Terminal Archaic Settlement Pattern and Land Cover Change in the Rio Ilave, Southwestern Lake Titicaca Basin, Perú

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Abstract: Researchers have argued the modern Altiplano land cover—one of bunch grasses and few indigenous tree species—is an anthropogenic artifact of land use practices initiated after the arrival of Europeans in the sixteenth century A.D. Recent paleoenvironmental studies of the Lake Titicaca Basin challenge this assertion. Archaeological survey and excavation data from the Rio Ilave drainage indicate that settlement aggregation and reduced residential mobility began in the Late Archaic Period about 3000 cal B.C. Terminal Archaic occupational intensity increased after 2000 cal B.C. and continued up until about 1300 cal B.C., which marks the beginning of the Formative in the basin. Pollen data from lake cores suggest that tree species were common throughout the basin until 2000 B.C., when they were replaced by pollens of herbaceous species. Combined with data on charcoal frequency and size, these data suggest that land use practices associated with the Terminal to Formative transition led to at least partial deforestation of the Titicaca Basin.

The Andean Cordillera extends along 5,500 km of western South America, and it is the longest mountain range in the world. The Altiplano is a high-elevation plateau that is formed by the Andean Cordillera, and the Altiplano is the largest high-elevation plateau in either the Western or Southern Hemisphere. The Altiplano has been inhabited since at least the Terminal Pleistocene.
tocene (Aldenderfer 2003, 2006). By the arrival of the Spanish in the Andes, the
Inca Empire had expanded to become the largest known in either the Western or
Southern Hemisphere.

Modern Altiplano land cover is dominated by bunch grass. Yet this is not
the land cover predicted by modern environmental conditions. As a result, some
ecologists have suggested that the disparity between observed and expected
land cover was caused by anthropogenic deforestation prior to, during, or just
following European contact.

Recent advances in paleoenvironmental investigations in the Andean high­
lands have greatly improved knowledge pertaining to climate and landscape
change from a natural sciences perspective. Likewise, ongoing archaeological
research at highland sites has advanced knowledge regarding both culture his­
tory and processes of change. Together, these natural and social science inves­
tigations indicate that the late Holocene in the Andes was a period of rapid and
dramatic change.

In this chapter we review the relevant material regarding modern ecology,
paleoclimatology, fluvial sedimentology, pollen, and charcoal records for the mid­
Holocene. These reconstructions are then related to archaeological research from
the Salar de Atacama, Junin Basin, Rio Osmore, and new results from survey and
cavation in the Rio Ilave of the Lake Titicaca Basin. Present evidence suggests
that major deforestation in the Lake Titicaca Basin occurred during the mid–late
Holocene transition. Sediment cores indicate that this was a period of increasing
precipitation. Yet, the charcoal record suggests that deforestation was probably
caused by fire. We present data from the Rio Ilave drainage that show that this
period of deforestation correlates to the first evidence of reduced residential mo­
bility, low-level food production, storage, and animal husbandry. Though more
research is clearly required to answer the question definitively, the convergence
of several lines of independent evidence indicates that anthropogenic fires were
the likely cause of deforestation during this period of dramatic natural and cul­
tural change.

Modern Ecology

Modern land cover of the central and south-central Andean Altipla­
nno is dominated by bunch grasses (Calamagrostis, Festuca, and Stipa). Polylepis
(ss.), a member of the Rosaceae family, is a genus of native Andean tree that
consists of about 20 species. Polylepis trees extend along the Andean range from
Venezuela to Chile (Kessler 1995a, 1995b, 2002; Simpson 1986). Throughout its
range, stands of Polylepis trees can be found growing above the closed timber­
line. In a modern variation of the "woodland climax hypothesis," the fact that
these native Altiplano trees are observed above the closed timberline has been
dubbed the "Polylepis problem" (Miehe and Miehe 1994). Several early ecologists
believed that this unusual distribution of tree stands above the timberline
was caused by naturally favorable microenvironments like boulder slopes and
evines. Yet, other ecologists who supported a position that would come to be
called the woodland climax hypothesis during the Terminal Pleistocene period (Smith 1979); (3) the structure of life on the Altiplano锄 agriculture (Miehe 1986); and (4) the primary mecha­
for the rapid deforestation was the harvesting of timber and livestock grazing (Miehe 1986; Driesch 1993).

