

# Aztec-Period Agricultural Terraces in Morelos, Mexico: Evidence for Household-level Agricultural Intensification

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*Excavation of Aztec-period agricultural features at the sites of Capilco and Cuexcomate in Morelos, Mexico, provides new data on the construction, function, and significance of agricultural terraces in Late Postclassic central Mexico. Stratigraphic and chemical analyses of alluvial deposits associated with cross-channel terraces ("check-dams") reveal that these features served an agricultural function. Terrace walls were built gradually in small increments, and associated sediments were created by alluvial deposition of eroding topsoil. These findings, together with demographic and social data from nearby excavated houses, suggest that Late Postclassic agricultural intensification was a household-level response to population pressure.*

## Introduction

The Aztecs of central Mexico employed three types of intensive agricultural methods to feed their dense, urbanized population: canal irrigation, raised fields (*chinampas*), and terracing (Sanders, Parsons, and Santley 1979: 222–281; Rojas Rabiela 1985). Terrace agriculture was not as productive as the other two types, and it has received less scientific attention; this was, however, probably the most widespread form of intensive cultivation in the mountainous core area of the Aztec empire. Donkin's (1979) study shows the presence of terracing throughout highland central Mexico, and most of the examples probably date to the Late Postclassic period (Sanders, Parsons, and Santley 1979; Evans 1990). Our excavations at sites in the Mexican state of Morelos comprise the most intensive archaeological analysis yet undertaken of ancient agricultural terraces in central Mexico. These data shed new light on Aztec-period farming, demography, and rural society.

## Setting

The state of Morelos is located in the central Mexican highlands just south of the Basin of Mexico. During the Late Postclassic period (A.C. 1350–1520) Morelos was divided into 50 or more small city-states, most of which were subject to one of five powerful regional states. These

larger states were in turn subject to the Aztec empire centered in the Basin of Mexico. Rapid Postclassic population growth in Morelos (see below) had three major consequences: construction of irrigation systems along major rivers (Maldonado 1990), accelerated political competition among city-states (Smith 1986), and the colonization of agriculturally-marginal upland areas. One such area was the Buenavista Lomas, a large, deeply dissected Plio-Pleistocene alluvial fan that extends westward from the modern city of Cuernavaca (Ortiz Pérez 1977).

Although the Buenavista Lomas area receives moderate rainfall (900–1000 mm annually), agricultural potential is limited by thin, rocky soils and a scarcity of level land. Apart from some Epiclassic (A.C. 700–950) sites associated with Xochicalco at the southern edge of the alluvial fan, prehistoric settlement was quite scanty in this area until the Late Postclassic period, when the Lomas area was colonized by new populations who built many miles of stone terrace walls for agricultural purposes. Two archaeological sites located near Xochicalco at the southern end of the alluvial fan, Cuexcomate and Capilco (FIG. 1), were excavated by the Postclassic Morelos Archaeological Project in 1986 (Smith 1992; Smith et al. 1989).

In addition to the terrace excavations described here, fieldwork at these sites concentrated on houses and associated domestic deposits in order to reconstruct rural so-

Table 1. Population estimates by phase.

Site	Number of houses			Population		
	Tem	EC	LC	Tem	EC	LC
Capilco	5	13	21	30	70	120
Cuexcomate	0	39	139	0	240	800
Region	—	—	—	460	2690	4000

Tem: Temazcalli (A.C. 1200–1350); EC: Early Cuauhnahuac (A.C. 1350–1430); LC: Late Cuauhnahuac (A.C. 1430–1550).

cioeconomic organization and its changes through time. House foundation walls were visible on the surface of the ground, and stratified random samples of houses were selected at each site to permit the analysis of site-wide conditions and variability. Nine of the 21 houses at Capilco were excavated, as were 35 of 139 houses at Cuexcomate. All occupation dates to the Postclassic period, with three phases represented: Temazcalli (A.C. 1200–1350), Early Cuauhnahuac (A.C. 1350–1430) and Late Cuauhnahuac (A.C. 1430–1550). Population estimates

(TABLE 1) were derived by extrapolating the house occupation patterns from the random sample, and using family size constants of 5.5 persons for nonelite houses and 11 persons for the small number of elite residences at Cuexcomate (Smith 1992: 335–345). The population growth at Capilco and Cuexcomate is matched in the southern Buenavista Lomas zone (O'Mack 1991; Osvaldo Sterpone, personal communication, 1991), and this provided a major impetus for the construction and use of agricultural terraces.

