Top-down or bottom-up: rural settlement and raised field agriculture in the Lake Titicaca Basin, Bolivia

John Wayne Janusek\textsuperscript{a,*}, Alan L. Kolata\textsuperscript{b}

\textsuperscript{a} Department of Anthropology, Vanderbilt University, Nashville, TN 37235, United States
\textsuperscript{b} Department of Anthropology, University of Chicago, Chicago, IL 60137, United States

Received 12 May 2004; revision received 10 August 2004

Abstract

Differing interpretations regarding the organization of past intensive farming are often distinguished as “top-down” or “bottom-up” perspectives. The development of intensive farming and its social organization are attributed to either nascent states and centralized governments or the incremental work of local communities or kin-based groups. We address the social organization of raised field farming in one region of the Lake Titicaca Basin of the Andean altiplano, Bolivia. We evaluate past research in the Katari Valley, including our own, based on recent settlement survey, excavation, and a variety of analyses. Taking a long-term perspective covering 2500 years, we find that relations of production and rural organization changed greatly over time in relation to changing sociopolitical conditions. Local communities played dynamic roles in the development and organization of raised field farming, yet its intensification and ultimate recession were keyed to the consolidation and decline of the Tiwanaku state. We conclude that the top-down/bottom-up dichotomy is overdrawn. Local communities and their productive practices never operated in a political or economic vacuum but both shaped and were transfigured by regional processes of state formation, consolidation, and fragmentation.

© 2004 Elsevier Inc. All rights reserved.

Keywords: Rural settlement; Raised fields; Andes; Lake Titicaca; Tiwanaku

Over the past fifty years rural society and agrarian landscapes have become increasingly important themes in the study of past complex societies. Beginning with Gordon Willey’s study of settlement systems in Peru, regional studies were foundational in emphasizing the importance of documenting all settlements, cultural features, and environmental conditions in a given landscape (e.g., Flannery, 1976; Parsons, 1972; Willey, 1953). Most recent studies have focused on the inseparable and dynamic interactions of past societies and their regional physical settings and environmental conditions (Ashmore and Bernard, 1999; Bender, 1993; Bradley, 1998; Crumley, 1994, 2001; Fischer et al., 1999; Gartner, 1999; Kirch and Hunt, 1997; Kolata, 1996b; Thurston, 1999; Tilley, 1994). Such studies emphasize that past landscapes were products, in part, of concrete human activity and experience, and thus were deeply imbued with social significance. Such an approach encourages a shift toward understanding the fundamental cultural and environmental matrices that gave rise to past cities and states.
Nevertheless, fundamental interpretive and epistemological differences, with roots in the foundations of Western social thought, typify rural and landscape studies. On the one hand, since the 1950s it has been common to attribute development of large-scale farming and irrigation systems to centralized governments and nascent states. Paradigmatic of such a perspective is Wittfogel’s (1957) model of “hydraulic civilizations,” in which states emerged to organize the construction, maintenance, and labor coordination that was deemed necessary to manage large-scale irrigation systems in challenging environmental conditions. Even though evidence globally demonstrates that complex irrigation systems rarely caused states to develop, it is common in archaeology to attribute archaeological evidence of large scale, highly integrated productive systems to the work of efficient, centralized governments. In this view such systems, like monumental architecture, imply the hand of a powerful state.

Recent alternative perspectives emphasize that cultural creativity and political power was also the product of local groups, not simply rulers and central governments. In many world regions, convincing evidence demonstrates that cultural elements once considered as diagnostic of state-directed actions, including monumental construction, craft specialization, and large-scale economic production, were at least as much the product of local kin-based groups as of the elites and leaders who, in some cases, coordinated such activities (Mosley, 1992; Pauketat, 2000). Local communities, social groups, and political factions played key roles in the formation and collapse of many complex societies in the New World (Brumfiel, 1994; Joyce and Weller, 2005). In the Andes abundant anthropological research illuminates the fundamental roles of kin-based groups and communities in managing long-distance exchange, craft production, and intensive farming (Brownman, 1997; Erickson, 1985, 1988; Janusek, 1999, 2002; Kolata, 2003; Murra, 1972; Nielsen, 2001; Núñez and Dillehay, 1995).

However, as with Wittfogel’s position, attention to local foundations for power is problematic when it becomes a bias determining ex ante the interpretation of empirical evidence. Such a situation has developed in the current climate of the social sciences in general, and in anthropology in particular, to the extent that the traditional role of writing about and interpreting other cultures has accrued a moral role of writing and speaking for other cultures. Often linked to such a position is a romantic “lure of the local” (Lippard, 1997) and its corollary, an ascription of negative value to the imperial and the exploitative in favor of those deemed subdominant or colonized. Illuminating the role of local groups and communities and giving them “voices” has become the symbolic capital of anthropology. In this climate attention to the institutions, power relations, and ruling regimes of past imperial systems is not just outmoded, it can be considered unethical.

Interpretive differences habitually follow old theoretical divides. Regarding the organization of past production systems, the debate has been construed as “top-down” versus “bottom-up” interpretations (Chambers, 1980; Erickson, 1993; Fischer et al., 1999). Proponents of both interpretations argue that intensive production was a highly effective, if costly means of adapting to particularly rigorous environments. Following top-down interpretations, intensive production was developed under the impetus of centralized state governments. Following bottom-up interpretations, intensive agriculture was developed and organized locally, without the involvement of overarching state systems or despite their impact. In one view, the dynamic locus is the state, and in the other it is the local community or kin-based group. The terms of debate, we believe, have been distorted by current disciplinary ethics that encourage the construction of easily-debunked “straw man” models, often without benefit of new empirical data. Determining who developed and managed intensive production in any specific case and with what technologies and resources requires rigorous interdisciplinary collaboration and empirical research.

In this paper we critically review recent research bearing on the prehistoric organization of rural settlement and intensive farming in the southern Lake Titicaca Basin of the Andean altiplano, Bolivia (Fig. 1A). Specifically, we detail shifting relations of prehispanic settlement and production in the Katari River Valley (Fig. 1B). The region is pivotal in part because it comprised, for several centuries, a major segment of the core of Tiwanaku, a prehispanic state that emerged around AD 500 in the Tiwanaku Valley just to the south (Kolata, 1993; Ponce, 1981). In the past few decades researchers have systematically studied native agrarian systems, in particular ancient raised field farming, in the Lake Titicaca basin and elsewhere (Denevan, 1970; Erickson, 1985, 1987, 1988, 1993; Kolata, 1983, 1985, 1986, 1991, 1996a; Lennon, 1983; Smith et al., 1968). This research has generated a vigorous debate centering on a few key questions: When were raised fields built and by whom? When and why were they abandoned? Did raised fields require state management, or were they the exclusive domain of local communities? With fresh and extensive data we re-examine the empirical record, accentuating complexities and temporal shifts in relations among state institutions, local communities, and the development of intensive farming.

The polarized character of theoretical differences coupled with a lack of rigorous empirical research in much of the Lake Titicaca basin emphasizes the need
for a research design focused precisely on these problems. The Katari Valley and its low flood plain, the Koani Pampa, is one major focus of such a debate (Fig. 2; Graffam, 1990, 1992; Kolata, 1986, 1991). Disagreement in the region has turned on results of small-scale research, including general reconnaissance, limited tran-
sect surveys, and test excavations in relatively small sections of the flood plain. To address this problem we completed a research program that entailed full-cover-age survey of the entire southern half of the lower Katari Valley (102 km²), nearly 200 trenches in fossil raised field systems in the Koani Pampa, and extensive excava-

Fig. 2. View of the Koani Pampa in the Katari Valley (A), with fossil and rehabilitated fields in the background, and a plan of raised field segments near the Quiripujo Mound Group (B; field beds are in gray, swales or canals in white).
tions at various sites (Fig. 3). Based on intensive ceramic analysis and a large suite of radiocarbon assays from raised fields and site occupations, this research program produced a reliable chronological framework.

Our conclusions provide a long-term (ca. 2500 years) characterization of rural society and production dating from the emergence of complex societies until European colonization. This long term perspective suggests that the top-down versus bottom-up dichotomy has been overdrawn. Like other elements of past Andean culture, intensive raised field production was embedded in multiple social domains, and over time, predominant relations of production shifted in relation to changing economic demands and sociopolitical conditions. Just as Bloch (1966) noted of 18th century French rural society, we conclude that in the Lake Titicaca basin local communities played dynamic roles in the unfolding histories of complex societies, including processes of state formation and collapse. However rural settlement and agrarian production must be understood in relation to broader sociopolitical histories, including emergent strategies of resource appropriation and social hegemony. Our evidence offers insight into the shifting social organization of intensive farming in the Tiwanaku polity, and the sociopolitical dynamics of Andean regional landscapes and rural histories.

Raised fields in the Lake Titicaca Basin

Altiplano landscape and environment conditioned the economic and ideological foundations of its past civilizations. Research in the Lake Titicaca basin demonstrates that populations developed raised field agricultural systems in this unique environment (Erickson, 1988, 1993, 1999; Kolata, 1986, 1991, 1993, 1996a; Kolata and Graffam, 1989; Kolata and Ortloff, 1996; Ortloff, 1996; Seddon, 1994). These systems were functionally similar to native raised field systems developed in other regions of the New World (Adams, 1983; Denevan, 1970; Gallagher et al., 1985; Matheny, 1976; Parsons, 1972; Riley and Freimuth, 1979; Turner and Denevan, 1985). They consisted of canals, or swales, alternating with elevated planting beds that ranged from 1.5 to 10 m in width (Fig. 2B). Swales in some areas were fed by natural springs or river networks, but in low-lying floodplains with high water tables, or pampas, many were fed by percolating groundwater. The elevated beds provide well-drained topsoil and optimal edaphic conditions for plant growth (Denevan, 1970; Denevan and Turner, 1974; Smith et al., 1968).