Earlier ecological discussions were largely focused on agricultural activities of the Inca Empire. However, deforestation caused by anthropogenic activities in the early To­enocene (Fausto 2000) may have been prevented success­
called the woodland climax hypothesis have either empirically or logically re­jected the major strands of the microenvironment model (see Ellenberg 1979; Kessler 2002:Appendix A). The general consensus now is that the modern en­vironment of the Altiplano holds the potential for far more tree growth than is observed today.

Ninety years ago, Cook (1916) observed discrepancies between modern floristic conditions in the South American Altiplano and the potential communi­ties that converging environmental conditions should produce. Cook believed that in the Altiplano there was more potential for tree growth than there were trees presently growing. Holdridge (1947, 1959; Holdridge et al. 1971) developed more quantitatively rigorous methods, known as the Life Zone Model, for deter­mining expected climax biotic communities in the Neotropics based largely on precipitation and temperature. Applying local adaptations of the Holdridge Life Zone Model, Tosi (1960) concluded that the instrumental record of temperature and precipitation indicated that montane humid forest should be the expected climax vegetation community of the Peruvian Altiplano. Using these same meth­ods, Unzueta (1975) arrived at similar conclusions for the Bolivian Altiplano. Through comparative observations of vegetation structure, plant indicators, soil profiles, and small-scale characteristics of ground relief, Ellenberg (1979) argued that forest was the expected climax plant cover for the Altiplano and dubbed this perspective the “woodland climax hypothesis.”

Stated in brief, the woodland climax hypothesis asserts that under modern conditions (1) there is sufficient rainfall to support tree growth (Tosi 1960); (2) there are trees, like those of the genus Polylepis, native to the region (Ellenberg 1979); (3) the structure of these native trees indicates that they are adapted to life on the Altiplano; (4) trees are found growing in areas that are unfavorable to agriculture (Miller 1929); and (5) trees will colonize valleys covered with ar­chaeological terraces (Cook 1916:288, Figure 2). According to the woodland climax hypothesis, regular anthropogenic land cover disturbance has allegedly prevented succession to climax conditions. Forms of disturbance include fire, harvesting of trees for firewood, clearing of forest for agricultural fields, and livestock grazing (Ellenberg 1979; Kessler 2002). Fire is generally considered to be the primary mechanism of disturbance (Fjeldså 2002; Kessler 2002; Kessler and Driesch 1993).

Earlier ecologists suggested that anthropogenic processes of disturbance may have been pre-Columbian (Cook 1916; Ellenberg 1979; Tosi 1960), and these discussions were largely limited to Late Horizon (A.D. 1476–1534) agricultural ac­tivities of the Inca Empire. More recently it has been suggested that deforestation caused by anthropogenic fires began with the first settlement of the Altiplano during the Terminal Pleistocene (Kessler and Driesch 1993), or that widespread deforestation may have begun 3,000–5,000 years ago with the development of agriculture in the highlands (Fjeldså 2002:113)—or during the Formative ca. 1000 cal b.c. (Fausto 2000:424). Contrary to early thoughts regarding the woodland climax hypothesis, it is now suggested that Late Horizon Inca actively practiced tree planting as a soil conservation strategy (Chepstow-Lusty and Winfield 2000), that these conservation practices may have begun as early as the preceding Late
Intermediate Period (Capriles and Flores Bedregal 2002), and that widespread deforestation occurred postcontact (Ettet and van Wyngaarden 2000:433).

Assertions that woodlands represent ancient climax plant communities rest heavily on the assumption that modern levels of precipitation reflect those of the past. What if this was not the case? Would woodlands still represent climax habitats?

**Paleoclimate**

Early dates for human entry into the Western Hemisphere and the peopling of the Altiplano remain contested though it is clear that humans inhabited the Altiplano since at least 7000 cal B.C. (Aldenderfer 1999; Dillehay 2002; Quilter 1991). Paleoclimatic research discussed below indicates that current climatic conditions did not persist throughout this span of time. Instead, temperature and precipitation both varied. This variability raises questions regarding the stability and antiquity of environmental conditions capable of resulting in woodland climax botanical communities during the region’s span of human occupation.