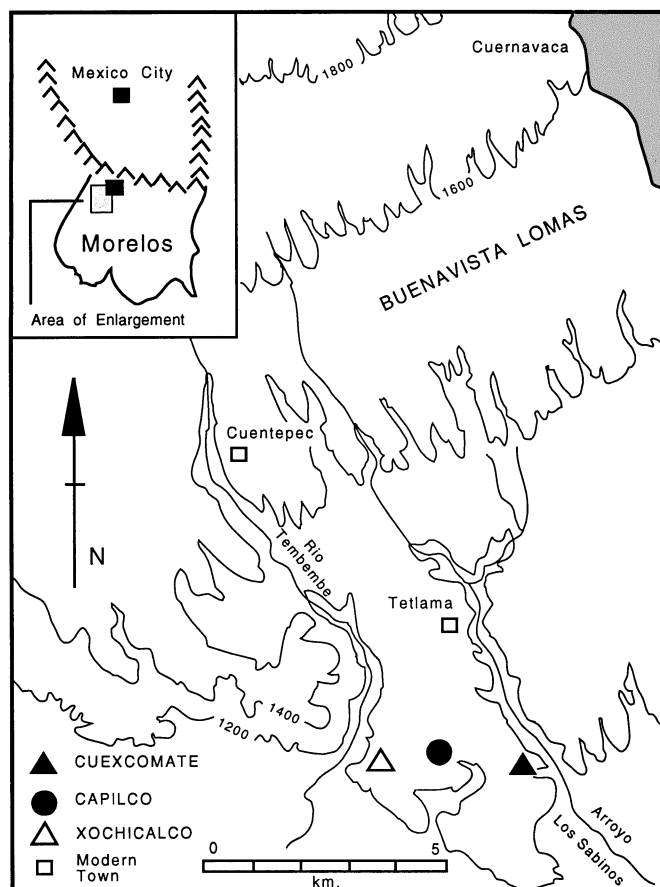
Capilco and Cuexcomate are both associated with areas of cross-channel terraces or check-dams (FIG. 2). Cross-channel terraces are stone walls built in gullies or ravines with an orientation perpendicular to the direction of water flow (Donkin 1979). We excavated two of the seven cross-channel terraces in a 0.2 ha alluvial bench along a seasonal stream just north of Capilco. At Cuexcomate we excavated three of the 36 terraces that cover an area of 1.1 ha in a small drainage basin along the SW edge of the site (FIG. 3). The hillslopes surrounding the Cuexcomate ridge are covered with the destroyed remnants of stone contour terraces, and we excavated a single trench that crossed five walls.

### Cross-Channel Terraces

This discussion focuses on the Unit 230 terrace at Cuexcomate, the most intensively excavated and analyzed example; full descriptions and data on this and all other excavations can be found in our original reports (Price 1988; Price and Smith 1992). The Unit 230 terrace is visible at ground surface as a low wall of unmodified cobbles that is 37 m long and crosses the drainage basin perpendicular to the stream channel. We tested the wall and its associated alluvial sediments with a 3 m-wide trench through the wall and a series of four 1 m × 3 m trenches parallel to the wall 3 m away on the upstream (north) side (FIG. 4). Trenches were excavated in 20 cm levels. Profile drawings and soil descriptions were made, and soil samples removed from specific strata for physical and chemical analyses.

The form of the terrace wall reveals a number of char-

Figure 1. Map of western Morelos, Mexico, showing the locations of Capilco, Cuexcomate, and the Buenavista Lomas area.



