THE SOCIAL ORGANIZATION OF
PREHISPANIC RAISED FIELD
AGRICULTURE IN THE LAKE
TITICACA BASIN

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INTRODUCTION

When flying or walking over the vast plains (pampas) of the high Andean plateau (alitiplano) of the northern Lake Titicaca basin, one is impressed by the immensity of landscape modification undertaken by pre-Columbian farmers. Hundreds of thousands of raised field platforms that extend in every direction are a stunning testimony, even in their eroded state, to Andean institutions for the sociopolitical organization of labor and land (see Figure 1). The highly structured patterning of the landscape reflects an explicit concern with order, both of land and society. The scope of the sophisticated engineering of water management is truly monumental. It would be easy to interpret these earthworks as the enterprise of a highly centralized state. After extensive...
archaeological survey and excavation of raised fields and associated settlements, and after working with contemporary Andean farmers on rehabilitating the ancient raised fields, I have become convinced otherwise. I argue here that various sources of evidence strongly indicate that raised field farming was organized, at least initially and probably throughout its history, at the local level. These precolombian agricultural works are the accumulation of the activities of many generations of farmers, producing a totally human-made landscape.

Two major theoretical issues have been continually addressed in studies of the evolution of intensive agricultural systems, but only recently in terms of raised fields. The most conspicuous has been the relationship between social organization and agriculture, in particular, the amount of centralization necessary to carry out intensive agriculture. If raised fields require administration, coordination, and planning, and massive amounts of labor, one would expect to find them inevitably associated with centralized bureaucratic government. The other issue involves the causes of agricultural evolution and agricultural intensification. If raised fields were labor intensive, they would not have been adopted unless the farmers were forced to do so by population pressure (according to the Boserup [1965] model) or by state demands for surplus production. These two issues are interrelated, although rarely discussed as such.

Traditionally, anthropologists have closely associated intensive agricultural systems with highly centralized political control. In the case of raised field agriculture, an analogy is often made to large irrigation systems, assumed to be associated with centralization and bureaucracy in the planning and operation of such systems, as argued by Karl Wittfogel (1957) many years ago. To the contrary, I have found that prehispanic raised field agriculture in the Lake Titicaca Basin developed early (ca. 1000 B.C.), apparently in the absence of population stress and state organization. I argue that, even during the various periods when state politics were present in the zone, raised fields were built and managed by local communities. Ethnographic analogy, experimental archaeology, ground survey, aerial photographic interpretation, and excavation provide evidence that raised field technology was well within the means of small-scale organizations.

A useful classification for the analysis of social organization associated with water management has been presented by Scarborough (1991:120), based on Chambers (1980). He contrasts the "top down view" with the "bottom up view." The top down view is in many ways similar to the elite-focused perspective taken by Wittfogel (1957) regarding irrigation systems. The bottom-up view takes the perspective of the farmer and the community-level institutions which make irrigation systems work. In discussing the case of the Lake Titicaca raised fields, Kolata (1991:100, 112-113) uses the terms, "bottom up perspective" (or "the ayllu/local level organization hypothesis") and "top down perspective."
A similar perspective is used here to contrast archaeological interpretations of the social organization of prehispanic raised field agriculture in the Lake Titicaca Basin. I would also like to show that a synthesis of these opposing approaches is possible.

THE TOP-DOWN APPROACH TO INTENSIVE AGRICULTURE

The Wittfogel Hypothesis and Its Critique

The relationship between sociopolitical organization and intensive agriculture has long been an important topic in anthropology, history, and geography. The most important treatment of the subject was Wittfogel’s *Oriental Despotism: A Comparative Study of Total Power* (1957; also see Wittfogel 1955, 1972) and the subsequent critical response by scholars from many disciplines. Wittfogel (1955, 1957) argued that large-scale hydraulic agriculture required a high degree of administrative centralization in order to mobilize and coordinate labor for irrigation activities, to plan hydraulic engineering, and to provide capital. Over time, the need for centralized administration gave rise to the stagnant “despotic societies” or “agro-managerial despotism” (adapted from Marx’s concept of the Asiatic Mode of Production) found historically in many parts of the world. Wittfogel saw inevitable deterministic links between water management and centralized social systems. In his comparative studies, he argued that centralized despotic societies arising out of a reliance on irrigation agriculture could be documented in the prehistoric record.


Neo-Wittfogelian Thinking Applied to Prehispanic Raised Fields

Although most scholars focusing on agricultural systems have rejected the causal relationship between hydraulic agriculture and the rise of the state, several archaeologists and geographers still support the assumption that intensive agriculture, such as raised fields (Kolata 1983, 1986, 1987, 1991; Wilkerson 1983, 1984; Matheny 1988, 200-210; Darch 1983, 2; Turner 1983, 15; Airmillan 1971, 660; Doolittle 1990, 115-135, 149, 154; Moore 1988; Stanish n.d.; Boehm de Lameiras 1988; Palerm 1955, 37-39, 1973; Matheny & Garr 1983; Parsons 1991; Brumfiel 1990; Sanders et al. 1979, 280-281; ter Horst 1979, 280-281; ter Horst 1983) are, by necessity, associated with centralized forms of sociopolitical organization, if not states. This perspective could be considered typical of the “top-down approach” to prehispanic agriculture.

Many scholars cited above would deny that they are following Wittfogel’s claims, agreeing, at least theoretically, that major agricultural landscapes could have been created by non-state organizations. However, except for Kolata (1986, 1991), their use of terms such as “centralization,” “centralized direction,” “centralized administration,” and “centrally organized” in describing raised field agriculture is vague and imprecise (for examples, see Wilkerson 1983, 64; Boehm de Lameiras 1988, 92; Parsons 1991, 22; 34; Brumfiel 1994, 44; Moore 1988, 274; Airmillan 1971, 660; Darch 1983, 2; Matheny & Garr 1983, 99). As a result, the critical question of causality and necessity is avoided, but customary assumptions about intensive agriculture can still be embraced comfortably. In the case of raised field agriculture, many of these scholars accept the assumptions that (1) raised fields are a labor intensive form of agriculture, (2) raised field planning, construction, and maintenance require a certain degree of centralized bureaucratic management, and (3) as a result, farmers would not (and could not) adopt the raised field agricultural system unless forced to and directed by authoritative centralized polities (e.g., states).

Much of the classical debate involving Wittfogel’s hydraulic hypothesis revolves around the problem of terminology. What do we mean by “centralization”? Can non-states be “centralized”? Can irrigation and social organization be quantified and compared cross-culturally? Several scholars have attempted to grapple with these issues (Million 1962, Leach 1959, Kelly 1983, Hunt & Hunt 1974, Hunt 1988, Geertz 1980, Gelis 1990), but it is beyond the scope of this paper to fully address these questions. I recognize that the

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various degrees of centralization fall along a continuum, but for the purposes of this paper, I use Gellner's (1990:20) definition of "centralization":

Centralization... generally refers to complex and stratified political systems which are characterized by "administrative machinery, judicial institutions, and specialists. The term refers to differentials in social structure or political-economic organization..." The Maya, for example, are often cited as an example of a complex societal structure, with a hierarchical political system, centralized administration, and a well-developed system of irrigation and agriculture.

Centralization, according to Flannery (1972:417), represents a "linearization" of the linkage between the special-purpose arm of a higher-order system (the federal government) and an important variable (water) in a lower-order system (the local village ecosystem); response is now direct, rather than buffered by the village government. Throughout this essay, I refer to centralized political system, centralized bureaucracy, centralized social organization, and the centralized state. These terms are used interchangeably with the concept of the state (see Flannery 1972:403-404).

Centralization is commonly associated with dense and urban populations, often within state societies (Boserup 1965, Sanders et al. 1979, Denevan & Turner 1985, Parsons 1991, and others). Economic models of preindustrial societies used by archaeologists generally stress the need for nonagricultural urban populations, especially an elite group, to develop efficient means to extract surplus agricultural production from the rural hinterlands (Parsons 1991). Common meanings of extracting such surpluses are tribute payments, markets, exchange, trade, and, more directly, the control of agricultural production.

The common association between intensive agriculture and centralized bureaucracy does not imply a relationship of causality or necessity. Many Mayaists have discussed the intensive nature of raised field farming and its apparent inherent relationship to centralization (Pohl 1990a,b, 12 & 1995, Matheny 1983, Garry & Matheny 1983, several chapters in Harrison & Turner 1978). Present-day Maya farmers are viewed as practicing "devolved" or "extensive" agriculture in the form of slash-and-burn, or swidden, whereas their distant ancestors practiced "evolutionarily advanced" forms of agriculture such as terracing, raised fields, and irrigation (e.g., Harrison & Turner 1978). Population pressure and/or complex sociopolitical organization is generally believed to have been responsible for the development of these intensive systems. Early radiocarbon dates on raised field agriculture in the Americas, such as those presented by Puleston (1977b) for Albion Island in Belize, are often dismissed as improvable because of the lack of population pressure and state organization at those dates (e.g., Pohl 1990b; Turner & Harrison 1978:358-359, 1983:255, 255, 270, and others). The Maya may have directly controlled the agricultural production of raised fields, as many scholars have argued, but this does not mean that earlier raised fields in a non-state context could not have also existed.

Through our raised field agricultural experiments, stratigraphic excavations, radiocarbon and thermoluminescence dating, survey, ethnohistory, soil studies, and aeriel photographic interpretation, I likewise hope to demonstrate that small groups of prehispanic farmers constructed and maintained raised fields in the Lake Titicaca Basin. I argue that these independent, expedient, and locally-derived data provide a better "fit" with the ethnohistoric, historical, and experimental case studies of the sociopolitical organization of raised field agriculture than do the archaeonological scenarios mentioned above (excluding Puleston's work 1977a, 1977b). This position does not deny the possibility that raised fields were on occasion constructed and managed directly by the state, but rather stress that small-scale farming communities are capable of producing the productive landscapes we see in the archaeological record.

