform boundaries are often indistinct, since they generally have eroded into the canals. Canal depth and volume provided indirect information from which to extrapolate the original field surface height and fill volume dimensions (Erickson 1988a).

The internal stratigraphic complexity of the raised field construction fill and sediment-filled canals was surprising (Figure 6.10). Clear superposition of discrete periods of raised fields separated by periods of field abandonment was documented in five of the nine trenches excavated. All trenches showed evidence of distinct construction fill stages and field disuse and abandonment. This demonstrates the importance of trenching in order to determine complex field history. The study of surface features alone cannot provide any information on the evolution of field form or distinct building and use periods. Analysis of vertical stratigraphy demonstrated that all field systems were constructed over a long period of time, rather than all at once, as was formerly believed.

Large scale horizontal excavations to uncover and expose buried canals and field surfaces over large areas could be useful for documenting the horizontal morphology of superimposed field systems. Unfortunately, our project did not have the resources to do this. Depending on the issues to be resolved, the effort necessary for large scale horizontal excavation may be worthwhile, although it is certainly much less efficient than trenching operations. Golson (1977) and Gorrecki (1982) found that horizontal excavations were productive in their investigations of raised fields and canals in highland New Guinea.

### The Chronology and Evolution of Field Systems

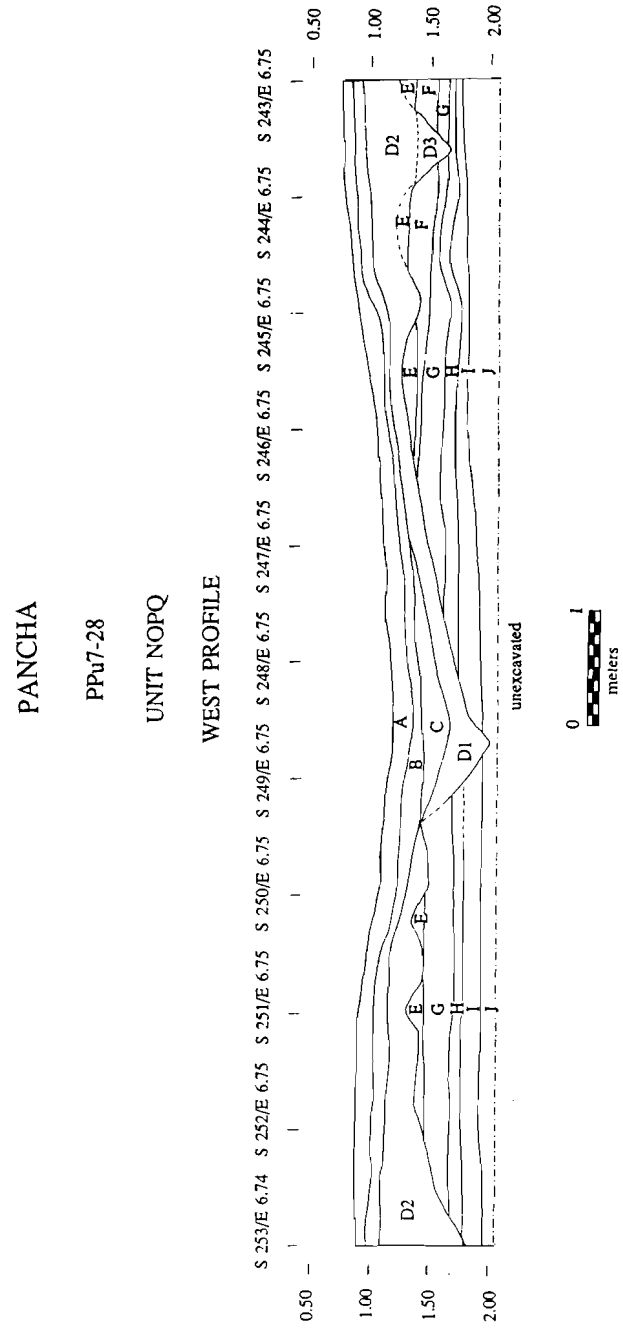
Ancient field systems are often assigned to the period of nearby dated occupation sites (for example, see Denevan 1970; Kolata 1986; Smith et al. 1968; Turner and Harrison 1983). In many cases, associated sites are dated by surface artifactual remains. The sites located in our archaeological survey of raised field zones and those that were excavated are *multicomponent* sites, many with occupations that span a period of 3000 years. The abundance of late prehistoric remains on site

surfaces gives no hint of the actual buried remains of earlier occupations. The only accurate way to determine when the fields were built, used, and abandoned is to directly date the field systems themselves. This can be done either through radiocarbon dating of organic remains within fields or the recovery of in situ diagnostic or datable artifacts.

As expected in non-occupational, agricultural features, absolute dating of construction phases, use, and abandonment proved difficult due to the paucity of in situ stylistically diagnostic or datable artifacts. Many trenches yielded few or no artifacts except the ubiquitous broken stone hoe flakes incorporated into the earthworks during use or resharpening of tools. Pottery fragments and organic materials were more plentiful in fields located near occupation sites, where garbage (bone, ash, lithics, and ceramics) had been incorporated intentionally or unintentionally into the field platform fill and canal sediments. Unfortunately, most ceramics recovered in situ were body sherds of utilitarian wares which could not be used for accurate stylistic dating. There was insufficient charcoal within canal and field strata for radiocarbon dating. A number of pottery sherds recovered in situ were submitted for thermoluminescence (TL) dating. Nine TL dates provided the basis for the establishment of an evolutionary chronology of raised field construction, use, and abandonment (see Erickson 1987, 1988a).

An example of the results of trenching, stratigraphic analysis, and TL dating of in situ ceramics within a complex stratigraphic profile (Trench NOPQ) of two raised fields and a canal at the site of Pancha Pampa is presented in Figures 6.10 and 6.11. These agricultural features are directly associated with a large occupation mound in the pampa southwest of Huatta. Surface collections and test excavations at the residential site of Pancha indicate nearly continuous occupation dating to as early as 1500 B.C. Without excavation, there was no way to determine if the fields also were constructed and used over this considerable time span or if they were associated with particular periods of occupation at the site. Stratigraphic analysis of the raised field profile indicated that there were two major periods of construction and use of the raised fields at this location. During Phase I, small

4. In some cases of raised field investigation, it has been possible to date canal sediments and in situ organic artifacts directly using radiocarbon analysis. Dates were obtained from raised field canals in Belize (Puleston 1978, Pohl 1989, Turner and Harrison 1983a, 1983b), the Guayas Basin (Parsons 1978), the San Jorge Basin (Eidt 1984), and the Llanos de Mojós (Erickson et al. 1991). Recently, accelerator mass spectrometric technique has been applied to dating raised fields in Cobweb Swamp, Belize (J. Jacob, pers. comm.).