**Paleolimnology**

Multiproxy data from Lake Titicaca (Baker, Rigsby, et al. 2001) and oxygen isotopic data from Lake Junin (Seltzer et al. 2000) show definitively that the central and southern Peruvian highlands were significantly more arid during the early and middle Holocene than the region is today.

Analysis of cored sediments from both Lakes Junin and Titicaca indicates peak aridity at the onset of the Holocene and gradual amelioration throughout the Holocene, punctuated by multcentennial periods of significantly higher- or lower-than-average precipitation (Baker et al. 2005; Ekdahl et al. 2008; Seltzer et al. 2000). These long-term trends throughout the Holocene were due in large part to the influence of the South American summer monsoon (Baker, Rigsby, et al. 2001 and references therein; Seltzer et al. 2000).

Between 6050 cal B.C. and 2050 cal B.C. (8000-4000 cal B.P.) the water level in Lake Titicaca was 50–100 m lower than today. Sediment cores and seismic-reflection data from Lago Grande indicate the early-middle Holocene maximum lowstand occurred ca. 3350 cal B.C. (5300 cal B.P.), and lake levels were between 85 and 100 m lower than present (Cross et al. 2000; Cross et al. 2001; Grove et al. 2003).

A significant decrease in effective moisture occurred during the mid-Holocene (Cross et al. 2001; Talbi et al. 1999:198), and predicted mean rainfall during the maximum lowstand would have been between 635 ± 50 mm yr⁻¹ and 600 ± 50 mm yr⁻¹ (Talbi et al. 1999:198). The amount of precipitation during the mid-Holocene would have been 18 percent (Talbi et al. 1999) and 40 percent (Cross et al. 2001) less than the modern amount. These more arid conditions are also reflected in higher dust concentrations from the Quelccaya ice cores (Thompson et al. 1998).
Arid periods were interrupted by wetter episodes that occurred in millennial intervals. The diatom record from Lake Titicaca shows a resurgence in lake level between ca. 5550 cal b.c. and 4550 cal b.c. (7500–6500 cal b.p.) during the overall dry trend of the mid-Holocene (Baker, Seltzer, et al. 2001; Tapia et al. 2003:158). Between ca. 6150 cal b.c. and 5760 cal b.c. (8100–7710 cal b.p.), a flooding episode occurred in Lago Huiñaimarca, the smaller sub-basin of Lake Titicaca (Mourguiart et al. 1998:68). After this, Lago Huiñaimarca remained relatively stable until ca. 1950 cal b.c. (3900 cal b.p.) except for a significant dry episode that occurred about 3350 cal b.c. (5300 cal b.p.).


**Fluvial Sedimentology**

Five major river systems feed into Lake Titicaca (Roche et al. 1992:64). These drainages are Ramis, Coata, Ilave, Huancané, and Suchez (Grove et al. 2003:293). The Rio Ilave has the lowest relative flow of these five systems. Fluvial geomorphological research in the Rio Ilave sheds light on the relationships between paleoprecipitation and landscape change (Baker, Seltzer, et al. 2001; Rigsby et al. 2003).

In the Rio Ilave, downcutting occurred from ca. 6300 cal b.c. (8250 cal b.p.) to ca. 4830 cal b.c. (6780 cal b.p.), producing a T4 structure. By ca. 4830 cal b.c. (6780 cal b.p.) a T4 equilibrium phase developed. This phase of equilibrium probably corresponds to the wetter period occurring sometime between ca. 5050 cal b.c. (7000 cal b.p.) and ca. 4050 cal b.c. (6000 cal b.p.) that was identified in the diatom record from sediment cores from Lago Grande (Baker, Seltzer, et al. 2001). Downcutting occurred again at ca. 4050 cal b.c. (6000 cal b.p.) to ca. 2050 cal b.c. (4000 cal b.p.; Rigsby et al. 2003:179). These episodes probably correlate with decreasing rainfall and lowering lake levels, perhaps correlating with the major lowstand that occurred ca. 3350 cal b.c. (5300 cal b.p.). A thicker soil cap in the sediment record suggests that the T4 equilibrium period was longer than the T3 equilibrium period.