The scale of the irrigation system has always been a key problem in the Wissogel thesis. Prehistoric, ethnographic, and ethnohistoric cases of irrigation societies demonstrate the diversity of alternatives of social organization from simple to complex and the ranges of scale from small to large regional systems (see Spouzer 1974, Hunt & Hunt 1974, Hunt 1988, Price 1971, Scarbrough 1991). Robert Hunt's (1988) detailed comparative study of irrigation agriculture and social organization concluded that many large irrigation systems (ranging from 700 to 455,000 ha) operate without any centralized authority. The implications of this scale problem have been generally neglected by archaeologists. Only a small minority of the archaeologists and geographers who have done research on raised fields have urged caution with regard to the assumption that raised field agriculture must be associated with large-scale, centralized organization (see Bronson 1978, Harris 1978:310-318, Siemans 1983:50; also see Turner & Harrison 1978:361-368, Denevan 1970:653, and Denevan 1982:166).

Local communities have developed complex means for managing large regional irrigation systems that do not always rely on the development of "irrigation complexes" or large-scale irrigation systems (e.g., the Andean region, see Mitchell 1973, 1976, 1977; Guillet 1987, 1992; Truesdell 1989a-b; Gellner 1986, 1990: n.d.a-c; Seiglmann & Bunker 1986, and Sherwood 1982, 1983, 1992; for Mesoamerica, see Hunt 1988, Hunt & Hunt 1974, Doolittle 1984, 1990). The local institutions developed for insuring the smooth functioning of hydraulic agriculture could be considered "complex" or "irregular" or complex sociopolitical institutions which rely on nonhierarchical, horizontal, cross-cutting infrastructure (Crummy 1987). This is a powerful, alternative way of viewing the concept of social complexity, while many traditional classifications deny complexity to societies or groups that are not centralized and/or
hierarchical. These alternative, heterarchical principles can be seen in Andean communities where ritual-symbolic traditions of water, earth and mountain worship, reciprocal labor exchange, rotating office of water mayors, the ayllu, and dual organization provide the basis for water management (e.g., Gelles 1986, 1990; n.d.a-c; Zuidema 1986; Sherbondy 1982, 1987, 1992; Guillet 1992; and others; see Lansing 1987, 1991, and Geertz 1980). Present-day raised field management in highland New Guinea (discussed below) also provides a good example of the noncentralized communal organization of irrigation fields. Top-down bureaucratic meddling in local community-based farming systems may actually be a detrimental and inefficient strategy (Tracey 1989a; Montmollin 1987, Netting 1990, Leaf 1992, Lansing 1991, Guillet 1992; Gelles 1990, n.d.a-b; Lees 1986). As Leaf (1992:116) notes, "Social scientists with practical involvements in irrigation management uniformly reject the idea that authoritarian control is natural or inevitable—or even workable." The nearly complete failure of the "Green Revolution" in the Andean region during the 1960s-70s is a prime example of the problems of a highly technical, top-down approach. In the case of raised field rehabilitation in the Lake Titicaca Basin, top-down approaches have been less successful than more grassroots approaches (Erickson & Beinakmeier n.d., Erickson & Candler 1989).

One could question whether the prehispanic elies of the Americas would be interested in local-level decisions regarding mundane agricultural production. Montmollin (1987) has provided an interesting critique of the "managerialist thesis" in archaeological interpretation. He considers these perspectives to be based in an "etnic," rational, maximizing, adaptationist interpretation (one which equates better managed with better adapted for long-term survival). In his "emic" approach to management by the prehispanic Mesoamerican elites, Montmollin notes that (1) the day-to-day production is managed at lower social levels, (2) the Mesoamerican elite were not professional bureaucrats, and (3) the concern for political resources, not economic rulership, was most prominent. According to Montmollin (1987:56), rulers were more interested in "being custodians of relations between polity and cosmos, cosmic balance" and "interactions between and within polities, tribe, successionship, usurpation, rotation, dynastic politics." One could argue that this emic approach could be extrapolated to the prehistoric elite of most of nuclear America. This would not be to claim that elites were never concerned about tributary flow, intensification of agriculture, and the co-opting of labor which sustained their position and the state, but rather that they were often disassociated from the tedious and routine management of local production. At the very least, Montmollin's argument requires a re-examination of the nature of centralized control.

Several studies support a model of local, not state, control of Andean agriculture. A major goal of Inka elite expansionist policy was to extend irrigation and terracing for the generation of state surplus (Conrad & Demarest 1984:129-130). Despite the overt interest of the Inka elite in irrigated terracing, local systems appear to have been managed by local community groups. Even within the Inka capital of Cuzco, terraces were constructed and managed by local ayllus, not the state (Zuidema 1986, Sherbondy 1982, 1987, 1992). Nor does the ethnographic record for terrace water management in the South Central Andes support a model of direct control by the Inka state (Tracey 1989b, Guillet 1987, 1992). On the North Coast, the large, intervalley La Cumbre canal constructed during the Late Intermediate Period has been attributed to the Chimu state (Kus 1980, Ortloff et al. 1982). Eversey, Netherly (1984) has demonstrated that the local irrigation network of the north coast of Peru were locally managed systems and that the inter-valley canal was probably a rare case of state intervention in local agriculture. The state's role in irrigation was probably limited to providing the capital and mui labor for rebuilding canal networks after natural disasters such as El Nifio flooding (Moseley et al. 1981, Netherly 1984).

Gelles (1990, n.d.a-b; see also Tracey 1989a, Guillet 1992) has discussed the dialectic between state and local organization of irrigation water in the community of Cahuasconde in the Colca Valley of Peru. The local system is based on the Andean dual organization model—the division of the community into "uper" and "ower" halves—and sacred water, mountain, and earth worship. It combines complex ritual and social mechanisms that have traditionally controlled the hydraulic resources. The local model, of which dual organization is a fundamental component, provides a form of cultural resistance to the secularization of water management and other modern state interventions and is intimately tied to ethnic identity. In contrast, the recently introduced Peruvian state system uses appointed managers as "water controllers" and stresses civic duty and the "rational," sequential distribution of water. The intrusion of the state system into the traditional local system has had a disorganizing effect on the distribution of water and tends to favor local elites, resulting in rising tensions and local resistance. These studies show that the relationship between state and local systems can be complex, and the issue of control cannot be assumed to have a simple answer. For example, it cannot be assumed that Tiwanaku elites managed the raised fields in the southern Lake Titicaca Basin. THE BOTTOM-UP APPROACH TO INTENSIVE AGRICULTURE

In response to the influential theory proposed by Wittfogel (1957) and Steward (1955) regarding the relationship between bureaucratic central organization (in particular, the despotic state) and intensive agriculture, anthropologists...
produced a wide range of ethnographic case studies of irrigation societies of different scales (e.g., Fernea 1970, Milou 1962, Woodbury 1961, Leach 1959, Mitchell 1976, Hunt & Hunt 1976, Gray 1963, Price 1971, Downing & Gibson 1974b, and others). The general consensus of these studies is that some level of coordination is necessary for the proper functioning of irrigation societies, but that the locally-based sociopolitical organization available to farmers in "traditional" peasant societies is sufficient for planning, construction, maintenance, distribution of water resources, and resolution of conflicts over water and land.

Stephen Lansing’s Priests and Programmers: Technologies of Power in the Engineered Landscape of Bali (1991) provides an excellent example of how sophisticated farming systems involving a network of tens of thousands of hectares of irrigated terraced rice paddies can be constructed, managed, and maintained independently of state control or interference, although they operate within the bounds of a modern state society. In Bali, kin-based cooperative groups of farmers are bound with other groups over wide areas through a hierarchical system of “water temples,” where necessary complex scheduling, decision making, and cooperation is accomplished in a ritual context. Lansing demonstrates that tightly ordered, technologically sophisticated “engineered agricultural landscapes” of regional proportions can be efficiently managed by local groups and local ceremonial centers. Although the irrigation system exists within the boundaries of a modern state, the farming activities are under local control. In the words of Valenti (1991:130), “this centered (rather than centralized) system of coordination is independent of the state and, in fact, somewhat in conflict with it.”

Ethnographic and contemporary raised field practices in New Guinea and Irian Jaya of Indonesia provide another possible analogy for examining the social organization of agriculture (see Hedez 1970 for the Dani, Pospisil 1963 for the Kpapuak, Serpenti 1965 for the Kiman, and Golon 1977 and Gerecki 1982 for the Kuk). Very dense populations are supported by a combination of raised field and swidden agriculture. Raised field systems, including some very large regional complexes, exhibit an impressive organization of raised field technologies, including irrigation platforms and canals, field boundaries, fence lines, and drainage canals. These agricultural earthworks appear similar to those of the Lake Titicaca basin in terms of scale and complexity. Despite the high degree of landscape order, many of the basins where raised fields are used today have been farmed only for a short time (a relatively recent reintroduction of raised fields). Although a wide range of sociopolitical organization is found within these societies, from relatively noncentralized, nonhierarchical, and relatively “egalitarian” kin-based activity.

Ethnographic analogy and cross-cultural comparison must be used cautiously. New Guinea raised field agriculture is practiced in a different environmental and cultural context from that of the Lake Titicaca Basin and

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should not be taken as a model of the Andean case. However, at a very general level, the New Guinea analogy demonstrates that sophisticated raised field farming sustaining large populations can be organized within family and localized sociopolitical units. The raised fields of New Guinea do not provide any evidence that Andean fields were associated with one type of sociopolitical organization or another. They do, however, prove that it is possible to practice raised field agriculture within a noncentralized organization, and this possibility must not be automatically discounted for the Andean case.