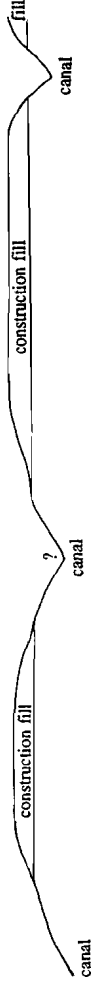
6.10. Stratigraphic profile of Unit NOPQ, Pancha.

# PANCHA UNIT NOPQ

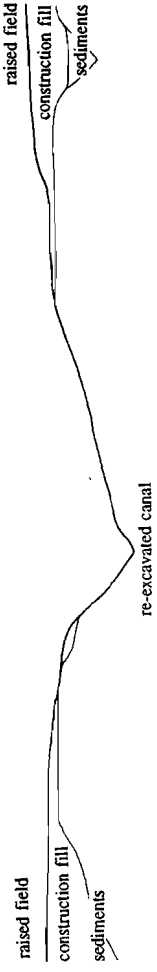
## I. ORIGINAL LANDSURFACE

---

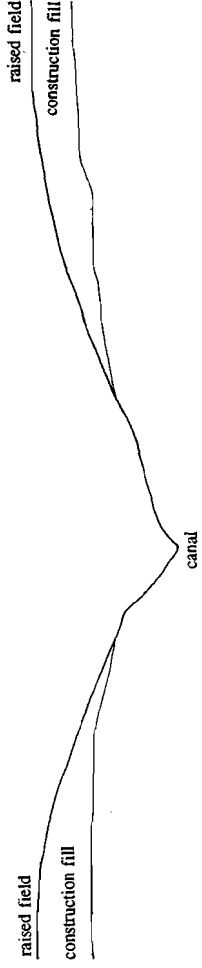
## II. RAISED FIELD CONSTRUCTION: PHASE I



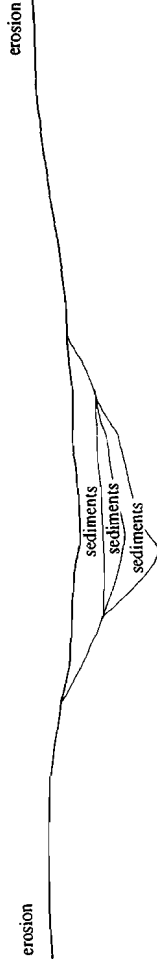
## III. ABANDONMENT, EROSION, AND SEDIMENTATION RAISED FIELD CONSTRUCTION: PHASE II-A



## IV. RAISED FIELD CONSTRUCTION: PHASE II-B



## V. ABANDONMENT, EROSION, AND SEDIMENTATION



## VI. PRESENT DAY LAND SURFACE



6.1.1. Reconstruction of stages of construction and abandonment based on the profile of Unit NOPQ, Pancha.

1–2 m wide raised fields were constructed with wavelengths of approximately 5 m between one canal and an adjacent canal and an elevation of 1–2 m between canal floor and field surface. At a later Phase II construction, the dimensions of the fields were expanded by closing every other Phase I canal with fill and constructing platforms of 5 m wide and up to 1 m tall. During this time, the canals were widened (up to 5 m) and excavated deep into the subsoil erasing the evidence of some of the earlier Phase I canals. The result produced raised fields with 10 m wavelengths of canal to canal. In addition, minor construction and maintenance activities could be detected in the microstrata of the raised field platform fill within both phases.

Thermoluminescence dating of ceramics recovered from various key contexts within the stratigraphic trench provided a means of direct dating of the relative chronology based on stratigraphy presented above. A date of 400 B.C.  $\pm$  500 years (DUR TL 26-1as) was recovered from the base of the Phase I raised field fill and is interpreted as dating the initial construction of the raised field. Another date of A.D. 440  $\pm$  310 years (DUR TL 8as) was obtained from ceramic pottery sherd in the sediments of the Phase I canal, probably deposited during a hiatus of raised field construction and use. Two overlapping dates of A.D. 1325  $\pm$  120 years (DUR TL 26-3as) and A.D. 1540  $\pm$  90 (DUR TL 35-7as) years on ceramics were recovered from samples in sediments of a Phase II canal. These are interpreted as dating the period after final abandonment of the fields as canals were gradually filled with sediments and occasional occupation midden.

Based on analysis of stratigraphic profiles, additional TL dates and stylistic dating of in situ ceramics from a total of 11 stratigraphic trenches in raised fields, we developed a tentative chronology of raised field construction, use, and abandonment (Erickson 1987, 1988a). The dating of ceramics within fields is internally consistent with the stratigraphy of the profiles and correlates closely with radiocarbon dating of the major occupations of associated sites within the pampa. There appear to have been two distinct periods of construction and use. The first period begins sometime around 1000 B.C. and lasted until A.D. 300 and is characterized by small raised fields. A second construction and use period probably began after a period of several hundred years of abandonment around A.D. 1000 and

5. Thermoluminescence (TL) dating is a relatively inexpensive and accurate technique for absolute dating. For TL dating, ceramic samples must be at least 2.5 cm in diameter and 0.6 cm thick. To prevent contamination by cosmic radiation, the samples must be sherds that were buried relatively quickly after deposition (preferably to a depth of at least 0.5 m). The context of raised fields helps insure that sherds recovered in raised field fill meet this criterion of rapid and deep burial.

lasted until the Inca conquest of the region around A.D. 1450. The complex internal stratigraphy and cycles of construction, use, and abandonment could never be accurately determined through study of eroded surface remains or associated occupation sites, only through careful analysis of long trenches excavated within the fields themselves.

Because agricultural fields are likely to have been regularly disturbed to a certain depth during the annual cultivation and harvest when in use, care must be taken in the interpretation of single dates. Because of this factor and the uncertainties inherent in TL dating, dates should be checked against independent data sets such as relative stratigraphy and ceramic stylistic dating. In our case, all TL dates were internally consistent with the relative dating of the stratigraphy within each TL date context and stylistic dating of the sherds. Despite potential problems, these methods are preferable to the common establishment of agricultural system chronology through dating of associated occupation sites.

### Ethnobotanical Analysis

Flotation and pollen samples collected from raised field contexts and associated occupation sites were analyzed. In situ botanical remains helped to determine some of the original food crops cultivated on the raised fields in the past, in addition to providing data on past local environments and other non-cultivated resources used by the farmers.

Pollen preservation was poor in the raised field and canal contexts, probably because of the annual alternation of wet and dry conditions of the soils (Wiseman 1984). Although hampered by a lack of comparative collection of local pollen, many weedy species of plants not common to the wet conditions of the pampa were identified, strongly suggesting intensive agriculture, and pollen grains of *Solanum* and *Chenopodium* may represent cultivated potatoes and quinoa or cañihua. Unfortunately, many important highland Andean crops leave little pollen signature because they are reproduced vegetatively. Pollen of several aquatic species were recovered from raised field canals indicating that raised field canals supported permanent aquatic communities. Floral evidence of year round moisture conservation in many canals supports our hypothesis that the features served important functions to minimize droughts and provide protection against frosts. The evidence of aquatic plants also indicates that the canals were important for the production and cycling of organic nutrients to sustain continuous raised field crop production.