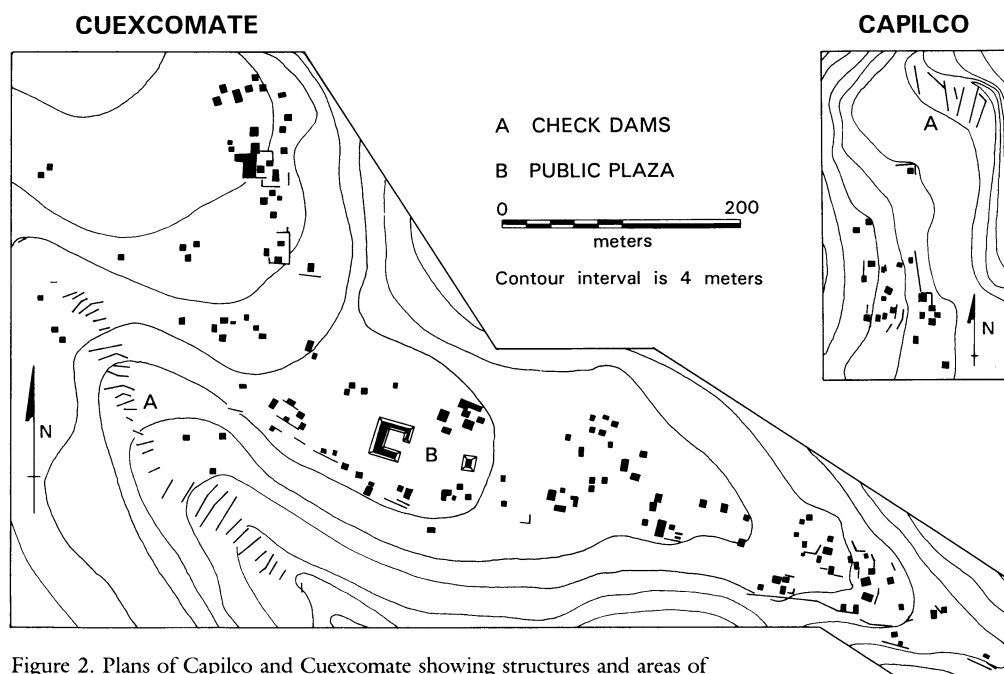


Figure 2. Plans of Capilco and Cuexcomate showing structures and areas of cross-channel terracing.

Figure 3. Small drainage at Cuexcomate with cross-channel terraces (looking north).