Rehabilitation projects (Erickson, 1985, 1988, 1993; Kolata et al., 1996) illustrate other ways that raised fields can enhance productivity in the altiplano. First,
water circulating in canals is rapidly colonized by nutrient-trapping macrophytes (Azolla, Myriophyllum, and Elodea) which, through periodic recycling of decayed organic matter provide a natural fertilizer for what are normally nitrogen-poor soils (Biesboer, 1999; Binford et al., 1996; Carney et al., 1996, 1993; Kolata, 1991, p. 102). Second, raised field systems effectively absorb and conserve heat from solar radiation during the day, forming a “heat envelope” that effectively protects maturing plants from possible frost damage at night (Erickson, 1985, 1988; Kolata, 1991, p. 103; Sanchez de Lozada, 1996; Smith et al., 1968). Third, raised field cultivation, because of its perennial water supply, can extend the short altiplano productive season by as much as 1–2 months, providing the possibility for double cropping (Knapp and Ryder, 1983; Kolata, 1991, p. 108). Based on such observations, Erickson, Kolata, and others agree that the indigenous technology of raised field agriculture could support dense human populations.

State and community: the timing and production of raised fields

Despite consensus on the productivity of raised field agriculture, researchers disagree about the social organization of raised field systems. Fundamental points of disagreement surround two key questions: Were raised fields developed before, during, or after Tiwanaku state emergence and consolidation (AD 500–1150)? Were they built and maintained by local kin-based corporate communities or elite groups and state leaders? Based on research in the northwest Titicaca basin, near Huatta, Peru, Erickson (1988, 1992, 1993, 1999) argues that state rulers never “tampered with” ancient raised field systems (Erickson, 1988, p. 348). He believes raised field agriculture developed out of the knowledge and skills of communities and kin-based social groups, or ayllus, who survived wave after wave of subjugation by Andean states. Erickson (1988, p. 315) points out that, unlike large-scale irrigation raised field agriculture “differs… in that there is no necessarily inherent need for large-scale cooperation, in the construction, use, nor maintenance of the system.” He concludes:

“states of the region developed and collapsed with regularity, but the agricultural systems organized at lower levels continued relatively unaffected and perhaps thrived. To suppose that raised field farming could only be planned, executed and maintained by the highly centralized state is to disregard the rich agricultural knowledge and organizational potential of the Andean farmer.” (Erickson, 1993, p. 413)

Others disagree. Research in the southern basin suggests that raised field systems were developed and organized by political elites who directly appropriated local labor and land (Kolata, 1986, 1991, 1993, 1996a; Kolata and Ortloff, 1989; Mathews, 1992; Ortloff and Kolata, 1989; Seddon, 1994; Stanish, 1994). Based on early research in the Koani Pampa, Kolata (1986, p. 160) first argued that raised field systems “were the proprietary agricultural estate of Tiwanaku” rulers; he hypothesized that intensive raised field agriculture here was a state strategy “devised and managed by a centralized arm of government (1986:760).” Based on further research he refined this interpretation, arguing that Tiwanaku rulers maintained a managerial role, seeking collaboration with local leaders in the construction and management of raised field systems. The resulting benefits, he believes, would have been “sufficient incentive such that local communities readily contributed their labor to enhance the collective forces of production” (Kolata, 1996a, p. 17). In this view state rulers, through the coordination of intensive productive systems, ultimately served society.

Based on research in the in the Juli-Pomata region of Peru, in the southwestern basin, Stanish (1994) reaches a similar conclusion. Stanish (1994, p. 329) hypothesizes that raised field agriculture was an “economic strategy employed by elite groups to maximize wealth extraction from subject populations.” However, he links the development of raised field agriculture with the emergence of political elites from as early as the Late Formative Period (200 BC to AD 500), during which raised fields formed one high-risk component in a diversified productive mosaic; one that preceded the state but was later intensified and expanded by Tiwanaku elites (Stanish, 2003). In interpreting the organization of these systems, he adopts a political rather than a managerial perspective. Stanish (1994, p. 329) sees the intensification of raised field farming as an “opportunistic political strategy.” Tiwanaku elites either “provided incentives or coerced” local populations into intensifying existing systems, but in either cases the extracted surplus primarily supported elites and their retainers. In this scenario, state rulers served themselves.

Disagreement about the organization of raised field production centers on a few key interpretive discrepancies. Two of the most significant include the interpretation of surface features and the timing of raised field construction and use. Surface patterns of fossil field systems have been one accessible way of interpreting their timing and organization. Erickson (1988, 1993), following a pioneering survey by Smith et al. (1968, p. 362), emphasizes the variable character of raised fields. He notes that raised field systems throughout the Titicaca basin demonstrate impressive hydraulic engineering, and that they tend to be oriented close to the cardinal directions (Erickson, 1988, pp. 335–337). However, they are segmented into discrete blocks that vary greatly in size and form, (Lennon, 1983; Smith et al., 1968), particularly in Huatta (Erickson, 1988, p. 334), suggesting that
they were built in an incremental fashion. Erickson concludes that raised fields were built and maintained by local groups, and that the boundaries between raised field blocks marked boundaries between the fields of specific groups. Formal variability among these blocks may be stylistic differences marking distinct group identities.

Kolata and colleagues, while acknowledging variability in raised field design, emphasize the regional features linking raised field segments (Kolata, 1986, 1991; Kolata and Ortloff, 1996; Ortloff and Kolata, 1989). In the Koani Pampa, they argue, centralization is reflected in integrated systems of causeways, dikes, canals and other hydrological features that extend from the piedmont zone (or cerro) across the pampa. Causeways served both as roads to provide transport and as dikes to prevent flooding when lake levels were high. According to Kolata regional administration is most salient in the artificial canalization of the Katari River (also Erickson, 1988, p. 333), which would have opened up hundreds of hectares of land to raised field production. Through such projects, leaders produced an integrated productive landscape requiring considerable planning and central co-ordination.

Disagreement about the organization of raised field production is perhaps most patently a question of when raised field systems were first developed and last used. The debate has centered both on the relationship between settlements and raised fields and on the absolute chronology of raised field construction and use. Erickson (1988, pp. 377–380) proposes two phases of raised-field construction and use in the northwestern basin: Phase I, dating to the Early and Middle Formative periods (1500–200 BC); and Phase II, dating to the post-Tiwanaku period (Erickson, 1987, 1988, pp. 377–380). According to this chronological scheme, raised fields fell into disuse during the intervening Tiwanaku Period.

Erickson bases his conclusions, in part, on regional settlement patterns. Distinguishing piedmont and pampa zones, he found no clear settlement hierarchy during the Tiwanaku period (Erickson, 1988, p. 347). Further, no sites with diagnostic Tiwanaku-style ceramics were located in the pampa, near fossil raised field systems (Erickson, 1988, pp. 377–378). All sites with Tiwanaku ceramics were located in the adjacent piedmont, including most of the “larger Huatta sites” (Erickson, 1988, p. 376). Sites in the pampa, those Erickson interpret as being directly associated with raised field production, dated to the Middle to Late Formative (800 BC to AD 300) and post-Tiwanaku periods.

To establish his chronology, Erickson (1987, 1988) also obtained seven thermoluminescence (TL) dates from ceramics recovered in three raised field contexts. Erickson (1988:194) himself notes that TL dates often are unreliable (also Graffam, 1990, p. 98), and the sigma values- or degrees of error- of the Huatta samples were extraordinarily high (Table 1). Of Erickson’s seven samples only two provided dates with a one-sigma (68% confidence) value of less than 500 years (DUR TL 26-3AS and 35-7AS), and both came from post-abandonment sediments post-dating the Tiwanaku Period. Two of the other three dates yielded centroid dates that Erickson considered earlier than expected, and one is close to the Tiwanaku period (DUR TL 25-6AS and 35-1AS).