Standard flotation recovery of small animal and plant remains was also employed. A simple flotation rig consisting of a 55-gallon barrel

and heavy fraction inset screen was used to recover carbonized macrobotanical remains (cf. Pearsall 1989). Flotation samples taken from raised field profiles did not yield any preserved macrobotanical remains. Soils from archaeological occupation sites associated with the raised fields did yield substantial quantities of identifiable remains of plants, some of which were potential cultigens. Among these were considerable numbers of seeds of *Chenopodium* (possibly the domestic quinoa and canihua), *Lupinus* sp. (possibly the domestic crop tarwi), tuber fragments (presumably of domesticated potatoes and other Andean tuber crops), various wild pampa grasses, aquatic plants, and weedy species. Surprisingly, the majority of carbonized seeds and other plant parts identified in the samples from occupation sites are not of crop species, but represent wild or weedy species. This bias may be due to the Andean practice of using camelid dung as household cooking fuel (cf. Miller and Smart 1984). The llama and alpacas may have ingested many of the seeds which were carbonized during dung burning and later recovered in flotation.

This botanical information, in addition to lists of important crops cultivated during the early Colonial Period and those still cultivated today in the region, provided a basic inventory of cultigens (and economically important weedy species) that may have been grown on raised fields in the past. This data base was used in the planning of raised field experiments (discussed below).

### Settlement Survey and Occupation Site Excavations

Large sections of the pampa and hillside around the community of Huatta were surveyed on foot. Of particular interest to this research were occupation sites on the pampa. Sites discovered using the aerial photographs were verified on the ground. It was relatively easy to locate sites and their boundaries in the pampa because of the elevation of sites, invariably located on low mounds, and because of the sparseness of vegetation on the overgrazed pampa. Sites were elevated both intentionally by the addition of fill and unintentionally by the collapse of adobe and sod structures and the accumulation of midden. Mounds tend to be spaced at regular intervals across the pampa. Several large sites have non-local cut stone on their surfaces and one large site has a substantial stone retaining wall suggesting important public architecture. At the other end of the spectrum are the temporary camps on small mounds within blocks of raised fields.

Sites were measured and diagnostic materials were surface collected for dating and determining site function. In addition to occu-

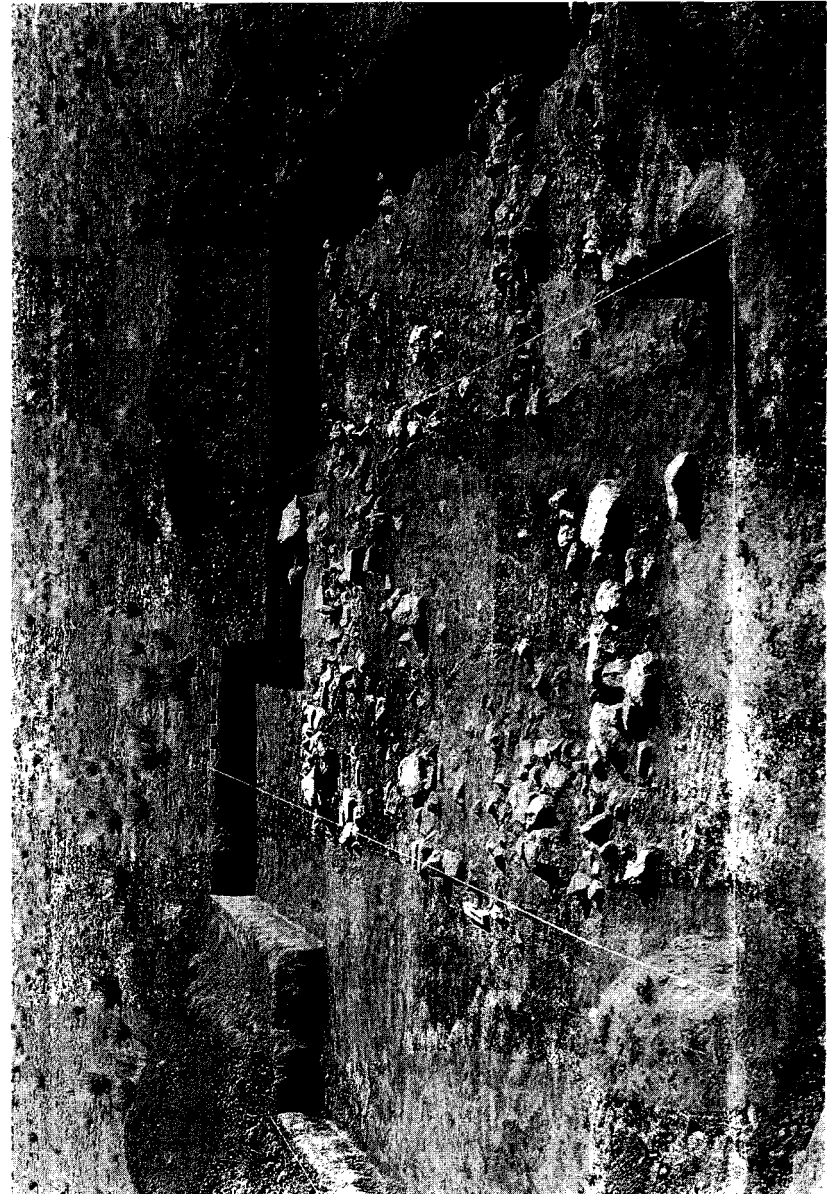
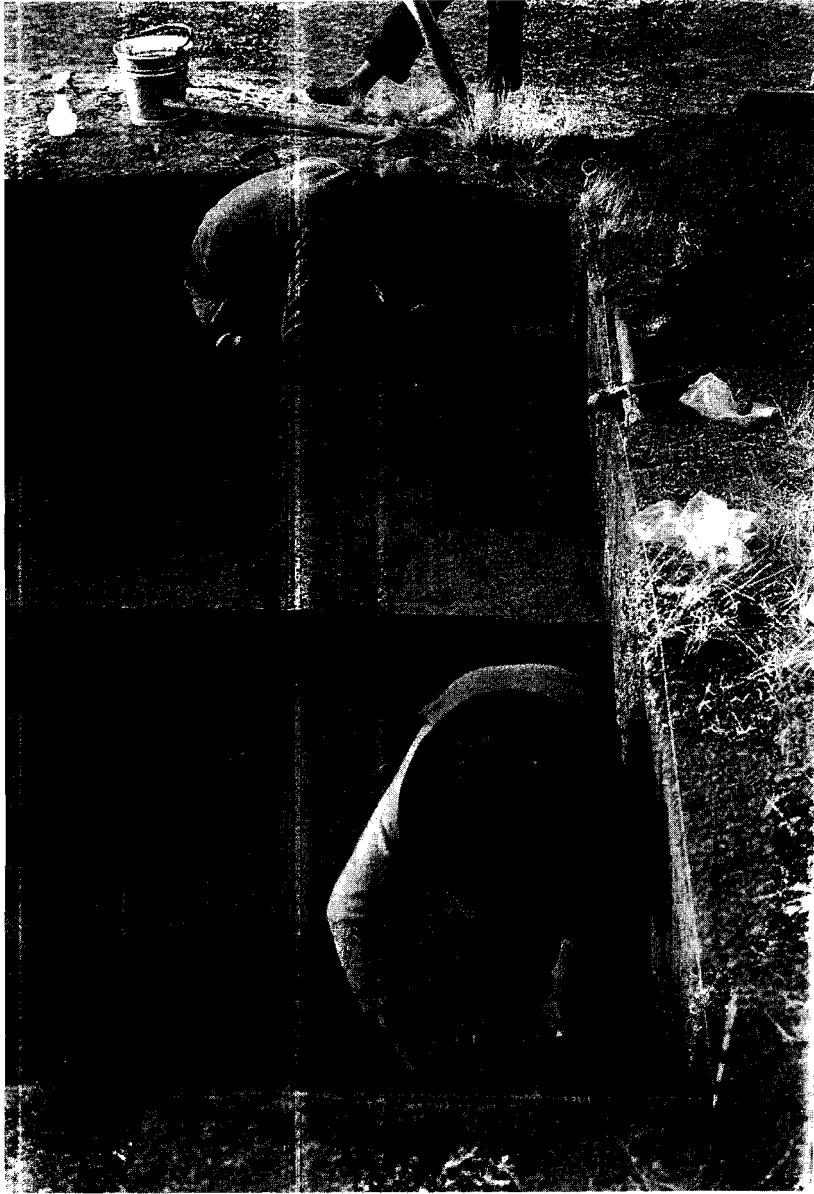
pation sites, several special function sites (quarries, kilns, and field huts) were located.