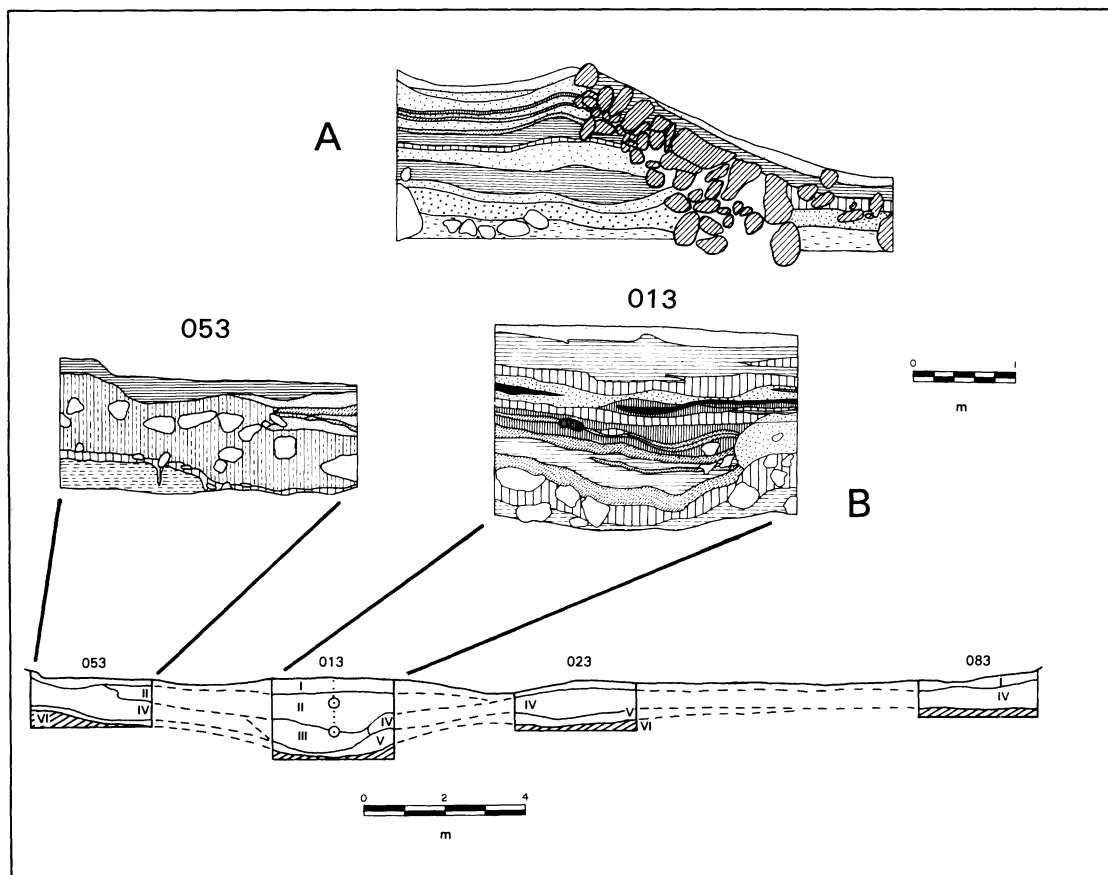


Figure 4. Excavation profiles of cross-channel terrace and associated alluvial deposits (excavation unit 230 at Cuexcomate). A: N-s section through terrace wall; B: E-w profiles from excavations 3 m north of the terrace wall. Dots show locations of soil samples; dots within circles denote samples with elevated levels of phosphorous and organic matter (see FIG. 6).

acteristics of its construction and use (FIG. 4A, 5). The lowest stones are set into *tepetate*, the pre-cultural C-horizon in this area. (Tepetate, the parent material in most central Mexican alluvial fans, consists of fluviially-deposited volcanic ash cemented by carbonate and silica; see Williams 1972; Nimlos 1989.) The slope of the wall indicates that it was constructed gradually over a period of time and was never free-standing. The parallel strata suggest that the sediments behind the wall were deposited by alluvial processes, not by human filling. The individual strata are classified into six soil zones to clarify the depositional history above the terrace (FIG. 4).

Zone VI is tepetate. All other zones contain low densities of Cuauhnahuac-phase potsherds. Although the sherds from the terrace deposits clearly date to the Cuauhnahuac period, they cannot be assigned to the Early or Late phase because of their small size and eroded condition, and low quantities; Early and Late Cuauhnahuac ceramics are difficult to distinguish even with large sam-

ples (Smith and Doershuk 1991). The original stream channel appears to have passed through the vicinity of trench 013 (FIG. 4B). Soil zone V, a gray to brown, coarse, sandy clay loam, is an alluvial deposit laid down during the Cuauhnahuac phase. The presence of this layer (with its Cuauhnahuac artifacts) directly on the tepetate surface suggests that erosion in this drainage basin began prior to or early in the Cuauhnahuac period, since the pre-occupational soil deposits above the tepetate had presumably washed away before the zone V deposition.

While zone V is found on both sides of the terrace wall, zone IV is present only on the upstream side and is associated with the use of the terrace. This is a thick clay deposit with many large and small stones, and the poor grain-size sorting points to turbulent stream flow as its source (Butzer 1976: 146). Although the drainage basin does not contain a permanent stream at present, intermittent flash flooding that is common during the rainy season probably accounts for this and the other alluvial deposits



Figure 5. View of cross-channel terrace, unit 230, during excavation.

behind the terrace. Soil zone IV may represent the initial filling-in behind the newly-built terrace. At some point after this, the central part of the wall may have collapsed (because of heavy discharge and/or inadequate maintenance), leading to the formation of a new gully and the removal of zone IV deposits from most of the trench 013 area. Soil zone III, consisting of a brown clay loam and a dark brown, sandy loam, was then deposited, filling the gully almost to the original height of zone IV. This was probably the result of rebuilding or repairing the terrace wall.