T2 and T1 aggradation occurred from ca. 1950 cal b.c. (3900 cal b.p.) up to ca. 550 cal b.c. (2500 cal b.p.) and then again from ca. 250 cal b.c. (2200 cal b.p.) to
A.D. 350 (1600 cal B.P.). These events correlate with periods of rising water levels in Lake Titicaca as well as with sedimentation in the Desaguadero valley and in the Rio Ilaye delta. These latter two episodes are separated by brief equilibrium periods and brief downcutting events (Rigsby et al. 2003:180).

**Palynology and Charcoal**

Fossil pollen and charcoal recovered from cored lake sediments provide proxies on paleoecology and fire history (Kangur 2002). Pollen spectra inform on the kinds of land cover present, but the record must be interpreted with caution because different plants produce pollen at different rates and the pollen of some species is more easily transported by wind than others. Still, pollen analysis is widely used as a proxy of ancient land cover (e.g., Baid and Wheeler 1993; Chepstow-Lusty and Winfield 2000; Paduano et al. 2003; Weng et al. 2004). Large-particle charcoal provides information on local fires while fine-particulate charcoal is used as a proxy for regional fires (Kangur 2002; Peters and Higuera 2007).

A recent synthesis of alder or *Alnus* pollen recovered from cores of eight lakes from the northern Altiplano indicated some common patterning across the Altiplano. Though the point of lowest *Alnus* abundance did not occur contemporaneously in all eight records, all of the records showed low *Alnus* representation about 2550 cal B.C. (Weng et al. 2004:687). Analysis of charcoal from these records indicated that fire became an important component of landscape disturbance beginning about 3050 cal B.C. (5000 cal B.P.; Weng et al. 2004:688). Moreover, "Markhu" *Ambrosia* and Chenopodiaceae/Amaranthaceae, species that are described as "anthropogenic indicators," increased nearly concurrently with the initial decline of *Alnus* about 2250 cal B.C. (4500 cal B.P.), which led some to suggest the possibility of downslope deforestation and replacement with agriculture (Weng et al. 2004:688–689).

Analysis of pollen and charcoal from sediment cored from Lago Grande provides comparable information on land cover changes. Charcoal in the core increases after 7050 cal B.C. (9000 cal B.P.), and this trend is consistent with the development of drier conditions and lowering lake levels (Paduano et al. 2003:273). Pollen spectra are consistent with a mid-Holocene arid period lasting from roughly 6010 cal B.C. to 1950 cal B.C. (7960-3900 cal B.P.). During this time, Poaceae and *Polylepis* pollen replaced Cyperaceae as the dominant taxa in the pollen assemblage (Paduano et al. 2003). Though this period is characterized as unusually spiky, the transition from Cyperaceae to *Polylepis* is likely associated with these trees invading the muds exposed by falling lake levels (Paduano et al. 2003:274).

The mid-Holocene becomes moister between 1950 cal B.C. (3900 cal B.P.) and 1150 cal B.C. (3100 cal B.P.) and this is reflected also by an increase in pollen associated with moist conditions (Apiaceae, *Alnus, Acalypha, Hedysmus*; Paduano et al. 2003:273). After 1750 cal B.C. (3700 cal B.P.) there is an increase in Cyperaceae, signaling the infilling of the lake and a flooding of the marshes on the western littoral (Paduano et al. 2003). During this time, the aquatic fern *Isidetes* returns to the western marshlands of the Puno and Achacachi bays. About 1150 cal B.C. (3100 cal B.P.) there is a return to forested land cover observed in those paleolake *Salar* levels.
cal B.P.) there is a drop in arboreal pollen species, which likely indicates a decline in forested land cover.


Archaeology

Salar de Atacama

The Silencio Arqueológico is a 4,500-year-long mid-Holocene depopulation observed in the Salar de Atacama (Núñez et al. 2002:822) that started about 7000 cal B.C. During the mid-Holocene, residents of the region ceased to occupy those paleolake basins that desiccated and formed salares. Basins that were of sufficient depth to permit the formation of wetlands continued to be occupied during this period. Thus, “people did not completely disappear from the area” (Núñez et al. 2002:824) but the nature of settlement patterns changed. The region was repopulated about 2500 cal B.C., and from 1740 B.C. to 1290 B.C. there was an increase in the number of sites, which suggests regional population growth. This settlement shift is accompanied by evidence for reduced residential mobility, as well as the adoption of domesticated plants and camelid pastoralism (Hesse 1982; Núñez 1982).