In the Koani Pampa itself the timing of raised field farming is under debate. Kolata (1986, p. 76, 1991) argued that raised field systems in the Koani Pampa were first developed and last implemented under the stimulus of the Tiwanaku state, based on his documentation of a four-tiered “hierarchical settlement network” of Tiwanaku sites “marked by unambiguous distinctions in size, status and function.” In his view the extensive centers of Lukurmata and Pajchiri in the piedmont zones on either side of the valley served as secondary regional centers that coordinated production for the whole valley. In the pampa itself Kolata located several small Tiwanaku mound sites and one relatively large site, CK 65. Because of its size, Kolata (1986, p. 755) interpreted this as a built monument “of paramount ritual and administrative importance, subordinate only to the two regional centers.” Located on or amidst fossil raised fields, Kolata (1986, 1991) considered these sites to be associated with their construction and use. The chronology supporting this interpretation was based largely on ceramic assemblages collected at sites considered to be associated

<table>
<thead>
<tr>
<th>Site</th>
<th>Provenience</th>
<th>Lab No.</th>
<th>Era</th>
<th>Date</th>
<th>Context</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pancha</td>
<td>T-8</td>
<td>DUR TL 35-5AS</td>
<td>BC</td>
<td>1310 ± 660</td>
<td>Phase I</td>
</tr>
<tr>
<td>Pancha</td>
<td>T-14</td>
<td>DUR TL 26 1AS</td>
<td>BC</td>
<td>400 ± 500</td>
<td>Phase I Construction/use</td>
</tr>
<tr>
<td>Pancha</td>
<td>T-12</td>
<td>DUR TL 35-8AS</td>
<td>AD</td>
<td>440 ± 310</td>
<td>Phase I Post-Abandonment</td>
</tr>
<tr>
<td>Pancha</td>
<td>T-10</td>
<td>DUR TL 26-3AS</td>
<td>AD</td>
<td>1325 ± 120</td>
<td>Phase II Post-Abandonment</td>
</tr>
<tr>
<td>Pancha</td>
<td>T-11</td>
<td>DUR TL 35-7AS</td>
<td>AD</td>
<td>1540 ± 90</td>
<td>Phase II Post-Abandonment</td>
</tr>
<tr>
<td>Pancha</td>
<td>T-9</td>
<td>DUR TL 35-6AS</td>
<td>AD</td>
<td>80 ± 380</td>
<td>Phase II Post-Abandonment</td>
</tr>
<tr>
<td>Juchata</td>
<td>T-3</td>
<td>DUR TL 35-1AS</td>
<td>AD</td>
<td>380 ± 320</td>
<td>Phase II</td>
</tr>
</tbody>
</table>
with raised field construction and use. However, most of the ceramics recovered were non-diagnostic, and at the time research was conducted little was known of undecorated ceramics from Formative, Tiwanaku, and post-Tiwanaku cultural phases.

Graffam’s (1990, 1992) dissertation research in the Koani Pampa reached a different conclusion. He conducted sampled survey transects and excavated test trenches in a small segment (13 km²) of the Koani Pampa, near the modern town of Chucara. Of the seven

Fig. 4. The location of four post-Tiwanaku mounds in relation to raised field systems of the Koani Pampa (sites were excavated by Graffam, 1990, figs. 30–36).
mound sites that he excavated, six of them (or 86%) dated to the post-Tiwanaku Early Pacajes Period (AD 1150-1450), and all of these he considered to be “stratigraphically tied” to visible fossil fields (1990, p. 187, 245). Graffam (1990, pp. 207–219; 1992) speculated that most of (68%) of the raised fields in the Katari Valley were built and managed by kin-based ayllus after Tiwanaku state collapse, as a local adaptation to changing sociopolitical conditions and the onset of a long-term drought.

A review of Graffam’s excavation data and maps indicates that he considered occupations on top of fossil raised field beds to be “stratigraphically tied” to the field systems (Fig. 4). These are relatively high areas in an otherwise undulating and often marshy landscape. Does location on top of field beds necessarily indicate contemporaneity, when concluding that post-Tiwanaku sites inhabited once-cultivated field beds just as simply explains the evidence? If Graffam’s proposed association between raised fields and post-Tiwanaku occupations is true, why was valuable cultivation area dedicated to human occupation, especially in drought conditions? And why would people inhabit a pampa characterized by the marshy conditions required to sustain raised fields?

These questions engage the larger issue of determining the chronological relationship between archaeological sites and fossil fields. First, previous interpretations of such relations in the Lake Titicaca basin have been based on the assumption that visible surface fields represent eroded remnants of past systems. As discussed below, our comprehensive research into the stratigraphy and depositional characteristics of raised fields reached a very different conclusion. Further, settlement on or near fields and their hydraulic sustaining features in Katari, Huatta, and Juli-Pomata have often been interpreted as an indication of contemporaneity (Erickson, 1988; Kolata, 1986; Stanish, 1994). In altiplano landscapes, however, piedmont and pampa zones are always juxtaposed, and walking distance from a site in the piedmont to fields in the pampa was in most cases far less than an hour. Today, as in the past, families ideally maintain numerous fields in a mosaic of distinct environments, some several hours from their primary residences. Clearly, assuming that proximity or superposition denotes direct association is problematic.

Disagreement about the organization of raised field production also engages theoretical issues regarding prehispanic sociopolitical organization in the Andes. In arguing that either state or community was the dynamic force in past Andean productive management, the debate has centered on an overly dichotomized view of Andean sociopolitical organization. Archaeologists have artificially divided and essentialized both state and community. In particular, most consider the ayllu a fundamental corporate group, a kin-based unit of social organization thriving outside of state organizations and interests (Erickson, 1993, p. 400; Graffam, 1990; Kolata, 1991, p. 113). Whether they are considered to have played a dynamic role in managing raised field systems, in most interpretations ayllus are considered to have had a peripheral role in a centralized polity such as Tiwanaku. Such a perspective exaggerates the most specific meaning of ayllu, as a group of kin who shared certain common lands and resources, local sacred places, and a focal ancestor.

The historically-documented ayllu, as a basic principle of social order and general term for “community,” could refer at once to multiple scales of social organization (Abercrombie, 1998; Platt, 1987; Rasnake, 1988). The term invoked regional ethnic-like groups that gathered during external conflicts and major ceremonies, and at the time of Spanish contact centralized polities, federations, and states (Abercrombie, 1998; Platt, 1987). At such scales, political relations were described as intimate relations within the family, and leaders were metaphorical “elder-brothers” or “fathers” (Abercrombie, 1986, p. 86; Platt, 1987). Ayllu could invoke any of multiple scales of affiliation, and at the broadest scales it was a form of political ideology, distilling hierarchical sociopolitical relations crossing vast landscapes. Joining kinship and broader political relations, ayllus were not simply homogeneous kin groups that survived in some primordial form as hegemonic systems rose and fell. Rather, emergent polities were inextricably comprised of such communities. Hierarchical sociopolitical relations were conceived of and subsumed in the social relations that characterized more intimate groupings.

In the following sections we discuss recent evidence bearing on the absolute chronology of raised fields, the relations of fields and past settlements, and whether the fields of the Katari Valley were built and managed by local communities or state leaders. In discussing the role of central authorities in raised field production, we also address the issue of whether state strategies were fundamentally managerial or political, or as we put it, incorporative or transformative. As we employ these terms, they define a continuum of strategies of productive organization and resource appropriation rather than a typology of broad political strategies (see D’Altroy, 1992 and Hassig, 1985 for analogous concepts). Incorporative strategies refer to relatively noninvasive or indirect strategies of productive intensification that leave direct management and distribution of resources in the hands of local communities. Transformative strategies involve direct control over local resources and productive systems and thus intervene in or transform local communities and sociopolitical networks. Incorporative strategies of productive organization tend to leave preexisting local productive systems and rural settlement networks relatively intact, while transformative strategies tend to impinge on or significantly transform prior
productive systems, fostering major shifts in local site roles, settlement networks, and social organizations. We raise the likelihood that intensive farming was managed within a mosaic of resource strategies that shifted over time in accord with changing relations between local communities and regional sociopolitical conditions.

Research in the Katari Valley

Our research program entailed three main components: full-coverage survey of the entire southern part of the Katari Valley, extensive excavations at selected habitation sites, and trench operations in a large sample of fossil raised fields. Survey covered 102 km² and identified 212 sites, 12 of which we excavated (Figs. 1 and 3B). These included the large site of Lukurmata (Bermann, 1994, 1997; Janusek, 1999, 2004a; Kolata, 1989; Wise, 1993), the mid-range piedmont site of Qeyakuntu (CK152), and several smaller mound sites in the pampa. Two of the latter, CK 65 and CK 70, formed part of a larger cluster, the Quiripu mound group, that had been the subject of Kolata’s earlier test excavations (Kolata, 1986).

Trench operations were designed to determine the nature and chronology of raised field construction, maintenance, and abandonment (Seddon, 1994). Considering that field use was influenced by fluctuating lake levels, we implemented a random sample stratified by contour intervals to optimize the spatial distribution of the sample. In total we excavated 193 trenches in the pampa, and encountered clear raised fields in 88 (46%) of them (Fig. 3). To address chronology we retrieved datable samples of mollusk shell and organic carbon from fields.

Table 2

Radiocarbon assays obtained from excavated raised field contexts in the Katari Valley, Bolivia