RAISED FIELD AGRICULTURE

Raised field agriculture is a remarkably efficient, sustainable, and productive technology. Raised fields are large, elevated platforms constructed to improve agricultural production by removal of soil from adjacent canals. Morphology of fields varies greatly, but the platforms in the Lake Titicaca basin (see Figure 2) tend to be rectangular, 0.2-1.0m tall, 5-10m wide and up to 50m long. Remains of prehispanic raised fields are found throughout the Americas in a wide range of environment and temporal contexts (Parsons & Denovan 1967, Denovan 1970, 1992, Simms 1989; and others). There is a large literature on prehistoric, ethnographic, and contemporary forms of raised field agriculture in various parts of the Old World (Farrington 1965, Denovan & Turner 1974). The most common context of raised field farming is permanent or seasonal wetlands, in particular, areas near rivers, lakes, poorly drained soils, or permanent swamps and marshes. The widespread distribution of the technology is time and space in both the Old and New Worlds suggests that it was adopted independently in most cases by farmers seeking to exploit wetland ecosystems. A number of archaeological, agronomic, and ethnographic studies have defined the function of raised field farming as improving soil conditions through increasing topsoil depth, providing aeration, mixing and burying organic matter by turning over soils, locally draining waterlogged soils, and ameliorating the effects of adverse weather like storms, floods, and flooding. Canals or ditches adjacent to the field platforms conserve water, act as a heat sink for storage of solar energy, collect and produce organic sediments, and provide a habitat for ecologically important species of plants and animals and possible aquaculture. Periodic “trucking,” or removal of organic sediments collected and/or produced in the canals for placement on the cropping platforms, provides soil renewal and sustainable high production (Denovan & Turner 1974). Raised field farming is a permanent spread out over the Andean landscape is an impressive sight. The orderliness of the patterning,
usually a highly structured, rectilinear grid of blocks or bundles of raised fields, is stunning. This vast anthropogenic landscape seems to have been associated with centralized bureaucratic states simply because of its massive scale and structural integration. When viewed with the commonly unspoken, unanalyzed Winogradian assumptions, it seems that these structured and orderly remains could not have been constructed by the local social organization of Andean farmers. I argue here that this reasoning is based on unsound assumptions. These landscapes represent the results of thousands of years of evolving local and regional farming systems and the gradual accumulation of landscape capital or landscape infrastructure by both communities and states.

THE IRRIGATION MODEL AND RAISED FIELD AGRICULTURE

Many researchers have supposed that raised fields are similar or identical to large-scale irrigation systems and have the same or similar requirements (Scarborough 1999; Matheny & Garry 1983; various chapters of Harrison & Turner 1978; Kolata 1986, 1991; Ortloff & Kolata 1989). This "irrigation model" of raised field agriculture has led to confusion about the functions and organization of the system. A strong hydraulic element has been documented for raised field farming (Lennon 1982, 1983; Erickson 1988a, Kolata 1991, Scarborough 1991, Ortloff & Kolata 1989, Denevan & Turner 1974, and others), but the specific needs and goals of raised field farmers are very different from those of farmers relying on irrigation.

Raised field agriculture can be considered a form of hydraulic agriculture. In both irrigation and raised field agriculture, water resources are managed through complex engineering constructions enabling the manipulation and conservation of water. Despite this similarity, raised fields differ from irrigation systems in several important ways. Irrigation systems are commonly found in arid areas, while raised field systems are most common in areas of seasonally high rainfall, waterlogging of soils and standing water, and/or high humidity (e.g., the tropical savannas of Ecuador, Colombia, Venezuela, and Bolivia; the highland basin of Lake Titicaca; and the highland regions of the Valley of Mexico). While water scarcity is a limiting factor in irrigation systems, an excess of water is commonly the problem in areas where raised fields are found. The removal of water from the raised planting surfaces never poses the kinds of problems that the distribution of water, as a scarce resource, presents in irrigation systems. Accordingly, scheduling and equitable distribution of water resources is a minimal importance in raised field agriculture. Irrigation systems require that water be transported and distributed over wide areas of cropland, potentially crossing political, social, and ethnic boundaries in the larger canal systems. Raised fields, on the other hand, do not require the movement of large amounts of water across territorial boundaries.
Although we lack detailed comparative data, raised fields appear to be less labor intensive than irrigation systems in terms of construction and general maintenance (at least in comparisons with Andean terrace irrigation farming; see Treacy 1989a-b, Erickson & Candler 1989, Erickson 1988a). For example, sedimentation of canals is a factor in both systems but, in contrast to irrigation, raised field functioning depends on the capture, removal, and recycling of sediments, which is considered to be a positive feature, not a detrimental drawback. It was probably advantageous to fill the canals with water as soon as possible at the beginning of the rainy season and to conserve the water in them as long as possible into the dry season, in order to extend the cropping period. The transport of water to achieve this goal is part of the hydraulic function of raised fields, whereas water is not transported long distances from source to destination in areas with little topographic relief. Hydraulic features also might have included eliminating encroachment of salt water into field canals (Orloff & Kolata 1989, Erickson 1988a, Palermo 1955), although this has not been adequately demonstrated.

Because of these differences, raised fields do not require the same amount of coordination and cooperation as irrigation systems. I will also argue that the small, modular blocks of raised field systems can function successfully without the coordination of regional systems, in contrast to most medium and large-scale irrigation systems. In other words, one does not have to rely on close coordination with one's neighbors in order to farm raised fields. This point has been clearly demonstrated in our experimental raised fields in Peru, where only small, isolated parts of the total system have been reconstructed, and in the ethnographic record of raised field farming in non-Western societies.

A STATE MODEL OF RAISED FIELD ORGANIZATION IN THE ANDES

Kolata (1983, 1986, 1987, 1988, 1991) has argued that the raised fields of Koani Pampa, the Tiwanaku Valley, and Desaguadero floodplain of Bolivia were "Tiwanaku estates" of the elite. He (1991:20) contends that "Tiwanaku established proprietary agricultural estates in which ownership and usufruct rights were vested directly in *riberos*, or perhaps more precisely in the hands of the elite, dominant classes.* Kolata (1991:100) believes that "the organization of agricultural production was hierarchical, with a high degree of political centralization and a mobilization of labor by social principles that reached beyond simple kinship relations.* Kolata goes beyond most archaeologists in arguing for the need for centralization and bureaucracy to do raised field agriculture, and he believes that the state was directly involved in the production system in terms of construction and general maintenance (at least in comparisons with Andean terrace irrigation farming; see Treacy 1989a-b, Erickson & Candler 1989, Erickson 1988a). For example, sedimentation of canals is a factor in both systems but, in contrast to irrigation, raised field functioning depends on the capture, removal, and recycling of sediments, which is considered to be a positive feature, not a detrimental drawback. It was probably advantageous to fill the canals with water as soon as possible at the beginning of the rainy season and to conserve the water in them as long as possible into the dry season, in order to extend the cropping period. The transport of water to achieve this goal is part of the hydraulic function of raised fields, whereas water is not transported long distances from source to destination in areas with little topographic relief. Hydraulic features also might have included eliminating encroachment of salt water into field canals (Orloff & Kolata 1989, Erickson 1988a, Palermo 1955), although this has not been adequately demonstrated.

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The argument provided by Kolata (1986:60, 1991:115) to support this thesis is (1) the apparent hierarchical structure of settlements associated with raised field in Koani Pampa, Bolivia, with evidence of elite administration, and common farmers' residences, (2) the need for a highly organized labor force directed by a technically sophisticated administration to construct and maintain fields and the agricultural hydraulic infrastructure, and (3) the relatively close correlation between the chronology of raised field use/abandonment and the origin/collapse of the Tiwanaku state.

Settlements range from small house mounds of farmers and field guardians to larger, "monumental" platform mounds attributed to elite state administrators. According to Kolata, residential settlements within the raised field area are not numerous enough to account for the labor necessary for construction and maintenance; thus, corvee labor had to be brought in by the Tiwanaku state from the outside. Structures such as "river-by-pass systems" or "river shunts" with artificial earthen levees, aqueducts associated with irrigation and drainage, river canals and diversion, canals, and dikes are examples of earthmoving projects believed to have been undertaken by Tiwanaku (Kolata 1991:101; Orloff & Kolata 1989). Kolata and colleagues have argued that these engineering elements are parts of a complex agricultural infrastructure constructed by Tiwanaku "agroengineers" (Kolata 1991:101), and that this infrastructure was beyond the capabilities of locally autonomous village production in the area (Kolata 1991:115). The dating of these infrastructural features has been difficult (Kolata 1986, 1991; Orloff & Kolata 1989), although indirect association with urban settlements suggests to Jermy a Tiwanaku IV and Tiwanaku V construction and use (A.D. 400-1100) (see Figure 3)."
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**Figure 3. Chronology of the Lake Titicaca Region**

Improved dikes and artificial levees on rivers to prevent flooding of the pampa lands are still constructed in the northern Lake Titicaca Basin. For instance, community projects have been undertaken for many years to prevent flooding of the Río Costa (see Figure 4) and Río Ilipa. Here, huge embankments up to 2.5m tall and 3m wide at the base are constructed of sod cut from the pampa. Some of these massive dikes run for kilometers on both sides of the rivers. Similar in terms of labor investment are the programs to construct raised roads within the pampa, using the same methods as those now used to reconstruct raised fields. These projects are undertaken by small local groups, under their own incentive and without external coordination.
Kolata (1991:120) notes that a pattern of "state action as a distance" in the settlement distribution, in contrast to what he hypothesizes is the model of local control of raised fields (e.g., key sites at critical infrastructural points in the water control system). As such, these fields would produce a dispersed pattern of settlement within field systems (different to what is found in Koani Pampa), and there would be no need for "hierarchical control points" of the raised field water management system.

Some raised fields may have been associated and contemporaneous with the Tiwanaku state, but the total distribution of these fields is unknown. Kolata (1991:124, n. 1) has calculated that Tiwanaku engineers constructed 150 km², or 15,000 ha, of raised fields. Assuming a raised field of 60,000 m²/km² is being considered, there are 150 km² of preserved fields in the Middle and Lower Tiwanaku Valley, and another 60-65 km² of fields are proposed to account for those that may have been destroyed through erosion (Kolata 1991:124, Albarracin & Mathews 1990:117). Many of these features are more similar to large lacy beds (warchos, or narrow coot platforms for potatoes) than to true raised fields (Mathews n.d.b). In addition, neither the Koani Pampa nor the Tiahuanaco Valley has been adequately surveyed.