Junin Basin

The Lake Junin Basin (4,300 m asl; Rick 1980:80) was occupied during the mid-Holocene by low residential mobility complex hunter-gatherers (Rick 1996:273). It was a time of great occupational intensity in all known Preceramic sites in the Junin region (Rick 1996:273).

At the rockshelter site of Pachamachay, excavation levels corresponding to 3000–2200 cal B.C. produced the greatest density of stone-tool materials recovered from the site. Projectile-point counts increased greatly during this period, though stylistic diversity was low and the styles highly localized. A decline in curved-edge unifacial tools also occurred during this time. This probably reflects a shift from using camelids for their hide to harvesting wool from them. The transition from camelid hunting to herding occurred from 2200 cal B.C. to 1500 cal B.C., and corralling is evident at Pachamachay by 1500 cal B.C. (Rick 1980).

Rio Osmore

Excavations at the open-air site of Asana located in the arid high sierra of the Osmore drainage of southern Peru demonstrate this region was occupied during the mid-Holocene (Aldenderfer 1998). The timing of the Alnus low at ca. 2800 cal B.C. (4500 cal B.P.) corresponds to the latter occupations at Asana. Dur-
ing earlier Qhuna phase levels IXc2–IXa (ca. 3000–2600 cal B.C.) tool assemblages suggest seed-grinding activity was of minor importance. However, by levels VIII–V (ca. 2600–2400 cal B.C.) tool assemblages indicate seed processing took on much greater importance. By these later levels batanes (grinding stones) were consistently left deposited within structures (Aldenderfer 1998).

Titicaca Basin: Survey

Survey and excavation reveal that the Rio Ilave was occupied throughout the mid-Holocene. Early to Late Archaic population expansion, followed by Terminal Archaic settlement aggregation, and finally filling in during the Formative has been proposed previously (Klink and Aldenderfer 1996). However, this analysis did not provide information on locale use tempo or estimates of territory size—both of which are useful to consider when evaluating land use practices. To track these latter processes, Craig (2005) independently replicated component counts based on diagnostic point types and applied temporal scaling to each time period.

From this, the number of points per time period and the number of points per site were both calculated (Figure 3-1). In addition, using the fixed kernel density method in ArcGIS 9.1, home ranges for each temporal period were estimated from site distributions and expressed as a use distribution (UD; Figure 3-2).

Few sites and few projectile points diagnostic to the Early Archaic have been found. The 95-percent home range UD is relatively constricted during this period but the 50-percent UD is quite large. These patterns suggest light occupation of the area with little occupational redundancy. Settlements are relatively restricted but there is variability in site location expanding the 95-percent UD.

The Middle Archaic is characterized by a large number of sites, an increasing number of diagnostic projectile points, and a slight rise in the number of points per site. Increases in the number of points and the number of points per site are largely the result of high numbers of 3B points (Klink and Aldenderfer 2005), which are a late Middle Archaic to early Late Archaic transitional form. The 95-percent UD continues to expand but there is a contraction in the 50-percent UD. The rise in the number of points coupled with the contracting home range suggests settlement may be more concentrated or tightly tethered to major watercourses. While home ranges contract, projectile-point count per time period remains low, and numbers of points per site are low but increasing. The rise in calibrated component counts between the Early and Middle Archaic likely represents in situ population growth and fissioning occurring within the Titicaca Basin.

The Late Archaic shows another increase in the number of sites and an increase in the number of points. This period also exhibits the highest number of points per site of any period in the survey. The UD for both the 50-percent and the 95-percent distributions are very large—sites are dispersed. Lake level resurgence (Baker, Seltzer, et al. 2001; Tapia et al. 2003) and fluvial aggradation (Rigsby et al. 2003) in the Rio Ilave during this period may have permitted a more dispersed settlement pattern than the previous arid period allowed. Unless there is compelling evidence for population growth, the Late Archaic population probably occurred during the late Holocene.

The number of points per site since the decline in the number of points per site during the Termi-
is compelling evidence for migration into the Titicaca Basin, it would seem that population growth occurred and occupational redundancy increased during the Late Archaic. Population growth seen at the Middle to Late Archaic transition occurs during the initial stages of climate amelioration occurring at the onset of the late Holocene.