<table>
<thead>
<tr>
<th>Context</th>
<th>Lab. Nos.</th>
<th>Material</th>
<th>Proveniencea</th>
<th>14CAge (BP)</th>
<th>Calibrated years (AD)</th>
<th>Calibrated 1-sigma age range (AD)b</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction/use</td>
<td>OS-2441</td>
<td>Mollusc</td>
<td>86-4-2</td>
<td>1040 ± 35</td>
<td>1010</td>
<td>990–1020</td>
</tr>
<tr>
<td></td>
<td>OS-2540</td>
<td>Mollusc</td>
<td>86-2-1</td>
<td>820 ± 30</td>
<td>1230</td>
<td>1220–1280</td>
</tr>
<tr>
<td></td>
<td>OS-2538</td>
<td>Mollusc</td>
<td>109-2-3</td>
<td>1070 ± 30</td>
<td>990</td>
<td>970–1010</td>
</tr>
<tr>
<td></td>
<td>OS-2539</td>
<td>Mollusc</td>
<td>88-3-3</td>
<td>1070 ± 30</td>
<td>990</td>
<td>970–1010</td>
</tr>
<tr>
<td></td>
<td>OS-2654</td>
<td>Mollusc</td>
<td>111-2-3</td>
<td>1030 ± 35</td>
<td>1010</td>
<td>990–1020</td>
</tr>
<tr>
<td></td>
<td>OS-2564</td>
<td>Carbon</td>
<td>111-2-3</td>
<td>1360 ± 40</td>
<td>670</td>
<td>650–680</td>
</tr>
<tr>
<td></td>
<td>OS-2651</td>
<td>Mollusc</td>
<td>111-2-4</td>
<td>930 ± 30</td>
<td>1050d</td>
<td>1040–1170</td>
</tr>
<tr>
<td></td>
<td>OS-2649</td>
<td>Mollusc</td>
<td>112-3-2</td>
<td>1290 ± 50</td>
<td>710e</td>
<td>670–780</td>
</tr>
<tr>
<td></td>
<td>OS-2557</td>
<td>Carbon</td>
<td>113-3-2</td>
<td>950 ± 30</td>
<td>1040d</td>
<td>1030–1160</td>
</tr>
<tr>
<td></td>
<td>OS-2565</td>
<td>Carbon</td>
<td>113-3-3</td>
<td>690 ± 30</td>
<td>1300</td>
<td>1290–1300</td>
</tr>
<tr>
<td></td>
<td>OS-2544</td>
<td>Mollusc</td>
<td>134-4-2</td>
<td>980 ± 30</td>
<td>1030</td>
<td>1020–1150</td>
</tr>
<tr>
<td></td>
<td>OS-2562</td>
<td>Mollusc</td>
<td>114-5-3</td>
<td>990 ± 30</td>
<td>1030</td>
<td>1020–1040</td>
</tr>
<tr>
<td></td>
<td>OS-2559</td>
<td>Carbon</td>
<td>35-1-7</td>
<td>1220 ± 40</td>
<td>790</td>
<td>780–880</td>
</tr>
<tr>
<td></td>
<td>OS-2653</td>
<td>Mollusc</td>
<td>89-3-4</td>
<td>1440 ± 45</td>
<td>640</td>
<td>600–660</td>
</tr>
<tr>
<td>Post-abandonment</td>
<td>OS-2542</td>
<td>Mollusc</td>
<td>83-2-1</td>
<td>775 ± 60</td>
<td>1280</td>
<td>1220–1290</td>
</tr>
<tr>
<td></td>
<td>OS-2563</td>
<td>Carbon</td>
<td>62-1-3</td>
<td>840 ± 45</td>
<td>1220</td>
<td>1170–1260</td>
</tr>
<tr>
<td></td>
<td>OS-2650</td>
<td>Mollusc</td>
<td>110-3-1</td>
<td>875 ± 35</td>
<td>1190</td>
<td>1160–1120</td>
</tr>
<tr>
<td></td>
<td>OS-2561</td>
<td>Carbon</td>
<td>110-3-2</td>
<td>955 ± 30</td>
<td>1040</td>
<td>1030–1160</td>
</tr>
<tr>
<td></td>
<td>OS-2566</td>
<td>Carbon</td>
<td>147-5-1</td>
<td>910 ± 30</td>
<td>1160</td>
<td>1050–1180</td>
</tr>
<tr>
<td></td>
<td>OS-2566</td>
<td>Carbon</td>
<td>114-5-1</td>
<td>840 ± 35</td>
<td>1220</td>
<td>1180–1250</td>
</tr>
<tr>
<td></td>
<td>OS-2558</td>
<td>Carbon</td>
<td>CC33-1</td>
<td>860 ± 40</td>
<td>1210</td>
<td>1170–1230</td>
</tr>
<tr>
<td>Problematicc</td>
<td>OS-2537</td>
<td>Mollusc</td>
<td>63-3-1</td>
<td>1410 ± 30</td>
<td>650</td>
<td>630–660</td>
</tr>
<tr>
<td></td>
<td>OS-2560</td>
<td>Carbon</td>
<td>63-3-1</td>
<td>615 ± 30</td>
<td>1320 ± 890</td>
<td>1310–1400</td>
</tr>
<tr>
<td></td>
<td>OS-2543</td>
<td>Mollusc</td>
<td>85-3-5</td>
<td>1140 ± 30</td>
<td>890–970</td>
<td>890–970</td>
</tr>
<tr>
<td></td>
<td>OS-2562</td>
<td>Carbon</td>
<td>85-3-5</td>
<td>425 ± 45</td>
<td>1450</td>
<td>1440–1480</td>
</tr>
</tbody>
</table>

a Additional calibrated dates generated by Oxcal 3 Program: 1340, 1390.

a For each provenience, the three hyphenated numbers represent trench quadrant, trench number, and stratum (see Seddon, 1994).

b All samples were processed at the National Ocean Sciences AMS facility (NOSAMS), at Woods Hole Oceanographic Institute, Woods Hole, MA. Calibrated dates were calculated using the Stuiver and Pearson (1993) calibration curve with CALIB 3.0 by the University of Washington.

c The four problematic assays represent two pairs of samples from identical stratigraphic contexts that returned highly divergent dates.

d Additional calibrated dates generated by Oxcal 3 Program: 1090, 1120, 1140, and 1160.

e Additional calibrated dates generated by Oxcal 3 Program: 750, and 760.

f Additional calibrated dates generated by Oxcal 3 Program: 1150.
and habitation sites, ultimately selecting 25 samples from raised field contexts for radiocarbon assays (Table 2). We also analyzed diagnostic cultural remains from field contexts, examined the potential superposition of raised field beds, and documented stratigraphic relationships between fields and habitation sites.

The Katari Valley was an ideal setting for raised field agriculture. The valley is low, flat, and poorly drained, and its pampa is extensive and prone to seasonal flooding. The slope of the Pampa Koani is so gradual that a rise in lake level of one meter will cause the lake shore to migrate ca. 5 km inland, covering dozens of square kilometers of potentially arable land (Binford and Kolata, 1996, p. 38). Visible fossil fields stretch nearly continuously across this pampa, from the current lake edge to the foot of Cerro Katavi. All documented raised field types – checkerboard, linear, curvilinear, and embanked – are represented, but linear and curvilinear field segments are most common (see Erickson, 1988 and Lennon, 1983 for typologies of raised field morphology).

An important prerequisite was a refined chronology for the southern Lake Titicaca Basin, which has been established over the past decade (Albarracín-Jordan and Mathews, 1990; Alconini, 1995; Burkholder, 1997; Janusek, 2003a; Steadman, 1995, 1999; Whitehead, 1999). Rigorous ceramic analyses, stratigraphic excavations, and a large suite of calibrated radiocarbon assays allow us to divide local prehispanic history into Early-Middle Formative, Late Formative, Tiwanaku, and Post-Tiwanaku (Pacajes) periods, each with significant sub-phases (Janusek, 2003a). Early-Middle Formative dates to 1500–200 BC, Late Formative dates to 200 BC to AD 500, Tiwanaku dates to AD 500–1150, and Post-Tiwanaku dates to AD 1150–1570. Both Late Formative and Tiwanaku encompass two important phases, Late Formative 1 and 2 and Tiwanaku IV and V. Notable is the late date of the Tiwanaku to Pacajes transition, corresponding to the collapse of the Tiwanaku state. The timing of this cultural transition, which is supported by numerous assays from undisturbed contexts at various sites (Table 3), bears significantly on the conclusions of this research.

In the following pages we discuss archaeological evidence for settlement and raised field production in the Katari Valley. First, we present settlement patterns for each period, discussing implications for predominant forms of sociopolitical organization, followed by results of research in raised field contexts.

### Settlement patterns over the long term

#### Early-middle formative periods

The earliest sites in Katari dated to the Early-Middle Formative periods (1500–200 BC) and were associated with the Chiripa cultural complex, centered on the Taraco peninsula just east of the Katari Valley (Bandy, 2001; Browman, 1978, 1980; Chávez, 1988; Hastorf, 1999a; Kolata, 1983; Ponce, 1970). We located seven Early-Middle Formative sites, three of which were over 3 ha (Fig. 5A). All occupied the upper or lower piedmont zones, and the largest was Qeyakuntu (6 ha). Excavations at Qeyakuntu yielded evidence for the production of agricultural hoes and the consumption of camelids, smaller mammals, and lake birds. Agricultural

---

**Table 3**

<table>
<thead>
<tr>
<th>Period</th>
<th>Region and site</th>
<th>Lab. No.</th>
<th>14C (years)</th>
<th>Calib. years AD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tiwanaku</td>
<td><strong>Tiwanaku Valley</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tiwanaku</td>
<td>SMU 2330</td>
<td>1080 ± 210</td>
<td>950 ± 110</td>
</tr>
<tr>
<td></td>
<td>Tiwanaku</td>
<td>SMU 2473</td>
<td>850 ± 243</td>
<td>1160 ± 210</td>
</tr>
<tr>
<td></td>
<td>Tiwanaku</td>
<td>SMU 2331</td>
<td>872 ± 197</td>
<td>1142 ± 174</td>
</tr>
<tr>
<td></td>
<td>Tiwanaku</td>
<td>SMU 2470</td>
<td>632 ± 183</td>
<td>1330 ± 140</td>
</tr>
<tr>
<td></td>
<td>LV-109</td>
<td>SMU 2564</td>
<td>Unpublished</td>
<td>1131 ± 171</td>
</tr>
<tr>
<td>Katari Valley</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lukurmata</td>
<td>ETH 3180</td>
<td>990 ± 95</td>
<td>1045 ± 100</td>
</tr>
<tr>
<td></td>
<td>Lukurmata</td>
<td>B 55488</td>
<td>1110 ± 90</td>
<td>1220 ± 90</td>
</tr>
<tr>
<td></td>
<td>Lukurmata</td>
<td>B 55489</td>
<td>1030 ± 70</td>
<td>1112 ± 80</td>
</tr>
<tr>
<td></td>
<td>Lukurmata</td>
<td>ETH 3178</td>
<td>1085 ± 90</td>
<td>950 ± 100</td>
</tr>
<tr>
<td></td>
<td>CK-65</td>
<td>B 91778</td>
<td>940 ± 40</td>
<td>1112 ± 60</td>
</tr>
<tr>
<td>Pacajes</td>
<td><strong>Tiwanaku Valley</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>LV-23</td>
<td>SMU 2559</td>
<td>Unpublished</td>
<td>1189 ± 128</td>
</tr>
<tr>
<td>Katari Valley</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CC-33</td>
<td>OS 2558</td>
<td>875 ± 35</td>
<td>1190 ± 30</td>
</tr>
</tbody>
</table>
hoes and their debitage comprised 20–23% of lithic artifacts at Qeyakuntu (Janusek, 2001; Janusek and Kolata, 2003). Small sites (<3 ha) clustered near larger sites, but settlement patterns yielded no clear settlement hierarchy. Even Chiripa itself, a local ceremonial center (Hastorf, 1999b), was, at 7.5 ha, just a little more extensive than Qeyakuntu and other nearby sites (Bandy, 1999, p. 24). Regional patterns point to the dynamic co-existence of multiple semi-autonomous communities, and perhaps small-scale polities, each of which thrived on broader political alliances, religious affiliations, and economic networks.