Soil zone II, found only in the central portion of the terrace area, consists of many alternating layers of fine- and coarse-textured sediments. The thin strata indicate the origin of this deposit during conditions of relatively quiet stream flow (Butzer 1976: 164) probably caused by the leveling effect of the check-dam. When a new row of stones was added, the runoff was initially blocked, leading to the deposition of both fine and coarse particles in the standing water. As the ground surface built up and reached the top of the wall, stream flow was no longer restricted and the smaller particles were carried away in solution, leaving mainly coarse sandy material behind the terrace. The end result over time was the alternation of finer and coarser sediment in soil zone II as new rows of stone were

added to the terrace. New stones were placed into the soil behind existing wall stones, resulting in the slanted configuration of the wall. As the wall was built higher over time, it had to be lengthened as well, increasing the ground surface area as the alluvial deposits became both wider and longer. Soil zone I is a topsoil deposit of dark gray, sandy clay covering the entire area.

Several lines of evidence point to an agricultural function for the cross-channel terraces. First, pollen grains from several cultigens were recovered in the Unit 230 sediments. These include *Zea mays* (maize), *Opuntia* (nopal cactus), *Cucurbitaceae* (squash), and *Chenopodium/Amaranthus* (either cultivated amaranth or chenopod weeds). Second, sediments from terrace deposits have consistently lower levels of organic matter, phosphorous, potassium, calcium, copper, and other nutrients than do soils from adjacent non-terraced areas (Price 1988). Ancient cultivation of the terrace soils must have depleted the nutrient levels, a pattern reported for ancient terraces in New Mexico (Sandor and Gersper 1988; Sandor, Gersper, and Hawley 1990) and characteristic of cultivated soils generally.

A third type of evidence for agricultural use of these terraces is the presence of elevated levels of organic matter and available phosphorous at key depths (Price 1988).

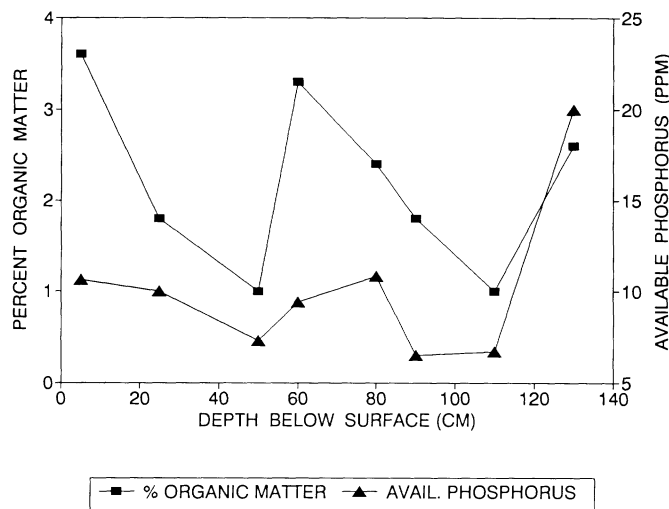


Figure 6. Concentrations of organic matter and available phosphorus plotted against depth below surface in terrace deposits (excavation unit 230 at Cuexcomate).

The concentrations for trench 013 of Unit 230 are plotted in Figure 6, revealing nutrient peaks at 60 and 130 cm below surface (the locations of the samples are shown in FIG. 1). These data suggest the presence of buried topsoils, when the planting surface was stable for periods long enough for a formation of an A horizon (Sandor 1987). A final line of evidence for attributing an agricultural function to the cross-channel terraces is their close resemblance to agricultural terraces still used in many parts of Mexico today (Donkin 1979; Wilken 1987).