The number of sites declines during the Terminal Archaic. There are a low number of points overall, and there is a slight decline in the number of points per site since the Late Archaic. Both the 50-percent and 95-percent UDs contract during the Terminal Archaic. However, there is an increase in site size and an increase in the number of large sites (Klink and Aldenderfer 1996). This may represent settlement aggregation, increasing occupational redundancy. This is an arid period in the Lake Titicaca Basin. Camelid domestication occurred during or immediately following this period in the other regions reviewed above. Thus, the decline in the number of points and points per site during the Terminal Archaic in the Rio Ilave, even though site size increased and aggregation probably occurred, likely reflects a reduction in the importance of projectile-point production for hunting.

**Figure 3-1.** Graph illustrating projectile-point frequencies scaled by time and mean number of projectile points per site. Diamonds represent the projectile-point count divided by the duration of the temporally diagnostic period of time. Squares represent the average number of points per site divided by the duration of the temporally diagnostic period of time. The horizontal axis indicates projectile-point types diagnostic to period as defined by Klink and Aldenderfer (1996). The vertical axis of the chart is number of points scaled by the duration of the time period.
The number of sites and the number of points per period both increase again during the Early Formative. If settlements were aggregated during the Terminal Archaic and then the increase in site counts during the Formative could represent an increase in population or regional “packing in.” If the area was abandoned during the Terminal Archaic, this rise in counts could represent reoccupation of the region. The number of points per site is very low—it declines to Early Archaic levels. Given the large number of sites, the low number of points suggests that hunting is of little importance during this period.

Survey results show both the number of points per time period and the number of points per site increase at about the same time. Coincident increases in both counts indicate population increases may have had a role to play regarding increased high-ranked resource pursuit costs. These changes were likely influential in decisions to shift foraging efforts toward broader and lower-ranked diets requiring higher processing costs that were likely related to reduced residential mobility.

Component counts reported by Klink (2005) were temporally calibrated to compare results from the Huenque to those for the Ilave. Comparison shows that similar settlement pattern changes took place in both regions, though overall site frequencies in the Huenque are higher in every period.

**Titicaca Basin: Excavation**

Jiskairumoko was the largest Terminal Archaic site encountered during survey of the Rio Ilave drainage (Aldenderfer and de la Vega 1996). Excavations at Jiskairumoko exposed a series of dwellings comprising a small village, the occupation of which, 25 radiocarbon dates demonstrate, spanned the Late Archaic to the Early Formative (Aldenderfer et al. 2008; Craig 2005).

Four pit structures were excavated (Table 3-1), and at least two more were detected by ground-penetrating radar. The oldest pit structure at the site was the largest exposed or detected in radar surveys. The structure’s central hearth had been repeatedly remodeled and was associated with a well-formed use scatter composed largely of bones. Thus, the performance was a number of smaller other deeply dug structure contain chenopod seeds. SEM analysis of shells revealed that the rock may have been used in the later part of the occupation. Neither was clay type of kitchen recurrence.

Two above-ground pits or alcoves. A ritual activity bore some similarity.
Table 3-1. Descriptive Metrics for Structures Exposed During Excavation of Jiskairumoko, Rio Ilave, Peru

<table>
<thead>
<tr>
<th>Structure Type</th>
<th>Area (m²)</th>
<th>Perimeter (m)</th>
<th>Depth/Thickness (m)</th>
<th>Liters Internal Storage</th>
<th>Liters External Storage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pithouse 1</td>
<td>13.20</td>
<td>12.92</td>
<td>.41</td>
<td>420</td>
<td>80</td>
</tr>
<tr>
<td>Pithouse 1 Outer</td>
<td>18.69</td>
<td>14.56</td>
<td>.16</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Pithouse 2</td>
<td>8.47</td>
<td>7.92</td>
<td>.32</td>
<td>130</td>
<td>510</td>
</tr>
<tr>
<td>Pithouse 3</td>
<td>5.21</td>
<td>7.92</td>
<td>.32</td>
<td>180</td>
<td>1,400</td>
</tr>
<tr>
<td>Semisubterranean 1</td>
<td>15.18</td>
<td>14.76</td>
<td>.25</td>
<td>1,400</td>
<td></td>
</tr>
<tr>
<td>Rectangular 1</td>
<td>9.85</td>
<td>12.95</td>
<td>.1</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Rectangular 2</td>
<td>22.96</td>
<td>20.66</td>
<td>15-2</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