These estimates for Tiwanaku raised field distribution remain uncertain until more detailed photographic interpretation, excavation, and ground survey are completed.

The areal extent of the fields is not the only problem. The affiliation of the Tiwanaku Valley raised fields to Tiwanaku IV and Tiwanaku V periods is based on the dating of raised fields in Koani Pampa (Kolata 1983, 1986, 1989, 1991). Mathews n.d.a, Kola & Graffam 1989, primarily use field associations with occupation sites (Albarracin & Mathews 1990:117). Recent excavations of raised fields in the Middle Tiwanaku Valley by Mathews (n.d.b) have demonstrated that some fields were constructed and used very late in the Tiwanaku sequence and well into the post-Tiwanaku period. According to the spatial and temporal distribution of rural occupations sites as presented in site survey maps (Mathews n.d.a; Maps 2-7), the raised fields could just as easily be attributed to site association dating to the whole spectrum of prehispanic cultures occupying the immediate area. For instance, fields near the urban center of Tiwanaku could be affiliated with any of the pre-Tiwanaku cultures, the mature Tiwanaku phases (A.D. 375-500/1100) or with the post-Tiwanaku presence on the site and vicinity. The only clear context with raised fields in Tiwanaku IV and Tiwanaku V (A.D. 400-1000; 1100) (Kolata & Graffam 1989, Graffam 1990:122-133, 243). Graffam's (1990:133-135, 243) ceramic analysis indicates that the fields were constructed and used between A.D. 400 and A.D. 1100. A corrected radiocarbon date of 1055 ± 20 BP (A.D. 865, ETJ 3718) from a hearth stratigraphically above the fields provides a terminus ante quem for use (Graffam 1990:135). A radiocarbon date of A.D. 950 ± 100 is given for a "raised field complex," although no archaeological context at the household or adobe level would be discerned (Graffam & Kolata 1989:517). Graffam (1990:153) has dated an aqueduct structure associated with a small raised field block near the type site of Chiripa to Tiwanaku III-V through ceramics. An aqueduct at Lukurumata to Tiwanaku IV-V by diagnostic sherds (Graffam & Kolata 1989). The river channelization structures in Koani Pampa and the river by-pass slumps of the Tiwanaku Valley have not been adequately dated. There is evidence that the canalization may be relatively recent, based on survey and excavation, but even this is considered uncertain (Albarracin & Mathews 1990:117). Many of these features are more similar to large lacy beds (warchos, or narrow coot platforms for potatoes) than to true raised fields (Mathews n.d.b). In addition, neither the Koani Pampa nor the Tiahuanaco Valley has been adequately surveyed.

Critical to Kolata's state administration argument is that the field system was abandoned with the collapse of the Tiwanaku bureaucracy (e.g., Kolata 1983:262, 1986:753, 1987:41). Graffam (1989, 1990, 1992) presents a more detailed archaeological interpretation of the field system in the prehispanic occupation and presents evidence of abandonment at the site of Tiwanaku. However, this evidence is not strong enough to argue for a contemporaneous collapse of the Tiwanaku state.
In this section, data on field chronology, field patterning, settlements and settlement survey, experimental archaeology, and abandonment are presented from fieldwork studies undertaken by the Raisel field Agricultural Project between 1981 and 1986 (Erickson 1985, 1987, 1988a, 1988b). These data provide insights into addressing issues regarding the social organization of raised field agriculture in the northern Lake Titicaca Basin. In addition, they may have wide-reaching implications for raised fields in other areas of the Andean highlands and elsewhere.

The Dating of Raised Field Agriculture

Raised fields appear to have been established at a relatively early date and have a long history in the northern Lake Titicaca Basin. The direct dating of ceramics recovered from excavations of 11 raised field locations by tetrachloro-1,1,2-trifluoroethane (TL) has provided data on the chronology and evolution of raised field agriculture. The TL-based chronology is internally consistent with raised field stratigraphy. Diagnostic ceramics from several contexts within raised fields also provide support. Radiocarbon dates and ceramic dates from excavations in occupation mounds within the raised field blocks provide indirect evidence to support this chronology. Two phases of construction and use have been documented. Phase I is characterized by small wavelengths (≤ 1000 B.C., 1987), stratigraphically buried under later large Phase II fields that probably date to the Late Intermediate period (A.D. 1476). Blocks of fields in the northern basin were partially abandoned or "deintensified" during the Tiwanaku Middle Horizon and the Inka Late Horizon (Erickson 1987, 1988a). It is clear that widespread raised field construction began long before the appearance of the state and continued during the periods of state collapse in the Lake Titicaca Basin. I have argued (Erickson 1987, 1988a) that this farming system evolved out of an early lacustrine and riverine wetland economy based on agriculture, hunting, fishing, and gathering. Because of the high yields to labor ratio and the simple organizational requirements, raised field agriculture would have been an efficient alternative to other agricultural technologies (discussed below). Sometimes during the Initial Period (900-900 B.C.), raised fields were first established in the northern lake plains around Huarâta and possibly in the southern basin, as well. The system gradually expanded to include over 8,000 ha of fields and became more sophisticated through time.

Field Patterning

The argument is commonly made that, if raised fields (or other forms of intensive agriculture) show patterning, planting, and formal structure, the...
construction must have been centrally planned and organized. All prehispanic and modern raised fields found in the Americas and elsewhere demonstrate formal structure, as do most agricultural systems. Since scholars disagree on their subjective evaluations of how to classify the continuous variation between unstructured and structured landscapes, this issue may never be resolved.

Raised fields in the Huastca pampa and elsewhere demonstrate clear structural patterning. This patterning has two very distinct levels. The most basic structure is one of individual bundles or blocks of 5-7 parallel fields (Leonn 1982, 1983; Smith et al. 1968) (see Figures 5 and 6) bounded by canals or encircling embankments (see Figures 7 and 8). In addition, these individual bundle units are prominent because of the alternating directions of field orientation between blocks. This has been called the “checkerboard pattern” (see Figure 5) the most common form of raised fields (Smith et al. 1968). All of the field types in the northern Lake Titicaca basin have a general orientation towards the cardinal directions. The regularity of size within and between field blocks indicates careful planning and suggests that there was a possible prehispanic measurement system for field layout. Nevertheless, our experiments demonstrate that raised fields are simple to plan and lay out using string and stakes.

In their discussion of field form and its potential relationship to social organization, Smith et al. (1968:357-359) interpret the general irregularity of overall field patterning and the lack of major irrigation canals as the work of small groups of cooperating individual farmers. Leonn (1982) disagrees with regard to field patterning, arguing that there is a strong indication that fields were constructed for relatively complex hydraulic functions; in terms of social organization necessary for construction, however, he conceives that these fields could have been built by individual farmers (ibid.:227, 189).

Leonn's (1912) detailed analysis of these individual bundles of raised fields (normally rectangular or square) is very important for my interpretation of the land tenure and social organization of raised field agriculture. He found that the average block size of fields (including canals) sampled in the riverine area was 2,300 m². This figure correlates closely with my calculations of the area of raised fields (2,665 m²) that a single household of 5 could construct and manage in a year, according to our experimental labor figures discussed below (Erickson 1988a). This figure is the prehispanic expression of the basic Andean tupa measurement used in the Colonial period and in some communities today. The crop production from such a unit would also provide the necessary caloric values estimated to maintain that household for a year (based on one potato production). In addition, I found that a family of 5 could easily construct a block this size in a season. This evidence strongly suggests a local organization of field tenure organized among family and local communities.

A second level of organization can be seen in larger divisions of complexes of raised fields into irregular polygons, the most common form being a narrow pie-shaped wedge. These complexes of fields are bounded by large straight canals (of greater length, depth, and width than the common raised field canals) (see Figure 7). These canals routinely radiate from “centers” (on low hills overlooking the plain, on mounds, and sometimes from no visible topographic feature) (see Figure 9). The arrangement of these canals is strikingly similar to the structure of the q'aruq described by Inka Cuzeo, a system of sociopolitical and ceremonial organization (Zuidema 1990, Bauer 1992). I argue that, in the case of raised fields in Huastca, these canals probably reflect ayllu divisions or subdivision of the community of raised field farmers. These radial systems are also a key feature of the rotational fallow systems and vectorial farming described for contemporary Andean farmers (Salvador & Godoy 1986, Guillot 1981), which may have also been used by raised field farmers to organize planting schedules, crop rotation, and land tenure. The patterning that occurs in the prehispanic raised field system is the one that would be expected in an Andean farming community where parcels of land (in this case, raised fields) are divided according to traditional Andean structures of family and communal land distribution, probably at the level of ayllu or sayo.

These agricultural earthwork structures in the raised field landscape of the Lake Titicaca region exhibit remarkable formal traits of symmetry, modularity, and hierarchy over a wide area. Within the 52,000 ha block of fields in the Huastca pampa, there is much regional diversity in field form (Erickson 1985, 1988a; Leonn 1982, 1983). These morphological distinctions probably represent different local community expressions of ethnicity or style, or possibly temporal differences in field construction and use. Despite these differences, there is a certain generic level of similarity of raised field morphology over time and space that suggests a shared regional tradition of a proper underlying structural principle of raised field layout and construction.

The raised fields of Koani Pampa, Lukanuma (Kola & Graffham 1989, Graffam 1990, Kolata 1986, 1991), and the Valley of Tiwanaku (Albarracin & Mathews 1990, Kolata 1991, Mathews n.d.b), assumed by Kolata to be contemporaneous with Tiwanaku IV and Tiwanaku V (A.D. 750-1000/1100), also show considerable variation in morphology. The social photographs and illustrations indicate that there are a remarkable variety of sizes and forms in a small, concentrated area of raised fields. Albarracin and Mathews (1993:37) note differences between the Tiwanaku Valley fields and Koani Pampa fields, suggesting that the contrasts are due to different ecological adaptations or different construction periods. The variety of field forms could also be related to decentralized construction, as well as ecological and chronological factors. Following Kolata's state model for raised field agricultural organization, one might expect that field patterns would be more regular and uniform, dictated by centralized bureaucratic planning. This is certainly not the case, even in the Tiwanaku heartland.
The density of residential sites associated with raised field farming is remarkable. In the contiguous block of 52,000 ha of raised fields around Huara, I estimate that there are some 1,000 mounds larger than single-house mounds. If single-house mounds are added to this list, the figure would be many times greater. Most of these mounds are relatively evenly distributed on the pampa, but the largest concentrations are near the lake edge or are islands within the lake shallows (see Figure 10). Dense concentrations of sites are also found on the hilltops and valleys that ring the raised field-covered plains. Occupation mounds are easy to locate on the ground in the flat terrain of the lake plain. They also are easy to distinguish on aerial photographs using stereo pairs to discern the low relief. Mounds range in size from individual house mounds or temporary field camps of several square meters to huge earthen structures covering many hectares and rising up to 15 meters above the natural surface of the pampa.