Two settlements were excavated (Figure 6.12). Because of the problems mentioned above, these sites were dated independently of the raised fields using radiocarbon dating and stylistic analysis of diagnostic ceramics. These excavations documented the long occupation sequence, beginning around 1000 B.C. There was clear overlap of occupation of these sites in the lower levels and the construction and use of raised fields (both Phase I and Phase II mentioned above). In addition to chronology, the test excavations recovered information on households, domesticated and collected foods (both plant and animal), local environments and farm economy, agricultural tools, and household ceramic inventories (Erickson in prep. a). Subsistence was primarily based on crops produced by raised field farming, in addition to the collection and hunting of wild lacustrine floral and faunal resources.

The two mound sites, Kaminaqa (3.5 m high) and Pancha 3.0 m high), were excavated using limited horizontal excavation and deep probing. Excavations demonstrated that the mounds were totally artificial, yet very little of the mound area appeared to be made up of intentional fill. Most of the mound matrix was a gradual accumulation of a continual series of occupation floors, possibly houses, patios, and other structures. Alternating with floors were bands of what appeared to be "melted" adobe and adobe debris and sometimes midden debris. It is quite possible that many of the structures were also made of sod building material cut from the pampa, a practice still used today. These mounds represent the gradual build-up of household collapse and intentional leveling, and garbage accumulations of numerous generations of raised field farmers. House structures appear to have been densely packed on the mound surface. As the mounds increased in elevation, their value as ideal occupation sites for farmers increased. These mounds prevented inundation of households and provided a vantage point from which to view the vast agricultural plain. Today, the larger mounds such as Coata and Pojsin Karata are densely occupied population centers for the area.

### Experiments in Raised Field Agriculture

Experimental archaeology (including simulations and replicative studies) has been a useful approach in a number of archaeological interpretations (Coles 1973). Although it is impossible to control all the experimental variables and to create the social and environmental



6.12. Excavations in households at the site of Viscachani Pampa (above) and Pancha (facing page).



conditions of prehistory, experiments can provide insights to how ancient technology functioned and how it was organized. Experimental archaeology has great potential for interpreting past agricultural systems (Coles 1973; Evenari et al. 1971; Puleston 1977a, 1977b; Steensberg 1980). Because raised fields, like many other prehistoric agricultural systems, are not currently used in the Andean region, direct ethnographic analogy can not be applied. Indirect analogy based on ethnographic situations in other parts of the world is of more limited use.<sup>6</sup> For example, a form of raised fields (the so-called "floating gardens" or chinampas) are still used on a limited scale in Central Highland Mexico (Coe 1964; Gomez-Pompa et al. 1982; Jimenez-Osornio and del Amo 1988). The inhabitants of the Wahgi and Baliem Valleys and Frederick-Hendrick Island of Papua and Indonesian New Guinea still farm using raised fields (Golson 1977; Heider 1970; Serpenti 1965; Steensberg 1980).

In Belize, Puleston (1977a, 1977b, 1978) conducted the earliest raised field archaeological experiments. He collected information on labor and maintenance costs, functions, and the crops potentially cultivated by the lowland Maya. The construction of the experimental fields was based on his archaeological research on pre-Hispanic Maya raised fields. Puleston's labor figures provided the basis for most raised field interpretations for the next decade. Other raised field reconstructions by archaeologists include small scale experimental work in Ecuador (Denevan and Mathewson 1983; Muse and Quintero 1987), Mexico (Gomez-Pompa et al. 1982), and the United States (Riley and Freimuth 1979). Unfortunately these projects did not extend beyond one year. New raised field experimental research is being conducted in Bolivia (Kolata 1991; Rivera 1989), although little of this work has been completed.

Most of the systems studied ethnographically and archaeologically are not directly analogous to Andean raised fields because they have very different cultural, historical, and environmental contexts. Local

6. Labor costs (construction and maintenance) and production (crop yields and sustainability) are very difficult to calculate without actual agricultural experimentation. Figures such as Erasmus's (1967) labor calculations for experimental construction of earthworks in Mesoamerica have been frequently applied to raised field construction (Denevan 1982). I argue that this application is inappropriate because different techniques are used and because of environmental differences. Investigations by Puleston (1977b) and Steensberg (1980) have also addressed the labor input of raised fields in their experiments. Estimates for raised field crop production have commonly relied on the regional production estimates for traditional agricultural systems (Denevan 1982, Harrison and Turner 1978, Turner and Harrison 1983b). These figures can only be considered indirect estimates of potential crop yield and may have little to do with the actual raised field production in functioning field systems.

raised field experimentation, based on the information obtained from direct archaeological investigation of prehistoric raised fields, is the most appropriate means of understanding the Lake Titicaca Basin field systems.

In our experiments, we rebuilt ancient abandoned raised fields as accurately as possible and planted them with traditional Andean crops. The original forms of raised fields were determined through the study of aerial photographs, topographic mapping, and excavation of stratigraphic trenches (Figure 6.13).