composed largely of thermally altered ochre and camelid and small-animal bone (Craig et al. 2006). Ochre pigments occurred in burials and painted on camelid bones. Thus, the hearth-side assemblage suggests that preparations for ritual performance were embedded in domestic settings. The structure also contained a number of small alcoves and pits that appear to have been for storage. Two other deeply dug pithouses were situated adjacent to the larger structure. Each structure contained small alcoves, and each had a well-formed hearth, though neither was clay lined. Large organically stained areas containing manos and chenopod seeds were encountered outside of each of the two smaller pithouses. SEM analysis of seed-coat thickness of chenopod specimens from these contexts revealed that they represent domesticated varieties (Murray 200Sa, 200Sb).

The fourth pit structure was situated in the northern portion of the site and was much shallower, better described as a semisubterranean structure. Its earliest occupation had a single large internal pit in the floor. By the end of the structure's span of use and reuse, this large pit had been sealed over and was no longer in use. No other interior alcoves were present. The central hearth showed evidence of repeated remodeling and was constructed out of a deep, well-formed metate. During the later part of the structure's use, a kitchen rock was placed inside the structure. The rock may not have been used during the structure's earlier occupations. This type of kitchen rock was not observed in any of the other pit structures.

Two above-ground structures were excavated (Table 3-1). The smaller of the two is a residence. Just as with the large pithouse, the larger structure appears to have been the site of some spiritual practice that was embedded in a domestic space. Neither of the above-ground structures bore evidence of internal storage pits or alcoves. A kitchen rock was placed in the smaller above-ground structure, but the larger structure lacked this kind of internal feature.

Ritual activities occurring in and adjacent to the larger above-ground structure bore some similarities to ritual preparations observed in the largest pithouse. Both contexts exhibited large deposits of thermally altered ground ochre dust.
Several ochre-painted camelid bone fragments, a camelid bone effigy, large concentrations of nonlocal obsidian debitage, and a ceramic vessel fragment were recovered in association with the large above-ground structure. While not directly dated, the ceramic vessel appears to represent the earliest known example of in situ pottery recovered in the Titicaca Basin (Craig 2005:649-668).

Faunal preservation at this open-air site was quite poor, and few elements were identifiable. The largest concentration of deer remains was recovered on the floor of the largest and oldest pithouse. Additional deer remains were recovered from other structures as well. Camelid remains dominated the identifiable specimens, though no corrals were encountered during excavations at Jiskairumoko. Many of the camelid long-bone elements exhibited unfused epiphyses, indicating they were from juvenile animals. This pattern suggests coralling.

Discussion and Conclusion

The mid-Holocene and the Silencio Arqueológico end around the time that *Alnus* pollen reaches its common low representation around 2800 cal B.C. (4500 cal B.P.) at the eight sites compared by Weng and colleagues (2004). Furthermore, their data show that *Alnus* reached high levels at several points during the mid-Holocene, at the heart of the Salar de Atacama Silencio Arqueológico. Droughts likely played a role in deforestation, but analyzed cores from Lake Titicaca show that increases in anthropogenic pollen and charcoal coincide with declines in tree pollen. The latter two trends suggest an anthropogenic component to late mid-Holocene deforestation.

The Silencio Arqueológico characterizes settlement patterns in the Salar de Atacama, and it is in fact a well-documented expansion of human activity in the southern Altiplano. However, the Silencio Arqueológico settlement pattern model is at odds with the archaeological record of both the northwestern Lake Titicaca and Lake Junin basins. Thus, research in neighboring arid regions of the Altiplano demonstrates that depopulation was localized—it is thus unlikely to apply to the far more humid Ecuadorian highlands as Weng and colleagues suggest.