Fig. 5. Maps of Early-Middle (A) and Late Formative settlement (B) in the Katari Valley.
Late formative period

During the Late Formative settlement patterns in the valley changed in several significant ways. The period (200 BC to AD 500) encompassed two phases, and during the second, Late Formative 2 (AD 300–500), Tiwanaku emerged as a major religious and political center (Janusek, 2004a; Ponce, 1981). In Late Formative 1, the number of sites increased by at least four times that in the Middle Formative period, and settlement expanded considerably in the pampa zone (Fig. 5B). In addition, settlement sizes diverged considerably. Lukurmata, located near the lake shore and at the edge of the Koani Pampa, became a major settlement of ca. 20 ha (Bermann, 1994). At this time, Lukurmata was the center of an emerging polity, one among many that were developing in the southern basin (Bandy, 2001; Janusek, 2004a).

Many sites, including those in the Quiripujo mound group, clustered near the elbow of the Katari River, over alluvial sands deposited in old river courses. Excavations at two of the Quiripujo sites, CK-65 and CK-70, had substantial occupations spanning the Late Formative. Residential occupations and middens yielded substantial quantities of stone hoes and debitage; they comprised 39–60% of lithic artifacts (Janusek, 2001; Janusek and Kolata, 2003). Furthermore at CK-65 two adult burials (one female and one male) included lithic hoes as mortuary offerings. Hoes were less common at Qeyakuntu and altogether infrequent at Lukurmata, suggesting that farming, or at least certain farming technologies, were more important at sites in the pampa than they were in some of the larger piedmont settlements.

Tiwanaku period

The number and average size of settlements increased significantly during the Tiwanaku Period (Fig. 6A). The piedmont zone remained the preferred area of settlement (Table 4). Some 73% of sites, or 96% of total settlement area, occupied the piedmont zone. Significantly, settlements ranged in size far more than they had in previous periods, and collectively formed multi-tiered site-size hierarchies. Lukurmata, already an extensive settlement in the Late Formative (Bermann, 1994, 1997), became in Tiwanaku IV an urban center with a prominent monumental complex, the ritual focus of a metropolitan community approaching 2 km². Settled along the low edge of the piedmont were several smaller sites of 3.5–15 ha, linked to one another by an ancient thoroughfare. Lakaya was strategically-located at the mouth of the Lillimani drainage system that originated near Tiwanaku. Line with Tiwanaku period sites, the Lillimani Valley may have been a direct transportation route between the valleys, with Lakaya serving as the local entrepôt for inter-valley traffic. Smaller sites (<3.5 ha) were distributed across the valley, less than a third of them (30%) located in the pampa.

Surface survey and excavation in Tiwanaku Period sites of various sizes revealed a range of significant regional patterns, including major changes between the Tiwanaku IV and V phases. From Late Formative 2 to Tiwanaku IV human settlement in the Katai Valley changed in several significant ways. First, frequencies of lithic hoes and hoe debitage at pampa sites, those presumably most heavily invested in farming, decreased precipitously. Second, ceramic assemblages at all sites included significant quantities of Tiwanaku style serving and ceremonial vessels. Unlike the distribution of elaborate vessels during the Late Formative, which was highly selective, elaborate serving and ceremonial wares were now ubiquitous (Janusek and Kolata, 2003). Tiwanaku serving wares were also far more specialized in form and function, forming an intricate technology geared to periodic rituals of consumption (Janusek, 2003a). The widespread appearance of such wares in local assemblages marks the establishment of Tiwanaku cultural hegemony, which may have been characterized by the distribution of elaborate wares with food and drink in return for services on the part of local groups. The ubiquity of Tiwanaku style vessels may represent, in part, the widespread distribution of state productive obligations among communities and groups in the region.

Significantly, though, a range of complementary patterns appear to represent the maintenance of regional identity in the Katari Valley (Janusek, 1999, 2002, 2004a). Tiwanaku ceramic wares predominated in residential and ritual contexts of all excavated piedmont and pampa sites, but each site also yielded a range of serving and ceremonial wares in a distinct local style. These local wares, found in high densities at sites such as Lukurmata (18–80% of ceramic assemblages) and Qeyakuntu (25% of assemblages), are either uncommon or absent at excavated sites in the adjacent Tiwanaku Valley (Bermann, 1994; Burkholder, 1997; Janusek, 1999, 2002; Janusek and Kolata, 2003, 153). Local patterns characterized other vehicles of stylistic expression and group identity. These included a predominant style of human cranial modification among individuals buried at Katari sites, an annular or “tapered” style far less common at Tiwanaku (Blom, 1999), as well as distinct mortuary patterns (Janusek, 2004a). This conjunction of patterns indicates an enduring regional identity that pre-dated, but remained vibrant during, Tiwanaku hegemony.

In Tiwanaku V (AD 800–1150) occupations at many sites changed significantly. Many residential sectors at Lukurmata and Qeyakuntu, two major centers in the region in Tiwanaku IV, were either abandoned or converted into middens and mortuary areas (Bermann, 1994; Janusek and Kolata, 2003). Population densities
at these sites, and thus the importance of the centers, apparently declined. Corresponding to these shifts were significant changes in Tiwanaku style ceramic wares. Assemblages now included much higher proportions of redundant and expediently-produced serving wares, implying a greater emphasis on mass production. Along with increasing relative proportions of large fermentation and storage jars, or tinajas, these patterns may indicate an increasing frequency and significance of communal consumption and large-scale feasting.

Changes at some small pampa sites were equally significant. Excavations at these sites demonstrated that Tiwanaku occupation, while most intensive in Tiwanaku V, was relatively ephemeral. In one characteristic mid-

Fig. 6. Maps of Tiwanaku (A) and Early Pacajes (B) settlement in the Katari Valley.
den, stratified Tiwanaku refuse accounted for only 10 cm (7%) of the entire sequence, whereas Late Formative accounted for 1 m (69%, Janusek and Kolata, 2003). More significant, occupations at these sites no longer consisted of substantial buildings but rather of movable, temporary structures. Clusters of small, angled post-holes near hearths and refuse pits indicate that residence consisted of portable tent-like structures, similar to those of contemporary field guardians, or kamani. Today, kamani is an annual position that rotates among families in a community. A person so charged guards community crops against theft, predation, and, through various ritual practices, hail and frost (see Kolata, 1991; Winterhalder and Thomas, 1978). During their tenure kamani live in tent-like structures of wooden poles covered with tarpaulin or reeds. The Quiripujo mound group, located in the Koani Pampa, appears to have served similar roles during the Tiwanaku Period.

By AD 1200, Tiwanaku ritual and domestic practices, material styles, and settlement patterns no longer characterized the Katari Valley. Proposed dates for Tiwanaku state collapse have ranged from AD 1000 to 1200 (Kolata, 1993; Ponce, 1981). To be sure, significant changes occurred in the several generations between AD 1000 and 1150, or Late Tiwanaku V. Research at Tiwanaku indicates that an elite residence was razed to the ground in the late tenth century (Couture and Sampeck, 2003), and not long after large-scale construction in monumental structures apparently ceased (Alconini, 1995; Vranich, 1999). Nevertheless, residential sectors in Tiwanaku and many sites in the Katari Valley, including Lukurmata and CK-65, continued to be occupied into the early 12th century as indicated by numerous radiocarbon assays (Table 3; Janusek, 2004b). Inhabitants of these sites continued to use Tiwanaku-style goods and engage in characteristic Tiwanaku residential and ritual practices. Tiwanaku collapse was a protracted and, most likely, chaotic process of state disintegration.