### Contour Terraces

Although contour terraces are far more abundant in our study area and central Mexico generally than are cross-channel terraces, we devoted less effort to their study for two reasons. First, there have been many more studies of contour terraces than of the cross-channel variety in Mesoamerica, and this type of agricultural feature is better understood (Donkin 1979; Healy et al. 1983; Sanders, Parsons, and Santley 1979; Turner 1983; Wilken 1987). Second, the contour terraces are very poorly preserved, consisting in most cases of wall remnants whose identification is often difficult in the field. We only carried out one excavation in an area of contour terraces.

Excavation Unit 232 was a 1 m-wide trench excavated on the northern slope below the eastern area of settlement at Cuexcomate (FIG. 7). The walls are quite modest, consisting of one or a few stones between 20 and 60 cm in height. Topsoil in this area is a dark brown, sandy clay loam to clay loam with small numbers of eroded artifacts,

while the lower deposits (above tepetate) are reddish brown, sandy clay loam with thin lenses of clay. It appears that the artifacts in the topsoil derive from erosion from the Cuauhnahuac-phase houses located up on the slope from the terraces. We could identify no deposits of sediment clearly associated with the use of terrace walls.

Although the locations, form, and prevalence of the contour terraces all indicate an agricultural function, our excavations leave many questions unanswered. Without any identifiable intact terrace sediments, we have no idea whether the presumed planting surfaces were created through natural erosion or deliberate filling. We cannot reconstruct the original height of the walls. If they were taller than the excavated remnants, the upper courses have washed away. It is also possible that the terraces were never much higher than they are today; small rudimentary contour terraces were common in the prehistoric American Southwest (Sandor and Gersper 1988; Sandor, Gersper, and Hawley 1990), and such features are easy to build and maintain.

### Terraces and Agricultural Intensification in Postclassic Morelos

Although the Cuauhnahuac period sherds recovered from the alluvial deposits are too few and eroded to be assigned to either the Early or Late phase, it is likely that terrace construction began in Early Cuauhnahuac times (A.C. 1350–1430), and then expanded greatly in the Late Cuauhnahuac phase (A.C. 1430–1550). Surveys by Osvaldo Sterpone (personal communication, 1991) and O'Mack (1991) indicate that the major colonization of the Buenavista Lomas began in Cuauhnahuac times, and Smith's examination of surface ceramics on a number of these sites identified Early Cuauhnahuac types. A reconstruction of regional carrying capacity by Kenneth Hirth (personal communication, 1991) indicates that a 6-km region around Capilco, Cuexcomate, and Xochicalco in the southern Buenavista Lomas could support about 1200 persons using level-field rainfall agriculture. In the Temazcalli phase (A.C. 1200–1350), settlement was clustered near Xochicalco, and the regional population is estimated at 460 (TABLE 1; see Smith 1992: 335–345 for the data and methods behind the population estimates), well within the limits of non-terrace cultivation. Regional population expanded rapidly during the Late Postclassic period, however, from 2690 in the Early Cuauhnahuac phase to 4000 in the Late Cuauhnahuac phase. These population figures suggest that terracing probably began in Early Cuauhnahuac times, and by the Late Cuauhnahuac phase terracing was an absolute necessity in this area.

The single radiocarbon date from a terrace excavation (ETH-6309) has a calibration curve intercept of A.C. 1476 (1 sigma range of A.C. 1440–1522; see Smith and Doershuk 1991). This sample, a piece of carbonized wood, is from the middle of soil zone II in Unit 230, a horizon relatively late in the history of that terrace, suggesting an Early Cuauhnahuac origin for the terrace. Terracing appears to have been initiated in the Early Cuauhnahuac phase (no Temazcalli phase terraces have been identified), and reached its maximum extension in Late Cuauhnahuac times.