The dating of these mounds is difficult without excavation. Surface collections made during 1981-1986 indicate that most, if not all, of the larger mounds are multicomponent sites, spanning the Initial Period to the present. This situation appears to be similar to that of Koani Pampa (Kolata 1986; Graffam 1989, 1990), the Taraco peninsula, and Juli Pampa (Stanish n.d.). Albarracin and Mathews (1990) had similar problems providing convincing associations of sites to raised field complexes in their Tiwanaku Valley survey.

Limited excavations in three prehispanic residential sites were made in 1983. The excavations confirmed that the sites were occupied primarily by farmers. Common artifacts included thousands of basalt flakes from the sharpening of stone tools, as well as numerous ceramics (from both well-made serving vessels and common utilitarian wares). Organic remains included fish, bird, and camelid bone, as well as carbonized plants such as chenopods, shrubs used for cooking, and tuber fragments. The mounds are clearly the result of "tell-like" accumulations of adobe and sod structures that had been occasionally leveled and constructed upon at later periods. The profiles of the excavations showed several meters of stratigraphically superimposed house floors. Excavations indicated that some areas had received quantities of fill to raise the occupation platform. A number of sites have cut stones on the surface, and one site, Pancha, may have held a platform with a stone retaining wall dating to the early Pokara (200 B.C.-A.D. 600) or possibly pre-Pokara (before 200 B.C.) occupation of the site. Other than this, there is no evidence of any administrative or bureaucratic "centers" identified with any known prehispanic state society within the farming settlements of the pampa. Evidence of a state administrative presence has not been found within the raised field blocks.
Many of these mounds are still occupied today, some seasonally and some permanently. There is no reason to expect that the use of these mounds was much different in the past, except that the population living on the pampa was probably much greater. House mounds near the lakeshore or within the lake (which become small islands during the rainy season) are occupied by fishermen or farmers who use these locations to gain access to the dense mats of aquatic plants for animal forage. These pampa sites were settlements of raised field farmers, not elite managers or bureaucrats. The distribution of small to large mounds is what would be expected in a rural landscape of farming communities exploiting the natural and agricultural resources of the lake and pampa. Locally produced fine Inka ceramics occur on many of the larger mounds, but these appear to have been occupations that post-date the use of the raised fields.

EXPERIMENTAL ARCHAEOLOGY: LABOR AND PRODUCTION

Between 1981 and 1986, the Raised Field Agricultural Project worked with local Quechua-speaking communities in a small-scale experimental program of raised field agriculture (Erickson 1985, 1988a-b; Erickson & Candela 1989, Erickson & Brindmeier n.d.; Garaycochea 1986a-b, 1987). In addition, several other related development projects promoting raised field rehabilitation were inspired by this work, on both the Peruvian and Bolivian sides of the Lake Titicaca basin (Ramos 1986, 1990; Rivera 1989; Kolaia 1991). Much of the work has been continued by governmental and nongovernmental institutions.

Experimental raised fields were modeled on archaeological data recovered from topographic mapping, survey, and excavation of prehistoric fields. Experimental fields were rehabilitated or reconstructed on prehistoric fields. Raised fields blocks of up to 10 ha in area were constructed in the communities of Huanta, Costa, and Capachica, Department of Puno, within the pampas on the edges of Lake Titicaca. Communities (pueblos) possibly descendants of the original ayllus were approached by the research team and meetings were organized to discuss raised fields with members (concerned). Participants were offered free potato seed as an incentive in return for the use of the individual’s or community’s land, the labor of the community for the construction, maintenance, and harvest of the fields, and the recording of labor and production data involved in raised field farming. The participants also received all the harvest, which was divided amongst the community group or families.
Anadean Social Organization and Labor Mobilization

The household and the suprathousehold ayllus have been considered the basic social, political, and economic units in the rural Central Andes. These institutions—combined with the dual organization of communities or ayllu, culturally defined land divisions such as ayuy, chu, and ceque, and reciprocal labor relationships—are very powerful and resistant structural forces for mobilizing labor, coordinating large public projects, resolving disputes, controlling land tenure, and spatially organizing p-ulations.

Although believed to be widespread and of considerable time depth, the ayllus is difficult to define precisely (see Zuidema 1990, Allen 1988, Isbell 1985, Conrad & Demarest 1984:97-99, 105). In an excellent survey of the concept, Urton describes ayllus as "particular units of social organization," and states (1992:230).

In general terms, ayllus are named, clanlike groupings of people whose internal unity and differentiation from each other are based on a variety of factors, including landholding, kinship, festival sponsorship, and the performance of public labor projects. Ayllus have been involved in social components of Andean life from pre-Hispanic times to the present day in the Andean nation-states of Peru, Bolivia, and Ecuador.

As Urton stresses, it is not an inflexible or static institution and "the persistent nature of the ayllus as a central institution of social organization in Pacacuqambo is linked to the support and services that certain members of the community are constantly in need of, and by the recurring demands associated with building and maintaining community facilities" (Urton 1992:235) and is "continually reproduced and transformed" (ibid. 235). In some cases, there appears to be a certain hierarchic nature to the ayllus, which can be formed at various levels, depending on local contexts and needs. In many cases, ayllus are ranked. Higher levels of community organization are the sayus, or asymmetrical moieties made up of numerous ayllus. Most scholars agree that the ayllus has a long history and is certainly responsible for many of the material/socioeconomic changes that are visible in the Andes. Because of the many material manifestations of the ayllus, it should be possible to archaeological and document the ayllus. Urton points to the segmental maintenance of the church plaza by the eight ayllus groups of the town, the territoriality of ayllu residence, and the land tenure organization of the agricultural landscape surrounding the town as examples.

As Urton (1992) notes, the ayllus' existence is centered around the need for organizing local services and labor. Institutions of Andean labor reciprocity are an efficient means of mobilizing work forces of various sizes to complete suprathousehold projects, ranging from individual agricultural fieldwork to sponsorship of public rituals and community construction projects. At the lowest level, work is shared through ayri, a symmetrical balanced form of labor between individuals who are equals. Labor performed by one individual is repaid at a later date. For larger projects, work is commonly done through minka or faena, other forms of reciprocal labor. Minka, organized at the group level, is asymmetrical and includes the exchange of goods for short-term labor or services mobilized for an individual's or community's benefit. Faena, also asymmetrical, is often a form of labor tax imposed by communities on their individual members for the construction and maintenance of local infrastructure (roads, schools, canals) and has a coercive component (Gelles 1986:130). The mtu, or state system of mass mobilization of rotational corve labor practiced by the Inka, is—at least functionally and symbolically—a form of minka or faena write large.21

Dual organization is ubiquitous in the ethnographic and literary literature on communities in the Central Andes. Its characterized as asymmetrical moieties, or sayus, usually referred to as amasuyus ("upper half") and arumayus ("lower half") in the Quechua-speaking zones. Traditional irrigation management, or "the local model of irrigation," revolves around dual organization of communities under "water magyus," and earth and mountain worship (Gelles 1990:154-156). Besides the spatial and social components of the system, this dual organization is also important in ritual. The organization of Andean irrigation is highly tied to calendrical rituals, which are an integral part of local water management (Zuidema 1990, Sherbondy 1982, 1987, 1992, Gelles 1990, n.d.b, Treacy 1989b, and others). Most scholars agree that the institutions of dual organization, earth and mountain worship, ayllus, and reciprocal labor relationships have deep historical roots in the Andes, although these institutions have certainly been transformed over time. Working with ethnohistorical documents in the north coast of Peru, Nettley (1984) has identified a local segmentary system of ranked dual organization and hierarchically nested community groups, which were in charge of hierarchical levels of the irrigation system.

In our experimental fields, labor was organized by the community groups or individual households. Specified workdays of 5 hours each were called on by the community for the communal work project (faena). Adult male heads of family (or designated adult substitutes) were responsible for showing up for the days of work. Communal work groups ranged from 5 to 60 individuals, depending upon interest and community membership. If additional days were required to complete the preplanned work, they were added to the community work schedule. Participation of the communal groups continued over many years, with field blocks becoming larger and more dispersed over time. Some groups utilized another traditional form of labor mobilization, referred to as sierra. Here, each comunero is assigned a set area of raised fields to reconstruct at his/ her own pace. This segmental organization for construction
for public works has been documented in Andean prehistory (Hastings & Mosley 1975). The tools used to construct the fields were those available to all farmers in the area—the Andean footplow (chakiqalpa), hoe (tawkasa), wooden clod-breaker (wayqana), shovel, and pick (see Figure 11). Large woolen cloths were also used to transport loose soil from canal to field surface. Field and canal boundaries were marked by string, using the old abandoned field and canal surfaces as models. The rich organic topsoil of the A horizon from the sediment-filled canals was cut into sod blocks using the footplow and placed as a retaining wall and fill for the raised field platform. The platforms were built up to a height of 20-50 cm and were bordered with correspondingly deep adjacent canals (see Figure 12). Sod blocks and cloths were broken up with picks and clod-breakers, and field surfaces were formed into a cambered shape for drainage.

Fields were planted in local crops—potatoes, oca, ulluco, inatu, quinoa, calabush, maize, winter wheat, peas, broad beans, tarwi, and various garden vegetables. Fields received no fertilizers. Maintenance activities such as weeding and banking of tuber crops were done in the same manner as in traditional fields.