### Table 4
Comparison of Tiwanaku and Pacajes Period sites for three ecological zones, according to number of identified sites and total settlement area

<table>
<thead>
<tr>
<th>Ecological zone</th>
<th>Tiwanaku Period</th>
<th>Pacajes Period</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>%</td>
</tr>
<tr>
<td>Lower Piedmont</td>
<td>33</td>
<td>69</td>
</tr>
<tr>
<td>Upper Piedmont</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Pampa</td>
<td>13</td>
<td>27</td>
</tr>
</tbody>
</table>

**Pacajes period**

Settlement patterns changed significantly again following Tiwanaku state collapse. During the Early Pacajes Period (AD 1150–1450) the number of sites in the survey area increased to 145, and they included 108 sites in new (non-Tiwanaku) locations (Fig. 6B). However, average site size decreased dramatically, from a mean of 4.77 to 1.12 ha. Thus, while the number of sites increased by a factor of three, average settlement size decreased by more than four times that of Tiwanaku Period sites. Bandy (2001) argues that population density decreased precipitously in the old Tiwanaku core during this phase. Settlement hierarchy fragmented and populations in the region dispersed as people left the nucleated centers once focused on Tiwanaku political activity, monumental constructions, rituals practices, and ceremonial feasting.

Accompanying settlement dispersal and overall population decrease were several other significant changes. First, unlike any previous cultural phase, people now settled the pampa on a major scale (Table 4). Seventy-five sites (52% of the total number, or 42% of total occupied area) now occupied the pampa. Sites clustered along packed earth roads that crisscrossed the pampa. Many sites (n = 17) surrounded Katavi, a massive limestone outcrop that may have been exploited for ceramic temper, among other uses. Sites in the pampa formed larger community clusters, and sites in the piedmont tended to cluster around large sites such as Tumuyu and Qeyakuntu. These clusters represent the formation of the micro-ayllus that continued to thrive into the Spanish Colonial Period.

Excavations at two piedmont sites and ten pampa sites demonstrated that many Early Pacajes occupations were ephemeral. Middens were thin, and evidence for primary occupation at most sites consisted of isolated hearths and refuse pits rather than clear structures and associated activity areas. These patterns suggest that Early Pacajes groups were relatively mobile. This, in addition to the fragmentation of sociopolitical networks, would account for the high number of Early Pacajes settlements. Overall, occupation middens at Pacajes sites revealed balanced proportions of camelid, small mammal, bird, and fish remains. However, an occupation associated with high densities of fish bone was located near the marshy north edge of Lukurmata (Wise, 1993). By all accounts these were lake and fishing specialists much like, and perhaps historically antecedent to the documented Uru communities that later inhabited the shore of Lake Titicaca. Productive specialization
among ayllus became important in post-Tiwanaku political economies.

Research in raised field systems

Study of raised fields and their sustaining features clarifies the relation between shifting settlement patterns and agricultural production in the Katari Valley. As noted above, most archaeologists consider occupation on or near visible raised field systems to indicate direct association between them. As Erickson (1988, pp. 331–332) points out, such associations are not reliable. In fact, substantial occupation on top of field beds may indicate that field systems had fallen into disuse. Of all pampa sites \((n = 111)\), more than half were located on or near raised field beds. Although Late Formative and Tiwanaku sites were located near raised fields, only Early Pacajes sites were consistently located directly on top of them. Of 74 total Early Pacajes sites in the pampa, some 40% were located directly on top of raised field beds, as demonstrated by excavations at CK-33 (Fig. 7; Seddon, 1994, pp. 137–139).

More general relationships between settlements and raised fields were identified in a series of raised causeways that led from the piedmont into the pampa (Kolata, 1986, 1991). Each site in the piedmont that had been a major settlement in the Late Formative and Tiwanaku Periods was also associated with at least one such causeway, and some sites with several. The longest led from Lakaya to the Katari River, but it was only one of several that linked Lakaya to raised field segments in the pampa (Kolata, 1986, Fig. 4). Similarly, several causeways linked Qeyakuntu to agricultural features in the pampa. One descended obliquely from the edge of an intermittent stream (Fig. 8), indicating that in addition to transport, it served to conduct running water into the pampa during the rainy season. Such a construction would have fed fields while slowing processes of erosion and sedimentation.

Trench excavations in visible raised fields were designed to determine the method and chronology of raised field construction, maintenance, and abandonment (Seddon, 1994). Of our 193 excavation units, 75 (40%) were in areas with visible surface fields, 10 (5%) were in visible habitation zones, and 105 (54%) were in areas with neither visible fields nor sites. The excavations consistently produced one significant result. Raised fields in the Katari Valley and undoubtedly in other pampas of the Lake Titicaca Basin have been buried since their abandonment by wind and water-borne sediment. Most archaeologists have assumed that the principal post-depositional process affecting raised fields, accounting for their low relief, has been erosion (e.g., Erickson, 1988, p. 59–204; Kolata, 1986; Stanish, 1994). Rather, our research indicates that the process has been substantial sediment aggradation (Janusek and Kolata, 2003; Seddon, 1994). Rather than having eroded, most agricultural features in the Katari basin were gradually buried after abandonment. This process is identical to the gradual burial of Post-Classic chinampa systems in the Basin of Mexico, as reported by Parsons et al. (1982, 1985). This observation seriously affects the way Koani Pampa and similar anthropogenic landscapes are interpreted, particularly with respect to the timing of construction, use, and abandonment cycles.

Field construction techniques were relatively expedient across the pampa. Most fields (89%) were built as single construction events, and only one demonstrated an additional sub-field layer of cobbles similar to the elaborate fields reported from Lukurmata (Fig. 9A; Kolata and Graffam, 1989). Only six fields (7%) demonstrated multiple periods of construction, and four of these were simple enlargements (Fig. 9B). Most multiple-period fields were located near the lake or in areas of high groundwater, raising the possibility that the earliest fields were built near readily accessible water

![Fig. 7. Profile of excavation unit in CK 33, showing post-Tiwanaku occupation on top of an older raised field bed.](image-url)
sources. In one case (Trench 109-2) a piece of charcoal between two sets of superimposed fields yielded a date of AD 990 (No. OS-2538, BP 1070 ± 30).

To date fields we recovered diagnostic artifacts (e.g., ceramic sherds) as well as datable mollusk shell (*Taphius montanus*) and organic samples from raised field contexts. Nearly all recovered artifacts were from habitation middens and features in post-abandonment overburden on raised field beds and swales (Seddon, 1994), and by far most of the diagnostic sherds we recovered from these contexts represented the Pacajes and Colonial periods (Seddon, 1994, p. 106). We recovered only one post-Tiwanaku sherd from a field use context. The abundance of post-Tiwanaku sherds over raised field use-contexts indicates that most fields had been abandoned by that time.

Further, radiocarbon assays were conducted on 25 samples of carbon and shell recovered from 17 different raised field complexes (Table 2) (Binford et al., 1997, Table 2; Kolata and Ortloff, 1996, Table 8.1). We followed an explicit sampling protocol: we collected samples from a broad geographic range in the study area; from a wide range of context types (e.g., pre-construction, construction, abandonment); and in several cases from the same contexts to cross-check assays. Samples dating “construction contexts” were from field bed fill, those dating “use contexts” were from canal cleanings, and those dating “post-abandonment contexts” were from sediment overburden or occupation features stratigraphically superimposed on fields.

When grouped by context, these dates demonstrate significant patterns. First, two pairs of samples, each pair from a single trench context, were problematic because they provided incompatibly divergent dates. Of the 11 fields that yielded construction/use dates, ten (91%) of them securely date before AD 1150 within one sigma range. Of these, six dated to the Tiwanaku V phase (post-AD 800). Only two fields securely dated before AD 800 within the one sigma range and one demonstrated use during both Tiwanaku IV and V. The earliest date from a field use context, AD 600–660, falls in Tiwanaku IV. One field dates to Early Pacajes and another field dates to both Tiwanaku V and Early Pacajes. Considering the 14 construction/use samples alone, three centered in Tiwanaku IV, nine in Tiwanaku V, and two in Early Pacajes. All but one of the Tiwanaku V dates fall toward the end of the phase, dating to AD 970–1170. Of the seven post-abandonment dates, one falls toward the end of the Tiwanaku V phase, while the remaining six fall in Pacajes Period.

We recovered no evidence for field construction earlier than AD 600, despite the large number of samples and the extensive area represented. This suggests that raised field construction and use began on a significant scale in the Tiwanaku IV phase. Apparently, most fields were built and farmed during the Tiwanaku V phase, particularly toward the end of that phase (AD 950–1150). Assuming our sample reflects a chronology of field system construction and use, ca. 24% of fields were
built and used during Tiwanaku IV, 64% during Tiwanaku V, and 12% during Early Pacajes. The absolute chronology of raised field construction, use, and abandonment are provocative when correlated with survey and excavation results. Many Pacajes sites, and most Pacajes ceramics from raised field contexts, were located in post-abandonment contexts on top of earlier fields. These data indicate that many fields fell out of use during this period.

Discussion: shifting settlement and land use in the Katari Valley

Synthesizing the various strands of evidence we reach several conclusions. By the Middle Formative, the Katari Valley housed a sparse network of well-spaced settlements and settlement clusters affiliated with the Chiripa cultural complex. The small scale of settlement and the “convexity” of the settlement network point to low (Johnson, 1977, 1980) or heterarchical integration (Crumley, 1987, 1994), and perhaps chiefly power and religious prestige as integrative principles (Bandy, 2001; Hastorf et al., 2001; Stanish, 1999, 2003). To date, there is no clear evidence for a direct relationship between these piedmont settlements and raised fields on the pampa. High proportions of quartzite hoes at Middle Formative sites indicate that farming was a central element of local and regional economies (Bandy, 2001; Janusek and Kolata, 2003). Most likely, people were practicing agriculture both in the piedmont and pampa zones, and we cannot discard the possibility that they built and used raised field segments on a small scale. Nevertheless, combined evidence here and on the Taraco
Peninsula indicates that Middle Formative groups maintained a diversified economy of lacustrine resources, camelid herding, and extensive forms of agriculture (Moore et al., 1999).