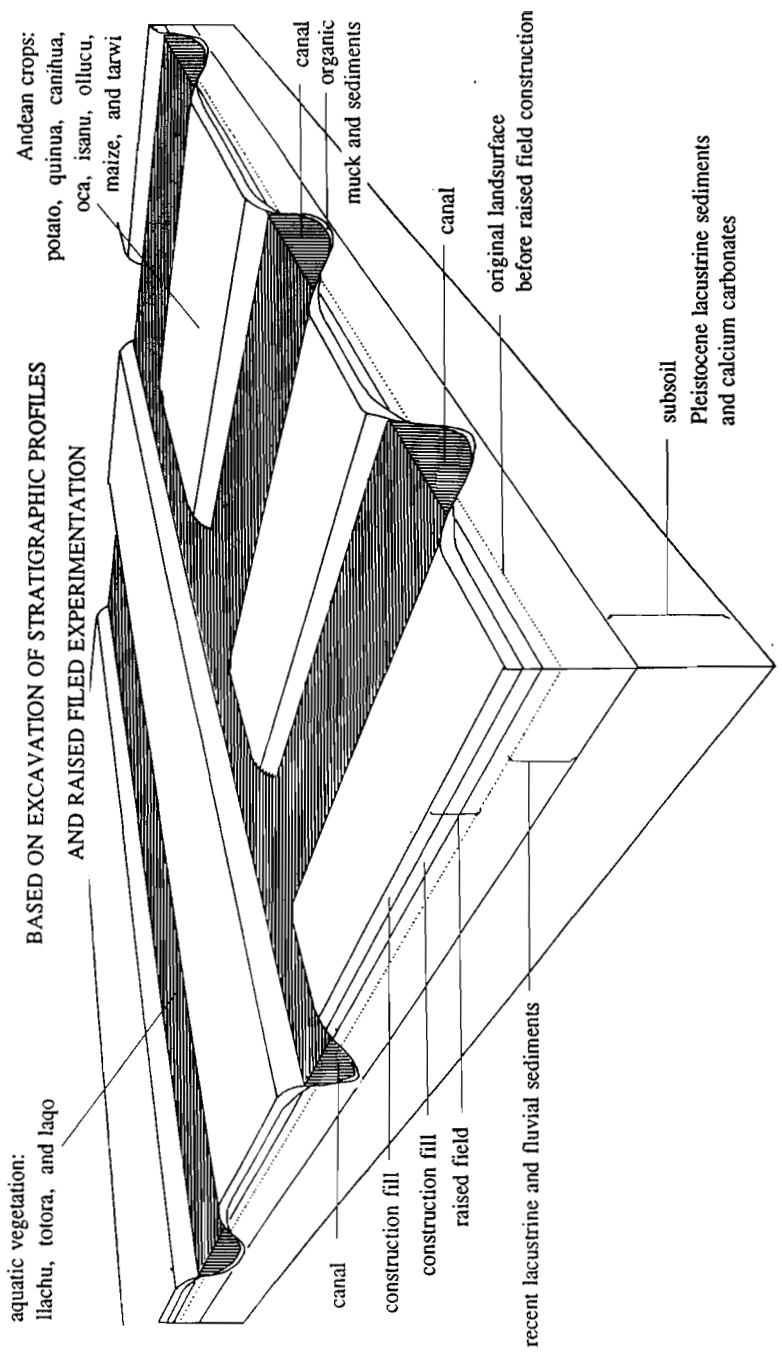
The experiments were conducted in collaboration with Quechua-speaking farmers of the communities of Huatta and Coata. Participant groups varied from single families farming privately owned lands to communities of up to 150 families farming communal lands. The family or community donated their land and labor in return for free seed (potato and other Andean crops) provided by the project, and the participants received all of the harvest. After our project ended in 1986, many farmers continued to experiment with raised field farming encouraged by various development projects that adopted raised field agriculture as part of their rural aid programs (Erickson and Brinkmeier 1991).

Traditional Andean tools (chakitaqlla [footplow], rawkana [hoe], waqtana [wooden clod breaker], and manta [carrying cloth for soils]) were used to construct the raised fields, in addition to shovels and picks (Figure 6.15). The area to be reconstructed was carefully marked off to delineate the canals and raised field boundaries. The area of the canal was approximately the same as the field platforms, as determined in the stratigraphic profile trenches. The chakitaqlla was used to cut rectangular sod blocks from the canals (Figure 6.16). The blocks were used to build a low 1–3 course wall, depending on the site's elevation and distance from the lake. The remaining soil from the canal (both as sod blocks and loose soil) was used for the platform fill, tossed between the sod retaining walls and broken up with clod breakers. A cambered planting surface was created to facilitate drainage (see Figures 6.14, 6.15, 6.16, 6.17). The fields were constructed most efficiently during the dry season when water levels are low.

Several forms of labor mobilization and organization were compared. The first two experimental fields were constructed in 1981 on private land worked by the owner and his family. The following year, experimental fields were also constructed with community labor. Communities of 35 to 150 families constructed raised fields on lands they control and farm communally. Group labor was first organized using *minka* (orfaena in Spanish), a traditional practice whereby each family must send one able-bodied member to work on a community project

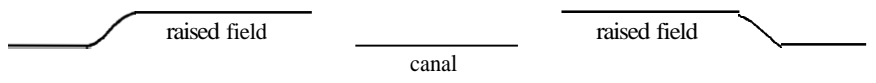


# HYPOTHETICAL PROFILE OF RAISED FIELDS IN HUATTA, PERU

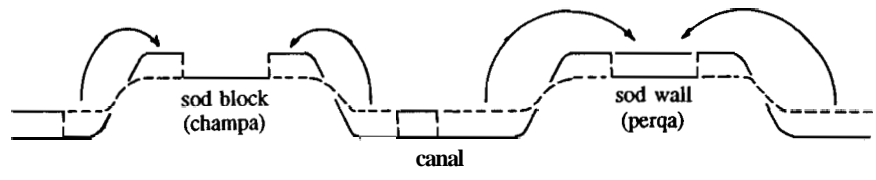


6.13. Block drawing of a typical raised field based on stratigraphic profiles of archaeological fields.

## UNRECONSTRUCTED RAISED FIELDS

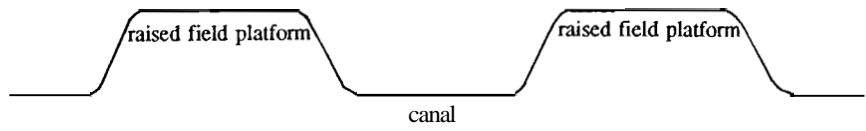


## RECONSTRUCTION OF RAISED FIELDS



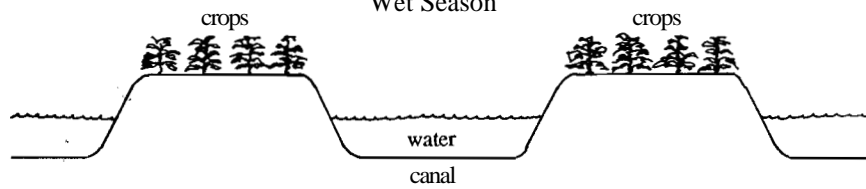
## RECONSTRUCTED RAISED FIELDS

Dry Season



## RECONSTRUCTED RAISED FIELDS

Wet Season



6.14. The process of reconstructing raised fields for experimental purposes.



6.15. The indigenous tools used in raised field construction (rawkana, hoe [right]; chakitaqlla, footplow [center]; waqtana; clod breaker [left]).