The research team also worked with some individual farmers (parcereños) and non-community groups of farmers. These farmers tended to construct small blocks of rehabilitated raised fields adjacent to households, taking on the form of house gardens. Labor was commonly mobilized using aymi, symmetrical reciprocal labor exchange between neighbors and extended-family members. These fields generally were better constructed and better maintained than the community fields. In 1989, individual farmers were adopting raised fields faster than community groups. Ground and aerial survey demonstrated that hundreds of families in the pampa of Huatta, Costa, and Caracoto had begun to construct small plots near their houses.

Several assumptions about the way raised fields work were shown to be erroneous in our experimental research. One erroneous assumption is that raised fields need a high level of centralized organization for construction and maintenance. The raised fields were constructed by communal groups and individual families using the traditional Andean labor reciprocity, aymi, minaka, and jaera. Piecemeal construction of raised fields over 10 years by individual households and communities has resulted in over 100 ha of rehabilitated fields in the Huatta area (Juan Paiaco, pers. com.) and 150 ha in the Koiapi Pampa/Valley of Twanaku (Osvaldo Riveria S. and Enrique González A., pers. comm.). Several blocks of communal fields in Huatta and Costa belonging to small communities have grown to over 15 ha by accretion over an 8-year period. The traditional reciprocal labor institutions, aymi and minaka, proved an efficient means of mobilizing labor for raised field turnover. Clearly, small groups of farmers are capable over time of creating a large-scale, heavily modified, regional landscape.

Figure 11. Cutting Sod Blocks with the Andean Footplow (chakiqalpa) for the Construction of Raised Fields, Community of Yasis. Huatta
Raised fields are not necessarily labor intensive. Because few experiments constructing raised fields with manual labor had been conducted (e.g., Puleston 1977a, Gómez-Pompa et al. 1982, Maze & Quintero 1987), previous labor estimates were based on simplistic comparisons with other forms of traditional agriculture or, more commonly, with labor estimates for moving earth (e.g., Erasmus 1965). According to the Boserup (1965) hypothesis on agricultural intensification and the "Law of Least Effort" (Ziffl 1949), intensive forms of agriculture requiring large inputs of labor and energy for construction and maintenance will be adopted by traditional farmers only if population stress becomes too great or, according to the Wifflarian counterpart to the theory, if the centralized political state forces local farmers to adopt the technology.

Our experimental data indicate otherwise. The initial construction of raised fields—digging canals and transferring soil to construct the platforms—involves a relatively large input of labor (in comparison to traditional wacho lazy bed construction). From several years of controlled experimental construction using manual labor in diverse locations in the Huasteca Pampa, we estimate that 283-1,000 person-days of labor are necessary to construct 1 ha of raised fields and canals (Erickson 1988a, Erickson & Cauley 1989, Garaycochea 1986a, 1987). These figures have been duplicated experimentally in other areas (Ramos 1986). The work is considerably slower than estimates previously calculated using earthmoving figures (Erasmus 1965) for prehispanic raised field construction (Devereux 1982, Turner 1963). This lower calculation for construction is probably due to the different techniques used in earthing moving and the advantages of working in the grasslands, where large sod blocks can be easily cut and moved using the Apech footpaw. In addition, the traditional labor mobilization institutions of the Arentian community and family groups are an efficient means of providing the necessary work force.

Labor input on raised fields becomes almost negligible when labor and production are considered over the long term. Raised field agriculture is efficient and sustainable because fields can be farmed continuously with high productivity for many years. Many raised field platforms in Vincachani Pampa in the Huasteca area have been farmed for over 10 years without a significant decline in productivity. Raised field maintenance requirements are low (occasional weeding, irrigation, and banking of ditches). Harvest takes longer than on regular potato fields because the production is so much higher (see Figure 13). The fertility of raised fields is maintained through the periodic re-excavation of sod in dry canals or organic mucks and sediments in wet canals and the placing of these materials on the field platforms. Estimates of 275 person-days/ha [58.6 hours/day] have been calculated for raised field construction and necessary maintenance (annual and periodic) over the long
Raised Fields in the Lake Titicaca Basin

run (a 10-year period), based on experimental results (Erickson 1988a, Erickson & Casdorl 1989). The figures are even more impressive in terms of the agricultural production returns on labor input. Production data from several years of experimental raised field potato harvests range from 8 to 16 metric tons of potatoes per hectare, or 2-3 times that of regular potato farming. This yield converts to 37 kg of potatoes per person-day of work, in sharp contrast to the 19 kg per person-day of work for regular fields in the Andean region (Erickson 1988a). Given such a reliable, sustainable production, farmers may have adopted raised field farming early in Andean prehistory without having been forced to do so by population pressure or other stresses such as state imperatives.

Another premise that the experimental fields showed to be incorrect was that the fields would not function without the rehabilitation of the complete regional hydraulic system envisioned by Kolata (1991). Small, isolated blocks of rehabilitated raised fields did produce remarkable harvests, despite being surrounded by eroded, unreconstructed, abandoned raised fields. It is clear that larger, contiguous blocks of fields would produce the desired microclimate effects better than small, isolated blocks (Erickson 1988a, Grace 1983), but the individual components of regional raised field systems do not require the rehabilitation of the whole system to function (see Figure 1). There is no need to invoke large-scale hydraulic integration and a state-level organizational apparatus for raised fields to function properly.

COLLAPSE AND ABANDONMENT

In discussing the Tiwanaku raised fields of the Koaní Pampa, Kolata (1983:262, 1986:753, 1987:41) suggests that one of the potential causes of the collapse of raised field farming was the disintegration of the Tiwanaku state after the Tiwanaku V Phase. He assumes that, without the bureaucratic organization of the state, raised field farming would break down. His evidence for the co-occurrence of the Tiwanaku collapse and raised field abandonment comes from early excavations of a limited number of occupation mounds within Koaní Pampa (Kolata 1986, 1987). Graffam (1989, 1990, 1992) has recently demonstrated that raised field construction continued in Koaní Pampa and the Taraco Peninsula after the fall of Tiwanaku during the Late Intermediate Period. According to Graffam’s investigation of house mounds and associated fields, the majority of visible raised fields in the best-preserved section of Koaní Pampa are post-Tiwanaku. Survey work in the Tiwanaku Valley itself demonstrates that raised fields, terraces and quichas (sunken gardens) continued to be constructed during the post-Tiwanaku period (Albarracin & Mathews 1990:146-147, Mathews n.d.b). There is considerable debate regarding the level of political organization present during the Late Intermediate Period in the
Lake basin, but most agree that it was less centralized than during the Middle Horizon (Stannish n.d., Graffam 1992:885). Thus, raised field production appears to have continued under local sociopolitical organization, independent of state administration.88

Our investigations in the Huatla pampa indicate that the rise and fall of local states had little to do with the success or failure of raised field systems. Field blocks may have been abandoned periodically as part of a rotational fallow system or because of demand. Two climaxes of raised field construction and use appear to have been before Puikara developed into a major center (and possible state) and during the Late Intermediate Period in the Huatla pampa (Erickson 1987, 1988b). Raised fields in the northern basin may have been abandoned for a time during the Middle Horizon (A.D. 600-1000) and Late Horizon (A.D. 1476-1534), the periods of state (Tiwanaku and Inca) presence in the region. Raised fields under community control were apparently resilient and functioning independently of centralized state control, which waxed and waned in the region.

INFRASTRUCTURE, CAPITAL, AND EVOLUTION OF REGIONAL LANDSCAPES

The vast Huatla pampa is covered with earthworks that could represent elements of agricultural infrastructure of a level beyond the basic organization of raised field blocks and bundles of fields. The most impressive are the extensive canal networks, discussed above, which divide and interconnect raised field blocks into social and functional units, and which may have also had a hydraulic function (Lennon 1982, 1983; Erickson 1988a). In addition, there are artificial levees associated with most, if not all, active and nonactive river and stream channels crossing the pampa. Smith et al. (1984) reported large causeways from Machacamarca associated with raised fields. Do these earthworks necessarily represent the work of supraregional bureaucratic organizations that controlled the labor of local farming communities? Are they beyond the scale of engineering ability of small social units?

Kolata (1991) has argued that the "regional" infrastructure of earthworks—

— including artificial canalized sections of the Rio Catari, the river-bypass systems or river sloughs in Koashi pampa and the Tiwanaku Valley, causeways/dikes, and aqueducts—are definitely projects of a state because they would have been far beyond the labor and organizational capability of local groups of farmers to do. One might add, these constructions are impressive engineering accomplishments, but it is premature to deny the possibility of local level construction.

What is often forgotten by scholars studying agricultural infrastructure is the considerable time depth of the evolution of cultural landscapes in the Americas. What we see today in the form of massive infrastructural modifications of the slopes, deserts, and pampas is the gradual accumulation of constructions produced by hundreds of generations of farmers. Archaeological evidence indicates that the raised fields of the Lake Titicaca Basin have a long evolutionary history and that they certainly were not all constructed at a single point in time. Agricultural landscapes take on a high degree of engineering complexity, or "integrative wholes," over time. Several scholars have referred to this phenomenon as the "landscape capital" by traditional farmers (Bruck 1986, Bronson 1972, 1975). This capital includes infrastructures such as terraces, irrigation systems, dikes, fences, ponds, aqueducts, road networks, and raised fields. As Doust (1984) has noted, these complex systems evolve over long periods of time, through what could be considured a piecemeal accretion process, the day-to-day activities "that take place in the normal course of cultivation and maintenance" (Doust 1990:151; also see Downing & Gibson 1974:ax, Donkin 1979:120, 113). Much of the early construction of fields, boundaries, canals, and settlements of any system is relatively haphazard and unstructured.