The main functions of agricultural terraces (both the contour and cross-channel varieties) are the creation of level planting surfaces, the control of soil erosion, and the formation of deep deposits that conserve moisture (Donkin 1979; Wilken 1987). Terrace cultivation is a more intensive form of agriculture than level-field rainwater cultivation in the sense that it produces higher yields per ha at the cost of greater labor input per unit output (see Boserup 1965 or Turner and Doolittle 1978 on the concepts of agricultural intensity and intensification). Of the major causes of agricultural intensification—population growth, environmental deterioration, political coercion, and marketing forces—the first two are most clearly implicated for the expansion of terracing in the Buenavista Lomas.

The high rate of population growth found in our study area (TABLE 1) was matched in the Basin of Mexico (Sanders, Parsons, and Santley 1979: 216–219) and in nearby parts of Morelos (Smith 1992: chapter 11). The movement of new populations into the Buenavista Lomas, an area of limited agricultural potential, created the need for intensive cultivation practices, and given local topography and resources, contour terracing was the most appropriate solution. Construction of contour terraces coupled with

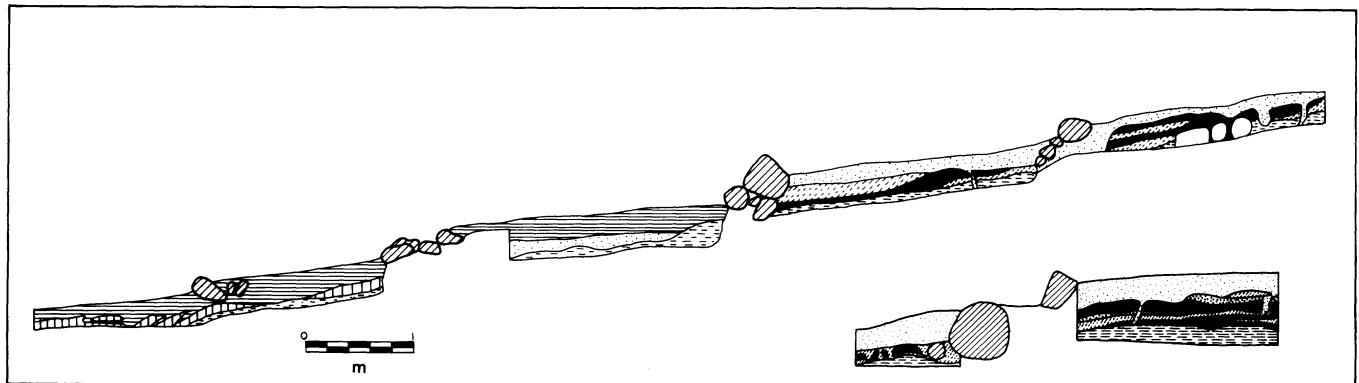
other human activities would have initiated or contributed to soil erosion on the hillsides, and the cross-channel terraces were built to take advantage of eroding sediments by creating new agricultural fields.

Our data clearly support Boserup's (1965) model of population pressure as the primary cause of agricultural intensification. These data, however, do not support the notion that population growth and agricultural intensification in turn stimulate political centralization. This extension of Boserup's original argument is a common theme in the anthropological literature (e.g., Spooner 1972; Sanders, Parsons, and Santley 1979), although Netting (1990) has recently challenged the model, arguing that while population pressure often leads to agricultural intensification, political development is not an outcome of this process and its causes must be sought elsewhere.

Our excavation of a palace at Cuexcomate reveals a chronology of elite activities and conditions inconsistent with the extended Boserupian model. Political control in Aztec-period central Mexico was in the hands of a powerful, hereditary nobility (Smith 1986). In Morelos, palace structures like the one excavated at Cuexcomate served as elite or noble residences and constituted the seats of local political administration; these palaces were present at many large and medium-sized settlements.

The elite group was present at Cuexcomate from its founding at the start of the early Cuauhnahuac phase around A.C. 1350. Both architectural and artifactual evidence indicate that the Cuexcomate elite were far more wealthy and powerful (relative to nonelite residents) in the Early Cuauhnahuac phase than in the Late Cuauhnahuac phase. Terrace construction began after the arrival or establishment of the Cuexcomate elite, but more significantly, as terraces were extensively expanded in the 15th century, the elite group declined in wealth and power

Figure 7. Excavation profiles of contour terraces and associated colluvial deposits (excavation unit 232 at Cuexcomate).