6.16. The use of chakitaqllas for construction of the retaining walls of experimental raised fields.



6.17. Raised field construction in Choñocoto by the Community of Yasin.

on a specified day. These are often festive occasions. In the second year some communities decided to try another local form of labor organization, the *tarea* ("role"). In the *tarea* system, each family is responsible for the construction of a specified area of raised field, and it is up to each family to decide how to organize the labor and time needed to complete the work.

All the major Andean crops that would have been available to the prehistoric farmers of the Lake Titicaca Basin were planted on the reconstructed raised fields (Figure 6. 18), including plants documented through our excavation. In addition to many varieties of potatoes (*Solanum* sp.), *isañu* (*Tropaeolum tuberosum* R. & p.), *ocas* (*Oxalis tuberosa* Mol.), *ollucu* (*Ullucus tuberosus* Caldas), *quinoa* (*Chenopodium quinoa* Willd.), *caiihua* (*Chenopodium pallidicaule* Allen), *tarwi* (*Lupinus mutabilis* Sweet), and *maize* (*Zea mays* Linn.), some introduced crops from the Old World were also planted. The crops were monitored throughout the growing season and weather stations were set up on several blocks of fields to record temperature readings.

We confirmed many of the various functions proposed for raised field agriculture (Erickson 1986, 1988a, 1992; Garaycochea 1987). The platforms raised above the pampa increased the rich topsoil depth and protected the crops from seasonal inundation. The canals between them collected and stored water that provided irrigation for the fields. This water also protected crops against radiation frosts by storing heat from the sun and releasing it at night, creating a more favorable microclimate. Aquatic plants, organic detritus, and rich sediments collected in the canals were periodically put on the fields to renew soil fertility for continuous cropping. The canals also produced locally important economic plants and animals which could easily be harvested. We found that aquaculture (fish and plants) could be practiced.

There were many advantages to working directly with indigenous communities on raised field rehabilitation and experimentation. This situation provided a more natural setting for a traditional agriculture study than would be possible in a laboratory or a governmental experimental station location. In addition, the number of groups and individual farmers participating permitted experimentation in a wide variety of environmental conditions. The community setting also provided a long term context for the experiments (as long as raised field technology is considered beneficial to the community). The traditional Andean tools used by the local farmers are probably similar to those used by the original raised field farmers, with the exception of metal blades of *chakitaqllas* and *rawkanas* replacing the stone and wooden blades of the past. Some of the traditional social organization

(ayllu) is still present and functioning. Most important, this context provided a rich source of hypotheses and alternative approaches. The Quechua farmers continually suggested both traditional and innovative ways to do raised field farming, and many of these were better approaches than the original hypotheses posed by the investigators (Erickson and Brinkmeier 1990). Each community group and individual family participating in the experiments developed its own ways of building and maintaining the raised fields, and of farming them. Their expertise in local farming methods and their interest in the project contributed greatly to its success.

Several problems were encountered in the experiments. The original crops specifically adapted for the cultivation conditions on raised fields have been lost since the abandonment of the fields, and the only traditional crops available were those developed for the very different conditions on the slopes surrounding the pampa. The small scattered experimental field blocks reconstructed during the early years of the project experienced an "edge effect" whereby their small size could not produce the desired microclimate and hydraulic effects of the original larger field systems. This was corrected with the reconstruction of larger field blocks in the later years. A few fields were not sufficiently elevated to survive the massive floods of 1985–86. During the severe drought of 1982–83, most canals had not been excavated deeply enough to reach the water table and some crops were lost. It was found that small wells could be dug into the canal floors for access to irrigation water. The advantage of long term experiments was that these problems were addressed and resolved over time.

#### Discussion of the Raised Field Project

Our investigations show that raised field agriculture has a remarkably long history in the Lake Titicaca Basin of southern Peru and northern Bolivia, much longer than previously believed. The system had its beginnings around 1000 B.C. and underwent two periods of major expansion, once around 600 B.C.-A.D. 2001300 and another period around A.D. 1000 (Erickson 1987, 1988). The fields were apparently abandoned after A.D. 300 and again after A.D. 1400. A similar evolutionary history has been recorded for fields in the southern basin although apparently different in chronological details (Kolata 1986, 1991; Kolata and Graffam 1989; Graffam, pers. comm. 1990). Although raised fields certainly provided much of the food surplus necessary for supporting the series of complex societies that developed within the basin (Pukara, Tiwanaku, and Late Intermediate Period



6.18. Raised fields planted in quinoa (*Chenopodium quinoa*) in the Community of Sanganaacachi, Capachica (1989).

Aymara Kingdoms), fields were constructed and managed at the local level (Erickson 1987, 1988a; Erickson and Candler 1989).

The agricultural experiments using raised fields provided several surprises in regard to pre-Hispanic labor, crop production, and social organization of the technology. The labor expended involved in the construction and maintenance of raised field systems is initially high, but over the long run, raised field systems are very efficient in terms of labor and energy. Crop yield on raised fields was remarkable, some two to three times higher than on fields farmed with traditional local methods. Raised fields are not as "labor intensive" as commonly believed and the efficiency of this system in terms of labor input for production output is very high. There was probably no population pressure or stress involved in the initial (and quite early) adoption of raised field agriculture. Another surprise related to the level of social organization necessary for construction and maintenance of the fields. It was found that small communal groups, organized in the traditional manner of the Andean region today, and even individual families are able to carry out raised field farming successfully. There is no need to invoke the centralized organization commonly believed responsible for the agricultural works.<sup>7</sup> The archaeological and experimental research indicate that the raised fields were constructed in an incremental process by many generations of farmers.

### Archaeology and Experimentation in Field and Garden Studies

Due to the impossibility of direct observation, the interpretation of abandoned raised field remains is usually based on analogy to other agricultural systems (complex irrigation systems or raised field systems in very different historical or environmental settings), known both from contemporary ethnographic and historical accounts. This paper demonstrates how useful it is to apply direct archaeological and experimental techniques to the interpretation of raised field agriculture.

The methods described here are basic and relatively inexpensive techniques that generate substantial data and interpretations about past agricultural systems. I believe these archaeological and experimental methods have great potential in other field and garden systems where direct historical and ethnographic analogy is not available.

Another contribution of archaeological and experimental research in gardens and fields is its potential for demonstrating the effective-

ness of ancient techniques (Erickson 1988a, 1988b, in prep. b). Abandoned farming systems such as raised fields have provided alternative models for rural development in the zones where their remains are found (Erickson 1992; Erickson and Brinkmeier 1990). In many cases, archaeological and traditional systems may be more sophisticated, more environmentally sound, more culturally appropriate, and more productive than those introduced from the outside. The methods utilized here allow us to determine the evolutionary trajectory of land use systems, information that should be useful for the planning of future sustainable land use strategies.