The process involves working out the kinks in the production system through experimentation and fine tuning. This process is not necessarily a conscious, intentional effort, or part of a long-term plan on the part of the farmers, but rather results from the simple annual rebuilding or maintenance activities which altered and improved elements of the infrastructural system. Over time, as a result of these activities, the system may take on a high degree of formal structural patterning. What we see today as archaeologists is a complex, sophisticated, and once highly productive system spread over a regional cultural landscape. This landscape is a result of the gradual accumulation of landscape capital. I would argue that the raised field systems and the associated irrigation, guagua, terracing complex are the result of a similar process of accumulation of landscape capital over a long period of time by small-scale farmers organized in traditional community structures such as the ayllu. As Glück (1970:173-174) notes, "The physical aspects of a system can be deceiving and Wittfogel... seems to say that an impressive irrigation system must be the work of an impressive government, an agricultural despotic command extending an empad labor force."

Leach's (1959) warning about scale, sociopolitical organization, and chronology is relevant here. He states that the 55 kanas of architecture in the Ceylon "looks like a colossal and highly organized piece of bureaucratic planning, the work of one of Wittfogel's idealized Oriental Despots. But if so, the planning must have been done by a kind of Durkheimian group mind! The system took about 1400 years to build." (Leach 1959:13). In addition, Leach (1959:14) states that, "although the Ceylon irrigation works and the associated palace and temple construction works do represent a gigantic accumulation of capital resulting from an enormous number of man-hours of labour, Dis
fact does not in itself imply any massive control over labour resources by the "bureaucratic rulers." If Tiwanaku IV and Tiwanaku V represent the period of the Tiwanaku state and the period of raised field construction, the creation of the now abandoned landscapes could have been spread over a 600-year period. An even longer period of 2,000 years of construction is suggested by dates for raised fields in the northern basin (Erickson 1987, 1988a; Stanish n.d.). This is more than enough time for small-scale organizations to produce these highly structured and productive agricultural landscapes. There is no need to invoke the state to explain the origin of all of these works.

Over the years of experimental construction of raised fields in the communities around Huacna between 1981 and the present, farmers have altered and improved the methods of construction and maintenance of the plots to increase labor efficiency and production and to reduce risk. This fine-tuning of the system involves primarily trial and error procedures. Raising the elevation of platforms after problems of flooding and using sod walls to protect field edges from erosion are some examples of such changes. These alterations are conducted seasonally or when maintenance is necessary. This form of landscape capital improvement can also be seen in the larger, regional hydraulic and transportation works such as the river canalization and dike program (discussed above), where dikes are periodically repaired and improved after serious flooding problems to prevent future inundation. This accretion process can also be seen in the construction and maintenance of community road causeways in the pampas, which are continually rebuilt and modified to provide the necessary drainage to use the pampas for farming and grazing. This is the gentle process of incremental change in action.

ALTERNATIVE SYSTEMS OF AGRICULTURAL PRODUCTION

Because raised field agriculture is such an impressive production system, a major misconception is the implication that raised fields were the main or only economic system available to farmers during the Middle Horizon (A.D. 600-1000) in the Tiwanaku core area, as implied by Kolata (1986:748, 760; 1991; Ortloff & Kolata 1988). Survey undertaken by Albarracin and Mathews (1990) also see Albarracin 1992) demonstrates that Tiwanaku peoples used multiple systems of production. Their work provides evidence of extensive terracing and quichas, in addition to raised fields.

Terracing has not been investigated in much detail, but the technology had been mastered by the Early Intermediate Period (300 B.C.-A.D. 600). The ceremonial precinct at Pukara was placed on monumental terraces. During the Middle Horizon, large areas of residential zones of Lukurmata and Pajchiri

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were located on artificial terraces (Kolata 1986, 1987). Many of the terrace systems in the Lake Titicaca Basin are integrated into raised field systems through continuation of boundary walls that extend from the hilltops into the pampas (Erickson 1988a). If terraces were constructed for occupation, they may also have been in use for agricultural production at a very early date. The advantages of favorable lakeshore microclimates, higher rainfall, better soils, and longer growing seasons made labor-intensive terracing a practical option for lake edge farmers. The archaeological record indicates that pre-Tiwanaku farmers, and colonial and contemporary farmers (Ayamaru, Quchocha, and Uru-Puquinas), also relied heavily on lacustrine and aquatic resources such as fish and gathered plants, as well as camelid herding (Erickson 1988a).

These diverse production strategies available to Tiwanaku, in addition to long-distance trade and establishment of agricultural production systems in the pampas, may have been crucial in the development of Andean states in the Lake Titicaca Basin.

THE RELATIONSHIP OF RAISED FIELD AGRICULTURE TO THE STATE

If the success of raised field agriculture does not rely on state bureaucratic management, then what is the relationship between the prehispanic state and raised fields? Raised fields did not "cause" the first state in the Lake Titicaca Basin, but this impressive agricultural system is certainly indirectly related to the development of the state. Raised fields farming preceded the state by possibly 500-1000 years (Erickson 1987, 1988a; Stanish n.d.). Because raised field agriculture is an intensive and effective form of production technology, it is usually discussed in the context of surplus production, not subsistence production. Inherent in discussions of the state's relationship to raised fields is the state's need to produce large quantities of surplus to sustain urban populations, craftpersons, the elite, and state activities. In the Tiwanaku Valley it is no doubt that the state would have had a strong interest in raised field agriculture, appropriating this surplus through taxation, expropriation of peasant labor for construction and maintenance of new fields, establishment of colonies of state agriculturists, and/or direct government control of fields.

Kolata, Graffam, and I have argued that the vast extension of raised fields represent much more than a subsistence economy. The highly productive regional landscape was definitely important in setting the stage for state development. The fields were effective means of generating huge surpluses and
sustaining large nonfarming populations. But, while the state may have had a strong influence over raised field production through taxation, it does not follow that the state necessarily had a direct hand in the planning, construction, and administration of raised fields. There is no need to invoke direct Tiwanaku state control over raised field farming, the "top-down" approach. Indirect demands and pressures such as taxation, co-optation of labor, and tribute demands can induce farmers to intensify and boost levels of surplus production. The Tiwanaku state may have had expanded the agricultural frontier into marginal zones. This still does not mean that the Tiwanaku elites necessarily planned and managed all of the fields in the Lake Titicaca Basin, or that raised field agriculture did not exist or was not productive before the Tiwanaku state.

What raised fields and other landscape capital systems did was to tie farmers to the land, making them relatively immobile and subject to labor taxes and tribute. Such a situation is beneficial to the state in that such farmers can easily be controlled and labor and goods can easily be appropriated for the elite's purposes. As in the Inka case of terracing (Conrad & Demarest 1984, Shevky 1982, Murra 1980), the state may have encouraged the expansion of raised fields at the community level in order to create a more favorable economic environment. As long as the tribute flowed from the local communities, it would not be in the state's best interest tomeddle with well-established and efficiently functioning raised field agriculture.

Raised fields have a long history in the Lake Titicaca Basin, much longer than that of the Tiwanaku state, which may have lasted less than 600 years. Why would early farmers adopt raised field agriculture at a time when there was no demand for surplus from urban populations and the state? Because raised field farming is more labor efficient, more productive, and less risky than alternative technologies, it would have been one of the best choices for early farmers in the Lake Titicaca basin making the transition from horticulture-based hunting and gathering economies (Erickson 1987, 1988a). Raised fields evolved from a subsistence to a surplus production system as local demands and population grew. By the initial period and Early Horizon, these demands could have included: taxation and tribute to local ayllus and supra-ayllu lords institutions. I have reviewed these perspectives and presented an alternative model, that they were developed and managed by local household and community organizations.

Hierarchically organized, highly centralized, complex state-level society was probably never the norm in Andean prehistory. Widespread "horizon style," commonly assumed to be associated with the expansion of state organizations, disappear and disappear throughout the Andean chronological sequence (Moseley 1992). Class struggle, ethnic unrest, and peasant rebellion date to at least the Late Horizon and possibly earlier (Patterson 1992). Documentary data for the Lake Titicaca Basin indicate widespread warfare and internecine unrest during the post-Tiwanaku Late Intermediate Period and late Horizon

CONCLUSIONS

Most discussions of raised fields have focused on the technology and the environmental and evolutionary context of raised field farming (Denevan 1970, 1982; Denevan & Turner 1984); and others). The cultural material and cultural ecology perspectives tend to dominate this literature. Little emphasis has been placed on the sociopolitical context of raised field agriculture, in contrast to the rich discussion regarding the organization of prehistoric irrigation systems. Kolata and others have presented a provocative hypothesis regarding the relationship of raised fields and the state. The primary assumption is that, because raised fields are an intensive form of agriculture, they must have been constructed and controlled by large supra-local lords institutions. I have reviewed these perspectives and presented an alternative model, that they were developed and managed by local household and community organizations.
Grants from the Social Science Research Council, the National Science Foundation, and the Inter-American Foundation. Gray Graffam, Charles Stanish, Barry Isaac, Paul Gelles, Kay Candler, and Jim Mathews provided detailed criticism at various stages of the manuscript. We strongly disagree on many key points and have resolved their unrest and lack of strong state presence, intensive raised field agriculture flourished in the northern Lake Titicaca Basin under local control. The raised field system did not need the state.

Archaeological, ethnohistorical, and ethnographic case studies document that large-scale regional, intensive forms of agriculture are associated with a wide range of social systems. To automatically assume that the sociopolitical organization associated with these systems has to be centralized and directed by bureaucracies would be a mistake. It is clear that raised field agriculture is highly sustainable and efficient for the production of subsistence and surplus foodstuffs. At times, large and dense populations must have been sustained by raised field agriculture. But it is important to remember that raised fields were used in the Titicaca Basin before, during, and after the Tiwanaku phenomenon. There is no necessary relationship between the Tiwanaku state and the construction and management of raised field systems.

The implications of the debate among scholars regarding the social organization of prehistoric raised field agriculture are potentially far reaching. Both the Peruvian and Bolivian governments, in addition to numerous governmental and nongovernmental organizations, have adopted raised field technology to certain degrees as part of development programs for the rural altiplano (Erickson & Candler 1989, Kolata 1991; Rivera 1989, Erickson & Brinkmeier n.d., Brinkmeier 1985, Erickson 1992b, Garaycocha 1988). Much of the planning and organization for the diffusion of this technology has been haphazard—some groups favoring a heavy-handed “top-down approach,” others focusing on a more grassroots development, or a “bottom-up approach” (for details, see Erickson & Brinkmeier n.d.). The future and success of raised field agriculture may depend heavily on what prehistoric archaeology can tell these development institutions about the optimal level of social organization for the reintroduction of raised field farming in the Andes.