During the Late Formative human settlement increased significantly in the southern part of the Katari Valley and emerging settlement networks demonstrated a more hierarchical arrangement focused on Lukurmata. Apparently for the first time, people moved into the pampa zone, concentrated in a substantial community of small villages (the Quiripuco Mound Group) near the Katari River. Most likely, part of the reason for this settlement shift was a change in emphasis on specific productive strategies. Whatever importance the pampa had in the past, during the Late Formative it now became a key productive zone. Inhabitants of the pampa fished, ate camelids and small mammals, and farmed. Stone hoes were extremely common, and not only were they produced at local sites but site inhabitants were buried with them. Farming was a central part of local economic and ritual practice. Most settlements, including the large settlements of Lukurmata and Qeyakuntu, were concentrated in the piedmont zone flanking the pampa, and they too yielded significant quantities of stone hoes. Combined evidence renders it likely that raised fields were first built in the pampa on a relatively small scale during this period (Janusek, 2001). Inhabitants of all settlements, however, herded camelids and maintained diverse diets that included guinea pig, fish, and lake birds. To the extent that they were cultivated, raised fields formed one part of a diversified economy that included herding, fishing, and other forms of agriculture.

The Tiwanaku Period, characterized by the emergence and consolidation of the Tiwanaku state, involved both continuity and dramatic innovation. Settlement locations changed little from those in Late Formative, and many patterns of previous domestic life endured throughout the Tiwanaku Period. Now, however, settlement patterns in the southern portion of the valley formed a clear multi-tiered scalar hierarchy focused on Lukurmata, an urban center with a major monumental complex. Several other settlements in the piedmont, located at regular distances from Lukurmata, became major towns and villages, each with their own monumental platforms. Overall, the range in settlement sizes was much greater than it had been previously or would be again, implying that the regional political system had become significantly more centralized and complex. Settlement consisted of four broad tiers, with the city of Lukurmata as a primary regional center, large towns (e.g., Lakaya) as major secondary centers, smaller towns (e.g., Qeyakuntu) as tertiary centers, and villages/hamlets as quaternary habitations or mortuary sites. Some small pampa sites, such as CK-65 and CK-70, maintained specialized roles in this settlement network.

Excavations and radiocarbon dates indicate that raised field cultivation in the valley was conducted on a major scale during the Tiwanaku Period. They suggest that raised fields were built and maintained during the Tiwanaku IV phase, perhaps as discrete segments near settlements, and then on a much greater scale during the ensuing Tiwanaku V phase. Thus, it appears that raised field production was initiated or at least greatly intensified under the stimulus of the Tiwanaku polity. In Tiwanaku IV, raised field production corresponded with a well-defined settlement hierarchy in which most large settlements lined the edges of the pampa. Yet key cultural features were not limited to Lukurmata but were distributed among a number of important sites. In addition to Lukurmata, large and small towns such as Lakaya and Qeyakuntu also had monumental platforms. Each large site also had a series of causeways linking it to a specific segment of raised field systems in the pampa. Thus, it is most likely that the task of building and maintaining these local field segments was distributed among local towns and villages. We suggest that each settlement planted, harvested, and directly controlled specific field segments drawing on the labor of that community, distributing it among constituent household units. Nevertheless, regional settlement hierarchy indicates that production was coordinated and managed through an emergent state network focused on Tiwanaku.

Overall, the organization of rural settlement networks and production systems in Tiwanaku IV was strategic and incorporative more than it was direct and transformative. The Katari Valley had a long history of pre-Tiwanaku occupation and was home to at least one autonomous polity centered at Lukurmata during the Late Formative. Stylistic expressions indicate that inhabitants of the valley maintained a distinct regional identity, most likely grounded in a periodically revitalized collective memory of this history as well as enduring social and spatial relations grounded in political and ritual practice. Facing such a scenario, Tiwanaku authority was of necessity indirect. Nevertheless, the ubiquity of Tiwanaku-style ceramics, local and otherwise, indicates that an ideology of reciprocal sociopolitical obligations grounded in rituals of consumption was central to the creation and reproduction of Tiwanaku state culture. In state-sponsored events of commensalism, these obligations were distributed among local groups, who reciprocated, in part, by working in raised fields.

Lukurmata, the most important local center by the end of the Late Formative, was a politically strategic and expedient place for a major Tiwanaku regional center. However, on the lake at the far southwest edge of the valley, it was not optimally located to oversee a regional economy focused on raised field farming across the vast pampa to the east, but rather one balancing fishing, lacustrine trade, and farming. Lakaya, at the termi-
nus of both a trans-pampa causeway and a route to Tiwanaku, most likely played a more central role in managing production in the Koani pampa. Thus, between AD 600 and 900 populations in Katari practiced a regional political economy balancing raised field farming and other endeavors, such as fishing. Raised field cultivation consisted of segments of raised fields managed by local towns and communities.

As part of an incorporative political economy, raised field cultivation was most likely integrated into the resource strategies and agrarian calendar of local Katari Valley populations. Pre-Tiwanaku economies had balanced agrarian, pastoral, and lacustrine resources, and a similar balance was maintained in the Tiwanaku period. Excavations at small sites in the Katari Valley indicate that, even when raised fields were most intensively cultivated, fishing and herding continued to thrive. In fact, because raised field cultivation would have extended the length of the productive season (Kolata, 1991, p. 108), in a given productive cycle local groups could have tended them while at other times pursuing other resource strategies. These may have included qochas, or sunken agricultural basins (Albarracín-Jordan, 1996; Kolata, 1986), visible as fossil systems east of Cerro Katavi. In light of settlement concentration in the piedmont, it is also likely that local communities continued to maintain rain-fed fields on hill tops and slopes (Bandy, 1999).

Changes in settlement patterns and productive strategies in Tiwanaku V are best understood in relation to a broad inter-regional perspective. Tiwanaku V witnessed important changes in Tiwanaku influence in many regions. Tiwanaku itself experienced substantial renewal, as manifested in an elaborate residential complex on the Akapana (Alconini, 1995; Kolata, 1993; Manzanilla, 1992), erection of the nearby Putuni and an attached elite residential complex (Couture, 2002; Couture and Sampeck, 2003), and construction of specialized feast production complexes at the edge of the urban core (Janusek, 2003b). Outside of the core, regional integration and interaction with Tiwanaku intensified on the Island of the Sun (Bauer and Stanish, 2001; Seddon, 1998), while in the Moquegua Valley, near the coast to the west, a specialized maize production center was established at Chen Chen (Blom et al., 1998; Goldstein, 1989). For reasons that remain unclear, and potentially in response to crisis or the ascendance of a new dynasty, many regions of the South-Central Andes experienced major settlement shift and power realignments as state rulers intensified control in strategic regions and contexts.

During the Tiwanaku V phase and in particular after AD 900 raised field cultivation increased dramatically in the Katari Valley. Significantly, evidence of productive intensification appears to contradict two other patterns. First, major settlements, including Lukurmata, decreased in size, intensity of occupation, and by inference, importance during the V phase. Second, lithic hoes declined in overall frequency throughout the Tiwanaku period, when raised fields were most intensively built and maintained. Overall, proportions of hoe production and use peaked during the Late Formative, declined during the Tiwanaku Period, and remained insignificant during Pacajes. What is the significance of each of these changes, and how does it relate to the initiation of intensification of raised field production in the valley?

Each pattern appears less anomalous when considered in relation to broader regional shifts in state development and political economy. Our evidence strongly suggests that after AD 900 Tiwanaku rulers concentrated their economic interests on raised field agriculture in the Katari Valley. Declining settlement density at the once-important settlements may mark local dissatisfaction with increasing state control and perhaps resistance to the appropriation of local productive systems, encouraging conflict and emigration. More likely, from our perspective, population decline at Lukurmata and Qeyakuntu may mark the strategic movement of local populations either within the region, to sites such as Lacya, or perhaps to other regions, including warm valleys such as Moquegua. Not outside of reason is the possibility that population movement was incited by conflict, as a form of proto-mitmaq resettlement similar to that instituted by Inca rulers several centuries later. In this light, evidence for extremely close genetic relationships between populations in the Katari and Moquegua Valleys, based on analysis of non-metric traits (Blom, 1999; Blom et al., 1998), are striking. Such data at least render possible a scenario in which Tiwanaku rulers moved local populations, with generations of experience as farmers but also with a vibrant regional identity and strong ties to their landscape, to new agricultural colonies, as an astute, imperialistic political strategy.

Tiwanaku authorities converted the entire Katari Valley into an extensive productive system in Tiwanaku V. Most likely, it is now that the Katari River was artificially straightened and canalized with a levee system, and that a complex series of canals and dikes were built to irrigate fields and control flooding (Kolata and Ortloff, 1989, 1996). It is in this phase that the Quiripujo Mound Group became a cluster of field guardian sites, their rotating inhabitants apparently drawn from settlements in the piedmont. Because some large sites had decreased in size, local populations remaining in the valley may not have been large enough to work raised field systems at all times. They were undoubtedly large enough to manage fields most of the year, but during planting and harvest, the agricultural “crunch time,” local leaders may have brought in temporary laborers from other regions, such as the nearby Tiwanaku Valley. It is at these times that reserves of rotating field guardians and laborers would have been most important.
In this light it is significant that serving ceramic assemblages in Katari Valley settlements were now more commonly produced for mass consumption and indicate a greater role for feasting. In Tiwanaku IV elite-sponsored rituals of consumption were a key element of the state political economy. In Tiwanaku V productive intensification in the region coupled with an increasing need for labor at specific times would have required ever more frequent and magnificent displays of ritual generosity in which to distribute social obligations. Commensalism was increasingly critical as a foundation for state power and intensive raised field production in the region (Janusek, 2004a).