The most appropriate and productive approach to ancient agriculture is to combine archaeological investigation of fields with agricultural experimentation. Only archaeological research can provide the basis for the accurate reconstruction of the technology such as field form and structure, field maintenance, and the crops cultivated in cases where direct ethnographic and historical analogy are not available. In turn, the agricultural experimental models based on this basic archaeological research can address issues that cannot be examined archaeologically such as field function, crop yields, nutrient recycling, microclimate management, labor input and maintenance costs, tool efficiency, and system sustainability.

Archaeologists have long utilized multidisciplinary approaches to study complex phenomena. The study of archaeological gardens and fields is one such phenomenon that benefits greatly from collaboration of scholars from various backgrounds. Basic archaeological and agronomic field techniques adapted to a specific case of prehistoric raised field systems were successfully combined with extensive experimental studies to address basic anthropological questions of past human cultures. As a long term case study, the experience of the Raised Field Agricultural Project and its successors may be useful for investigations of ancient garden and field systems in other parts of the world. An approach that combines basic archaeological techniques with agricultural experimentation not only can yield many insights on now-abandoned agricultural features, but may also provide models for present day rural development in landscapes where archaeological remains of cultivation systems are found.

The research for this paper was supported by a National Science Foundation Dissertation Improvement Grant and a Social Science Research Council Fellowship. I would also like to thank Ing. Ignacio Garaycochea Z., Dr. Kay Candler, and Dan Brinkmeier. Permission for this research was granted by the Comisión Técnica of the Instituto Nacional de Cultura of Peru. The Proyecto de Investigación de Siste-

7. For an alternative opinion, see Kolata (1986, 1991).

mas Agrícolas, the Convenio Peru-Canada, the Ministerio de Agricultura del Peru, arid CARE of Peru also provided support. My deepest thanks goes to our friends in Huatta, Peru, who permitted us to conduct the archaeological research in their community and who played an important role in the experimental and applied aspects of the investigation.

## References

- Bray, W., L. Herrera. M. Cardale Schrimppff, P. Botero, and J.G. Monsalve. 1987. The Ancient Agricultural Landscape of Calima, Colombia. In *Pre-Hispanic Agricultural Fields in the Andean Region*, ed. W. Denevan, K. Mathewson, and G. Knapp, pp. 443–481. British Archaeological Reports, International Series 359. Oxford.
- Brinkmeier, D.A. 1985. *A Plan for Disseminating Information about Traditional Agriculture to Indigenous Farmers in the Department of Puno, Peru*, Master's thesis, Department of Journalism and Mass Communication, Iowa State University, Ames.
- Broadbent, S. 1987. The Chibcha Raised-Field System in the Sabana de Bogota, Colombia: Further Investigations. In *Pre-Hispanic Agricultural Fields in the Andean Region*, ed. W. Denevan, K. Mathewson, and G. Knapp, pp. 425–442. British Archaeological Reports, International Series 359. Oxford.
- Burga, M. and C. de la Torre (editors). 1986. *Andenes y camellones en el Peru Andino: Historia Presente y Futuro*. Consejo Nacional de Ciencia y Tecnologia, Lima.
- Coe, M. 1964. The Chinampas of Mexico. *Scientific American* 211 :90-98.
- Coles, J.M. 1973. *Archaeology by Experiment*. Heinemann, London.
- Culbert, T.P., L. Levi, and L. Cruz. 1991. Lowland Maya Wetland Agriculture. In *Vision and Revision in Maya Studies*, ed. F. Clancy and P. Harrison. University of New Mexico Press, Albuquerque.
- Denevan, W.M. 1970. Aboriginal Drained Field Cultivation in the Americas. *Science* 169: 647-654.
- . 1980. Latin America. In *World Systems of Traditional Resource Management*, ed. G. Klee, pp. 217-244. Wiley, New York.
- . 1982. Hydraulic Agriculture in the American Tropics: Forms, Measures, and Recent Research. In *Maya Subsistence*, ed. K.V. Flannery, pp. 181-203. Academic Press, New York.
- Denevan, W.M. and K. Mathewson. 1983. Preliminary Results of the Samborondon Raised Field Project, Guayas Basin, Ecuador In *Drained Field Agriculture in Central and South America*, ed. J.P. Darch, pp. 167–182. British Archaeological Reports, International Series 189. Oxford.
- Denevan, W.M., K. Mathewson, and G. Knapp (editors). 1987. *Pre-Hispanic Agricultural Fields in the Andean Region*. British Archaeological Reports, International Series 359. Oxford.
- Denevan, W.M. and B.L. Turner II. 1974. Forms, Functions, and Associations of Raised Fields in the Old World Tropics. *Journal of Tropical Geography* 39: 24–33.
- Eidt, R.C. 1984. *Advances in Abandoned Settlement Analysis: Application of Prehistoric Anthrosols in Colombia, South America*. Center for Latin America, University of Wisconsin, Milwaukee.
- Erasmus, C.J. 1965. Monument Building: Some Field Experiments. *Southwestern Journal of Anthropology* 21(4):277–301.
- Erickson, C.L. 1985. Applications of Prehistoric Andean Technology: Experiments in Raised Field Agriculture, Huatta, Lake Titicaca, 1982- 1983. In *Prehistoric Intensive Agriculture in the Tropics*, ed. I. Farrington, pp. 209-232. British Archaeological Reports, International Series 232. Oxford.
- . 1986. Agricultura en camellones en la cuenca del Lago Titicaca: aspectos tecnicos y su futuro. In *Andenes y camellones en el Peru Andino: historia presente y futuro*, ed. M. Burga and C. de la Torre, pp. 331–350. CONCYTEC, Lima.
- . 1987. The Dating of Raised-Field Agriculture in the Lake Titicaca Basin, Peru. In *Pre-Hispanic Agricultural Fields in the Andean Region*, ed. W.M. Denevan, K. Mathewson, and G. Knapp, pp. 373-384. British Archaeological Reports, International Series 359. Oxford.
- . 1988a. *An Archaeological Investigation of Raked Field Agriculture in the Lake Titicaca Basin of Peru*, Unpublished Ph.D. dissertation. Department of Anthropology, University of Illinois, Urbana-Champaign.
- . 1988b. Raised Field Agriculture in the Lake Titicaca Basin: Putting Ancient Andean Agriculture back to Work. *Expedition* 30(3):8- 16.
- . 1992. Prehistoric Landscape Management in the Andean Highlands: Raised Field Agriculture and Its Environmental Impact. *Population and Environment* 13(4):285-300.
- . 1993. The Social Organization of Prehispanic Raised Field Agriculture in the Lake Titicaca Basin of Peru. In *Aspects of Water Management in the Prehistoric New World*, ed. V. Scarborough and B. Isaac, 367-424. Research in Economic Anthropology, Supplement 7. JAI Press, Greenwich, CT.
- . In prep. a. *The Archaeology of Early Farming Communities in the Lake Titicaca Basin*. Manuscript in preparation, University Museum, University of Pennsylvania, Philadelphia.
- . In prep. b. *Waru Waru: Ancient Andean Agriculture*. Manuscript in preparation, University Museum, University of Pennsylvania, Philadelphia.
- Erickson, C.L. and D.A. Brinkmeier. 1991. *Raised Field Rehabilitation Projects in the Lake Titicaca Basin of Peru*. Unpublished manuscript submitted to the Interamerican Foundation, Washington, DC.
- Erickson, C.L. and K.L. Candler. 1989. Raised Fields and Sustainable Agriculture in the Lake Titicaca Basin of Peru. In *Fragile Lands in Latin America: Strategies for Sustainable Development*, ed. J.O. Browder, pp. 230–248. Westview Press, Boulder, CO.
- Erickson, C.L., J. Esteves, M. Michel, and W. Winkler. 1991. *Estudio preliminar de los sistemas agricolas precolombinos en el departamento del Beni, Bolivia* Unpublished manuscript.
- Evenari, M., L. Shanan, and N. Tadmor. 1971. *The Negev: The Challenge of a Desert*. Harvard University Press, Cambridge, MA.
- Farrington, I. 1983. Prehistoric Land Reclamation Schemes: Preliminary Notes on River Canalization in the Sacred Valley of the Incas. In *Drained Field Agriculture in Central and South America*, ed. J.P. Darch, pp. 221-235. British Archaeological Reports, International Series 189. Oxford.