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of a single outstanding monarch, archaeology shows each has been slowly developed over a long period of time (Lack 1959:13).  

8. I have argued that many of the large canals that bias raised field blocks may have been used to contain and maintain artificial wetlands instead of "draining" these areas (Eriksen 1986a). Much of the structure of fields, canals, and embankments would have actually impeded the drainage of water.  

9. Several scholars have hypothesized that salination of raised field surfaces was prevented by moving and distributing fresh water to canal systems (Slaton, pers. comm., Kolta & Orfield 1989). It has not been demonstrated that salination was a problem facing raised field farmers. Our experiments have shown that rehabilitated fields in areas with extensive surface water supplies need less than two percent of rainfall to maintain salinity-free environments.  

10. In the 1991 article, Kolta appears to equate the sophisticated nature of the raised field technology with terracing and protection management of hydrostatic controls, high sustainable production, elevated carrying capacity, production and recycling of nutrients, and micro-climate improvements) with the need for a canal system for the same purposes in the late Holocene. I have argued that these two concepts are distinct and have no necessary relationship (Eriksen 1988a). Also implied in Kolta's and other's work is the assumption that raised fields are necessary "insure" and, following the "Law of Least Effort," that farmers will not adopt this system unless faced by the need for a canal system for the same purposes. I do not necessarily mean that the impetus for the generation of these systems was state policy.  

11. Stanish (n.d.) also argues that, in the case of Muyompana, Peru, the larger, more integrated raised field complexes associated with hydraulic structures (aquedup and canals) must have been state controlled, while smaller blocks without these features may have been organized at a lower level by authority.  

12. If the aqueducts and river channelization found within the Tiwanaku fields block system, as Kolta and Osorio (1989) argue, have prevented flooding and lower water tables within the land by diverting water directly into Lake Titicaca, the optimal hydraulic conditions within field canals may have been disputed. Graffan (1990:23, 172) has argued that these hydraulic modifications are more appropriate for pastoral use of the canals during later prehistory or the historical period. The recent artificial landaming with the annual flooding of the Huatana pampas, a necessary factor in prehistoric and contemporary raised field farming, has been detrimental to the raised field agriculture being reintroduced in the area (Eriksen & Birket-Smith n.d., Eriksen & Charles Flitton 1993).  

13. Mathews (n.d.) reports on excavations of several raised fields near the urban center of "Tiahuanaco," the optimal hydraulic conditions within field canals may have been disputed. Graffan (1990:23, 172) has argued that these hydraulic modifications are more appropriate for pastoral use of the canals during later prehistory or the historical period. The recent artificial landaming with the annual flooding of the Huatana pampas, a necessary factor in prehistoric and contemporary raised field farming, has been detrimental to the raised field agriculture being reintroduced in the area (Eriksen & Birket-Smith n.d., Eriksen & Charles Flitton 1993).  


15. It should be noted that the raised fields of the Koani Pampa are highly variable according to the published maps (Koani 1986:Figure 4), also see Graffan (1990) and aerial photographs that I have studied from the Instituto de Geografía Millu archives. Fields within the Valley of Tiwanaku near the site of Tiahuanaco are similar, but at the more orderly checkboard and ladder formation (Mathews n.d.a, n.d.b, n.d.c) suggests that these differences may be due to the Tiwanaku Valley fields being older than those of Koani Pampa or to the different ecological context (riverine vs. lacustrine).  

16. Wastewater is the distance from canal center to adjacent canal passage (passing over a raised field platform). More accurate measures can be made by counting many measurements. It provides an important and accurate measure with which raised fields can be compared (Eriksen 1988a).  

17. Koani (1986, 1987) and Graffan (1990) report finding Chiripa ceramics (which date to Initial Period and Early Horizon) within the fill of Middle Horizon and Late Intermediate Period occupation mounds in the pampa of Koani. These sherds possibly represent earlier occupations by raised field farmers in the pampa, but this has not been firmly established (Koani 1986, 1991; Graffan 1990). There is also Early Horizon material at the site of Llusterapata (Bernstein 1990). A short survey conducted in 1973 along the northern shore of the Tiwanaku Pampa by the Taris Pampa Project documented numerous Early Horizon settlements adjacent to prime raised field land. This has also been addressed by Graffan (1990). At the beginning of the Tiwanaku state, the raised field zones were already being occupied and utilized by farmers.  

18. Long "linear" raised fields extending several kilometers are commonly found in the Capachica region north of Huanta (Smith et al. 1968). They extend perpendicular from the base of the slopes and cross the pampa to the lake edge. Another rare form is the "tall" ladder field pattern, a bundle of short fields between two parallel canals, found in the Lake Titicaca Basin. The tall ladder field pattern is commonly organized as long, thin strips of land extending from hilltops across the pampa to the lake edge, sometimes extending out from the hilltops into the lake itself.  

19. There is evidence that the local agro-ecological organization of irrigation agriculture in Cusco was based on the form of the irrigator (Scheffler 1982, 1986, 1990).  

20. This radial system of organization has been discussed for various pre-Columbian cultures, such as its presence in the Nasca lines (Hven 1968), Inka irrigation (Scheffler 1982, 1987, 1990-91, 1993; Zuidema 1968, 1990), and Inka settlement patterning (Hven 1990). Other, related but non-radial forms, have been documented (Unnow 1992).  

21. Dating of occupation mounds by surface collections is inadequate. There tends to be an overabundance of diagnostic late pre-Hispanic ceramics on the surface, which masks the presence of occupation at earlier periods. Relating these mounds to the construction and use of the raised fields is even more difficult. Koani (1986) has attempted to relate mounds and fields by associations of pre-Andean culture, such as its presence in the Nasca lines. (Hven 1968), Inka irrigation (Scheffler 1982, 1987, 1990-91, 1993; Zuidema 1968, 1990), and Inka settlement patterning (Hven 1990). Other, related but non-radial forms, have been documented (Unnow 1992).  

22. Even though the raised fields were not directly dated during survey, Mathews and Alvarado (1990) assume that most of the fields are associated with, and thus contemporaneous with, Tiwanaku IV and Tiwanaku V periods sites. It is interesting that their maps (Figures 6-17) show that the numbers of settlements increase in the raised field zones after Tiwanaku collapses. They note (1990:146) that some of the fields are larger than those known to be occupied by farmers today, but the map shows a much reduced area under cultivation. How they determined this reduction of field use from surface evidence is not clear.  

23. A monograph presenting these excavation results is currently in preparation. Preliminary analysis is briefly summarized in Eriksen (1988a-b).  

24. Bernstein's 19th-century data and Fischer's study of the Ximara ayahuasca used by Graffan (1990:286) and Alvarado (n.d.) to support the presence of hierarchy in traditional ayahuasca organizations.  

25. There are many terms used in the literature for a variety of Andean institutions of labor mobilization. Some additional examples include chapa (Graffan 1990:172), wakara-wakara, tama, uawi, carer, narcopo (Fitzsimons 1974:87), and volante, wai-sajo, campi, and yacuta (Mayer 1974:47). There is a little agreement on precise definitions of these terms, and their use is highly variable, depending on ethnic identity.  

26. Geller (n.d.c) recently argued that certain elements of the system of dual organization were imposed by the Inka on the farming populations of the Colca Valley as a means of organizing production, taxation, and exportation of labor. According to Geller, this system, combining
elements of both Inka and Spanish Colonial political economy, has been transformed over time into a local model of water management.

27. By "regular fields." I mean the fields currently used by Quechus and Aymaras farmers in the Lake Titicaca Basin. These are dry fields on slopes and hills ringing the pampas and the waqchas, or narrow sod beds constructed for potato cultivation. These fields are prepared by wooden scratch plows pulled by teams of oxen, mules, or the chañayto. The use of irrigation is rare in Huanta.

28. Raised field experiments conducted in the southern Lake Titicaca Basin have recorded even higher estimates of potato production using fertilizers (Knorr 1991).

29. Knorr states that "there seems to have been a massive agricultural collapse, probably brought about by the political disintegration of the Tiwanaku empire. After this time, the drained fields of the Pampa Koavi were never reutilized" (1983:62), and that "the evident decline in human activity on the Pampa Koavi after Tiwanaku V times was related to the disintegration of the Tiwanaku state, with the collapse of strong central authority inducing disruption of the formidable seasonal maintenance requirements of the field system" (1986:752).

30. In a recent article, Griffith (1992) argues that the post-Tiwanaku, ayllu-based Pacha polity relied on raised field agriculture as a means of subsidizing a large, pastoral herding component.

31. Doob (1990:3) has recognized that, "Studies that either compare ancient irrigation systems in their temporal contexts or emphasize the environmental factors responsible for the rise of different systems fall to recognize the long-term and cumulative nature of technological change. Carl O. Sauer's (1952) observation that "ideas must build upon ideas" seems to have been lost. For the most part, technological change involves degree rather than kind. Although changes in types of technology have never been uncommon, change in the nature of a particular kind of technology have been more typical."

This process is obvious in the evolution of raised fields in the Northern Titicaca basin, where earlier Late Period and Early Horizon fields have wadways of 100, whereas the later Late Intermediate Period fields have wadways of over 100 (Erickson 1987, 1988a). The fields are morphologically and structurally the same, the scale has simply changed over time. I do not mean to suggest that ancient agricultural landscapes were never formed rapidly or that states are incapable of implementing or dramatically altering large scale production systems. Inka agricultural policies, such as that practiced for the establishment of agricultural colonies in Cochabamba (Waldrit 1982) or the reworking of production systems in the Maras Valley (D'Amory 1992, Hartnell 1992), are prime examples of the state's role in redefining the Andean landscape.

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