A second apparent anomaly, the decreasing importance of lithic hoes during the Tiwanaku Period, makes sense in relation to overall changes in agricultural technologies. By the Tiwanaku IV phase, lithic agricultural tools were negligible, and they remained an unimportant component of lithic assemblages thereafter. These data point to a gradual but profound shift in agricultural technology. We suggest that during the Tiwanaku Period the large hyuso, or foot plow, became important as an agricultural digging tool (Fig. 10). Until recently, the foot plow, in most cases made solely of durable wood and tied with cordage, served as the primary agricultural digging tool throughout much of the Andes. In the altiplano, these wooden implements have left no trace in the archaeological record. The hyuso most likely emerged as the most efficient tool for building and cleaning raised field systems during the Tiwanaku period. Much more than extensive dry-field systems, rehabilitation projects demonstrate, raised fields demand intensive digging and in dense, clayey soils that are highly durable. One deep stratum under much of the Koani Pampa consists of a natural, concrete-like crystalline mineral that would have rendered stone hoes inefficient as digging tools (Seddon, 1994). Unlike stone hoes, wooden foot plows would not have shattered frequently while building and maintaining raised field beds. Systematic analysis of carbonized wood from rural sites promises to shed more light on this hypothesis.

Initiating the Pacajes Period were dramatic shifts in regional settlement patterns and overall population decline. New mortuary practices and serving assemblages mark a profound shift in cultural values and practices. Most Tiwanaku sites continued to be occupied, but large settlements fragmented into a greater number of much smaller settlements. The number of settlements in the region increased significantly, due to population dispersal and an increasing emphasis on human mobility (Bandy, 2001; Janusek, 2004b). Significantly, the pampa was settled on a major scale for the first time. Small sites in the pampa lined a network of thoroughfares, and in the piedmont they tended to cluster around larger towns. These clusters represent the formation of historically documented ayllus, focused on multiple centers of social and ceremonial convergence, or markas (Albarracín-Jordan, 1996; Isbell, 1997; Janusek, 2004a).

Some raised fields continued to be cultivated, most likely as local systems under the authority of local ayllu leaders, as Erickson and Graffam argue. Yet contrary to Graffam’s conclusions, field beds were now the favored

Fig. 10. Traditional farming tools in the region: A and B, liukana, and C, lupana, are mattocks; D is the hyuso, or foot plow.
locations of Early Pacajes settlement, indicating in relation to a suite of other evidence that raised field cultivation was far more restricted in scope and intensity. In the face of severe environmental and sociopolitical stress post-Tiwanaku populations invested in a highly diversified range of resource strategies in which raised fields played a more peripheral role.

Changes in regional landscape dynamics over the long term correspond remarkably well with evidence for long term environmental shifts in the Lake Titicaca basin. Although Erickson (1999) has labeled the consideration of major environmental shifts “neo-environmental determinism,” recent El Niño events make poignantly clear that environmental shifts seriously affect the lives and livelihoods of Andean people on a vast scale. Limnological evidence (Abbott et al., 1997; Binford et al., 1997) in accordance with results of cores taken from the Quelccaya ice cap by Thompson (Thompson et al., 1985; Thompson and Moseley-Thompson, 1987) document several major lake level shifts. Lake cores indicate that around 800 BC, the beginning of the Middle Formative and classic Chiripa culture, the lake rose significantly after a 300 year period of relatively low levels. Rising water tables would have potentially opened up more land to cultivation throughout the Katari Valley, in particular inland areas between Lakaya and Cerro Katavi. Conditions amenable to raised field cultivation remained in place, for the most part, through the Late Formative and Tiwanaku Periods.

However, both lake and ice cores unanimously and independently point to a major reduction in lake levels >17 m after AD 1100, the result of severe drought conditions (Abbott et al., 1997; Binford et al., 1997; Kolata and Ortloff, 1996). This drought caused the shores of Lake Titicaca to recede for kilometers, and local water tables to drop far below the surface. Decreasing lake levels effectively stranded huge tracts of raised fields and rendered their hydraulic sustaining systems inoperable, particularly in inland areas. Decreasing lake levels would have opened the pampa to occupation on a major scale, precisely what happened after AD 1150. The pampa zone shifted from a marshy landscape of intensive productive systems to a drier landscape devoted both to habitation and less intensive, more diversified strategies of production. In this scenario, climate change did not in itself cause state collapse. Rather protracted drought conditions destroyed the viability of the large-scale, integrated production managed predominantly by and for state rulers, thereby inducing sociopolitical fragmentation by aggravating pre-existing and emerging tensions in the region.

A long-term approach exposes both the top-down and bottom-up perspectives as overly simplistic interpretations of rural settlement and intensive production in the southern Lake Titicaca Basin. The broader framework in which such perspectives have been defined is seen to be rigidly dichotomized and, for the case of the Katari Valley, inapplicable. Raised field agriculture always remained firmly situated in the dynamic relations between political authorities and local communities. It is likely that this cultivation technology was developed prior to state emergence, during the Late Formative (Janusek, 2001), as one in a diversified mosaic of productive enterprises adapted the high-altitude conditions. Even so now, as under Tiwanaku, raised fields were developed and maintained not by romantically egalitarian kin-groups, but hierarchical kin-based communities that inhabited multi-tiered settlement networks. Tiwanaku manifested a broad scale of hegemony that encompassed prior settlement networks and transformed existing productive enterprises. Tiwanaku eventually transformed the Katari Valley into an integrated, state-managed “breadbasket.” Yet in such a precarious and dynamic high-altitude environment, and in the face of an increasingly top-heavy and appropriative elite class, such conditions were inherently unstable. Following state fragmentation, hierarchical ayllu communities incorporated raised field segments into productive regimes that, once again, favored a more balanced mosaic of agropastoral enterprises.

Conclusions

Rural settlement and regional landscapes are effectively studied employing a rigorous research design emphasizing historical change. A long-term perspective emphasizes the need to consider intensive agriculture in relation to shifting sociopolitical dynamics, resource strategies, and macro-environmental changes. Combined surface observation, excavation results, and radiocarbon dates demonstrate conclusively that the construction and use of raised field systems began on a large scale after AD 600 and declined precipitously after AD 1150. Evidence also suggests that forms of state management and control changed significantly over time, following the historical trajectory of state consolidation and growth. During the Tiwanaku IV phase, we conclude, Tiwanaku leaders and local communities implemented a managerial or incorporative approach to the management of raised field systems in the Koani Pampa. During the Tiwanaku V phase, Tiwanaku developed transformative strategies of resource appropriation, embarking on major projects of demographic and productive reorganization to transform the valley into a directly controlled agricultural estate. Raised field technology undoubtedly developed out of the knowledge and practices of local groups, perhaps during the Formative Period, but it was intensified on a monumental scale in response to the desires and needs of emergent elite groups. Upon state disintegration and in drier conditions, local corporate groups continued to cultivate
raised fields on a much-reduced scale, as part of a more diversified subsistence strategy.

Intensive agriculture in the Katarí Valley was neither invented by the state nor solely controlled by ruling elites. Intensive farming had a long and diverse history in the Lake Titicaca Basin, one with organizational complexities, historical turns, and perhaps regional variations that remain unclear. Nevertheless, our conclusions confirm Bender’s (1999, p. 632) suspicion that some theorists, “in creating a bottom up picture and emphasizing the voices and work of local lake-side inhabitants that usually go unheard… [sidestep] the issue of changing political and social relations and perceptions associated with periods of state formation and urbanization.” Inhabitants of local communities in the Katari basin were dynamic players in shifting political dynamics and the organization of regional landscapes such as the Katari Valley. Yet as Friedman (1994) notes, by participating in encompassing social and political fields, local societies and productive regimes were transformed. As Bloch (1966, p. 235) remarked of turbulent 18th century French rural history, “If all the nuances are to be appreciated… it needs constantly to be related to the course of… political revolution”.

Rural settlement and agrarian production are fully understood only when keyed to such sociopolitical changes. Rural practices in the Katari Valley were tenuous, and ancient farmers responded creatively to changing environmental conditions. Still, they never operated in a political or environmental vacuum. Traditional practices and local societies both shaped and were transfigured by regional processes of state formation, consolidation, and disintegration. Of necessity, rural settlement, farming strategies, and agricultural landscapes were in mutual interaction and continual flux.

Acknowledgments

We acknowledge grants provided by the National Science Foundation and the National Oceanic and Atmospheric Administration (NOAA) of the U.S. Department of Commerce (to Alan Kolata and Michael Binford). We thank the following individuals for their invaluable contribution to the research: Oswaldo Rivera, Cesar Calisaya, Felipe “Papi” Choque, Matthew Seddon, Deborah Blom, Joanne Harrison Isabel Ander- ton, Santiago Morales, and J. Joaquin Narváez; as well as Matt Bandy and Clark Erickson for helping us develop and sharpen our argument.

References


Parsons, J.R., Parsons, M., Popper, V., Taft, M., 1982. Late Prehistoric Chinampa Agriculture on Lake Chalco-Xochimilco, Mexico. Report submitted to the National Science Foundation and the Instituto Nacional de Antropología e Historia, Mexico City.