- tensive Agriculture in the Tropics*, ed. I. Farrington, pp. 49–96. British Archaeological Reports, International Series 232. Oxford.
- Pearsall, D.M. 1989. *Paleoethnobotany, A Handbook of Procedures*. Academic Press, San Diego.
- Pohl, M. (editor). 1989. *Ancient Maya Agriculture: Excavations on Albion Island, Northern Belize*. Westview Press, Boulder, CO.
- Puleston, D. 1976. The People of the Cayman/Crocodile: Riparian Agriculture and the Origin of Aquatic Motifs in Ancient Maya Iconography. In *Aspects of Ancient Maya Civilization*, ed. F.-A. de Montequin, pp. 1–26. Hamline University, St. Paul, MN.
- . 1977a. The Art and Archaeology of Hydraulic Agriculture in the Maya Lowlands. In *Social Processes in Maya Prehistory* ed. N. Hammond, pp. 449–467. Academic Press, New York.
- . 1977b. Experiments in Prehistoric Raised Field Agriculture: Learning from the Past. *Journal of Belizian Affairs* 5:36–43.
- . 1978. Terracing, Raised Fields, and Tree Cropping in the Maya Lowlands: A Few Perspectives on the Geography of Power. In *Pre-Hispanic Maya Agriculture* ed. P.D. Harrison and B.L. Turner II, pp. 225–246. University of New Mexico Press, Albuquerque.
- Ramos, C. 1986. Evaluacion y rehabilitacion de camellones o "kurus" en Asillo. *Allpanchis* 27, año 18: 239–284. Cuzco.
- Riley, T.J. and G. Freimuth. 1979. Field Systems and Frost Drainage in the Prehistoric Agriculture of the Upper Great Lakes. *American Antiquity* 44:271–285.
- Rivera Sundt, O. 1989. Una tecnologia que viene del pasado. *Anales del seminario de desarrollo rural*, Serie Documentos 4-1-119-90, La Paz, pp. 60–91.
- Serpenti, L.M. 1965. *Cultivators of the Swamps*. Van Gorcum, Assen.
- Siemans, A. 1989. *Tierra Configurada* Consejo para la Cultura y las Artes, Mexico City.
- Smith, C.T., W.M. Denevan, and P. Hamilton. 1968. Ancient Ridged Fields in the Region of Lake Titicaca. *Geographical Journal* 134:353–367.
- Steensberg, A. 1980. *New Guinea Gardens*. Academic Press, New York.
- Stemper, D. 1987. Raised Fields and Agricultural Production, A.D. 1400–1600, Rio Daule, Guayas, Ecuador. In *Prehispanic Agricultural Fields in the Andean Region*, ed. W.M. Denevan, K. Mathewson, and G. Knapp, pp. 297–319. British Archaeological Reports, International Series 395. Oxford.
- Turner, B.L. II and P. Harrison. 1983a. Pulltrouser Swamp and Maya Raised Fields: A Summary in *Pulltrouser Swamp: Ancient Maya Habitat, Agriculture and Settlement in Northern Belize*, ed. B.L. Turner II and P. Harrison, pp. 246–270. University of Texas Press, Austin.
- Turner, B.L. II and P. Harrison (editors). 1983b. *Pulltrouser Swamp: Ancient Maya Habitat, Agriculture, and Settlement in Northern Belize*. University of Texas Press, Austin.
- Wiseman, F. 1984. *Pollen Analysis of Raised Fields and Canals, Northwest Margin of Lake Titicaca, Peru*. Unpublished manuscript on file at the Department of Anthropology, University of Pennsylvania.
- Zucchi, A. and W.M. Denevan. 1979. *Campos elevados e historia cultural prehispanica en los llanos occidentales de Venezuela*. Universidad Catolica Andres Bello, Caracas.

# The Archaeology of Garden and Field

edited by Naomi F. Miller and Kathryn L. Gleason

- |   |     |
|---|-----|
| 1. To Bound and to Cultivate: An Introduction to the Archaeology of Gardens and Fields<br><i>Kathryn L. Gleason</i>                       | 1   |
| 2. Fertilizer in the Identification and Analysis of Cultivated Soil<br><i>Naomi F. Miller and Kathryn L. Gleason</i>                      | 25  |
| 3. Archaeological Palynology of Gardens and Fields<br><i>Suzanne K. Fish</i>  | 44  |
| 4. Remote Sensing of Gardens and Fields<br><i>Bruce Beuan</i>   | 70  |
| 5; The Creation of Cultivable Land Through Terracing<br><i>John M. Treacy and William M. Denevan</i>                                      | 91  |
| 6. Methodological Considerations in the Study of Ancient Andean Field Systems<br><i>Clark L. Erickson</i>                                 | 111 |
| 7. The "Celtic" Field Systems on the Berkshire Downs, England<br><i>Stephen Ford, Mark Bowden, Vincent Gaffney, and Geoffrey C. Mees.</i> | 153 |
| 8. Techniques for Excavating and Analyzing Buried Eighteenth-Century Garden Landscapes<br><i>Anne E. Yentsch and Judson M. Kratzer</i>    | 168 |
| 9. The Landscapes and Ideational Roles of Caribbean Slave Gardens<br><i>Lydia Mihelic Pulsipher</i>                                       | 202 |