The Silencio Arqueológico serves as a potent articulation of paleoclimatic and paleoenvironmental analyses with archaeological data for the Salar de Atacama. However, the model has been proposed for other contexts in which it is not well supported by archaeological data. Núñez and colleagues (2002:824) note that "the Silencio Arqueológico applies best to the most arid areas of the Andes, where aridity thresholds for early societies were critical" and that during this time even the Salar de Atacama was not completely depopulated (Núñez et al. 2002:822). Yet, citing Sandweiss and colleagues (1999), Núñez and colleagues (2002:824) assert that the Silencio Arqueológico "is also found on the coastal Perú in sites that are associated with ephemeral streams." The term *Silencio Arqueológico* was not used in Sandweiss and colleagues' (1999) article, and they do not report either a depopulation or repopulation of the Peruvian coast. Instead, the article (Sandweiss et al. 1999) characterizes the mid-Holocene Peruvian coast in terms of reduced El Niño–Southern Oscillation (ENSO) amplitude and suggests that the environmental conditions were harsher during this time period.
that the environment may have become more productive as ENSO increased in amplitude during the mid–late Holocene transition.

Even though multiproxy data from Lake Titicaca indicate mid-Holocene precipitation may have been as much as 18 percent (Talbi et al. 1999) to 40 percent (Cross et al. 2001) less than the modern amount, tree pollen is present throughout this arid time period. Therefore, at least in the Titicaca Basin the potential for climax woodland communities persisted. However, as precipitation amounts fluctuated over the long term there is a change from Cyperaceae to Polylepis as lake levels declined around 6010 cal B.C. and then a transition back to Cyperaceae that occurred when lake levels rose around 1750 cal B.C. Thus while the potential for woodland climax persisted in the Titicaca Basin, the kind of forest cover appears to have changed in relation to climate.

From the perspective of anthropogenic environments, the charcoal record provides the most intriguing line of data currently available for the Lake Titicaca Basin. Since the Last Glacial Maximum in the Lake Titicaca Basin, charcoal increases during arid periods and decreases during moist periods. Yet, the rise of fine-particulate charcoal after 2050 cal B.C. represents the first time in the history of the lake that there was an increase in charcoal that occurred during a period of greater precipitation. This suggests that fires occurring during this time were not purely of natural origin. They may be related to new forms of disturbance associated with new dimensions of human occupation of the region—namely the beginnings of low-level food production (sensu Smith 2001) in the form of early agropastoralism. The large drop in arboreal pollen species, rather than a transition in species, suggests that environmental changes are not purely of natural origin. The disappearance of fine-particulate charcoal about 50 cal B.C. (2000 cal B.P.) could represent a loss or shortage of firewood and a conversion to a more open and grassy land cover.

The decline in arboreal pollen, increase in chenopod pollen, and increase in particulate charcoal—all occurring during a period of increased moisture—happen during a period of significant cultural changes.

In the Rio Ilave drainage, there is an increase in locale use tempo followed by settlement aggregation at fewer and larger sites and a decline in the importance of hunting. Excavation of one of these sites demonstrates a reduction in residential mobility, the adoption of domesticated plants, and probably camelid pastoralism. Excavation and geophysical survey reveal that early pithouse structures at Jiskairumoko are very closely spaced, but later semisubterranean and aboveground structures were spaced much farther apart. Ethnoarchaeological research indicates this shift reflects a decrease in the genetic relatedness (Garget and Hayden 1991; Gould and Yellen 1987) and a decline in sharing of resources (Brooks et al. 1984; Gould and Yellen 1987; Kaplan et al. 1984; O’Connell et al. 1991) between occupants of neighboring structures.

There is a shift from numerous internal storage pits to a single large storage pit to the abandonment of internal storage pits altogether. The incorporation of kitchen rocks appears to have taken place around the same time that use of internal storage pits is abandoned.
Since the early Holocene, the northern and western Titicaca Basin was never abandoned; present data indicate population growth was steady over time. When the mid-Holocene was most arid, population levels reached a critical threshold at which point diet breadth expanded, residential mobility declined, and settlement aggregation occurred. Stress appears to have stimulated a suite of cultural adaptations (i.e., Jones et al. 1999). Following this, climate amelioration occurred, floodplains widened, and settlements expanded (sensu Smith 2001). During this Late-Terminal Archaic to Formative transition, as residential mobility declined and resource use intensified, independent sources of data suggest deforestation was beginning to take place. Soon after, full-fledged use of domesticates and sedentary villages emerged during the Early Formative and by this time deforestation in the Lake Titicaca Basin may have been significant.

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