(see Smith 1992 for discussion of the Cuexcomate elite).

Another theoretical approach turns the extended Bose-rupian model around, arguing that elites promote and stimulate agricultural intensification in order to bolster their own political and economic control (Brumfiel and Earle 1987; Gilman 1981; Polgar 1975). Although there is little direct evidence one way or the other regarding elite participation in or sponsorship of terrace agriculture, the Cuexcomate elite did not exercise a controlling role in other economic realms such as long-distance trade or local craft production (see Smith and Heath-Smith 1994). Nevertheless, ethnohistory reveals that the basis of the central Mexican nobility's power was control over land and labor (Carrasco 1976), and it is entirely possible that the provincial elites at Cuexcomate and other sites promoted terracing to increase their own wealth and power. Only additional fieldwork at terrace sites and elite residences will clarify this issue.

Studies of ancient and modern Mesoamerican agriculture show that compared with canal irrigation and raised field cultivation—the other major forms of Aztec intensive agriculture—terracing requires less planning and coordination of labor, and terracing has fewer direct links to centralized political institutions (Rojas Rabiela 1985; Sanders, Parsons, and Santley 1979; Wilken 1987). Wilken (1987: 100) notes that today most agricultural terraces in Mesoamerica are built by small groups of people, often individual families. They tend to be constructed gradually, over a period of time, rather than in short, intensive bursts of labor. Once built, the maintenance requirements of terraces are minor but nearly continuous. Wilken (1987: 100) calls terrace agriculture an example of “the process-rather-than-project approach of so many traditional management activities.” This approach contrasts with agrosystems such as canal irrigation, which often involve large-scale investments of organized labor for construction and maintenance tasks.

Netting's (1989, 1990) research, which demonstrates a cross-cultural association among high population density, household-level intensive agriculture (e.g., terracing), and the development of the household as a cohesive and important social and economic institution, is applicable here. In areas where terrace agriculture is predominant, farmers tend to live close to their fields because of the continual labor requirements of maintenance and cultivation (Netting 1989, 1990). This situation can produce a dispersed settlement pattern with a high regional population density, as among the Nigerian terrace-farming Kofyar (Netting 1968, 1989). Drennan (1988) has applied a more generalized version of this argument to Mesoamerica, suggesting that the labor requirements of various types of

intensive agriculture led to dispersed settlement patterns in many areas. Late Aztec rural population in the Basin of Mexico was quite dense yet dispersed, and contour terracing was widespread (Donkin 1979; Evans 1990; Sanders, Parsons, and Santley 1979); a parallel situation is present in the Buenavista Lomas north of Cuexcomate and Capilco.

These comparative observations suggest that it is not necessary to invoke elite or state control to explain the extensive distribution of terrace agriculture in Postclassic Morelos. Rather, terrace construction and use were most likely organized on a household basis and therefore were not under centralized political control. This interpretation is supported by the spatial configuration of contour terraces, which tend to be built in short, irregular segments with little indication of coordinated planning (Price and Smith 1992: figure 10.11). Settlement at Cuexcomate was dispersed along a ridge, an arrangement that would allow each household easy access to a nearby group of agricultural terraces. This pattern is characteristic of the entire Buenavista Lomas area. Figure 8 shows a portion of Cuauhnahuac phase settlement on the Loma de Santa Clara, several km north of the excavated sites. The light-colored squares in the center of the photograph are house remains on the ridgetop, and linear stone terraces can be seen extending down the slope to the seasonal streambed at the base of the hill (at the bottom of the photo). While most of the linear features are contour terraces, there are also lines of stone running down the slope perpendicular to the terraces. The functions and significance of these descending walls are unknown at this time. Similar features are also visible among the Veracruz contour terraces depicted in Sluyter and Siemens (1992), but the authors do not offer any interpretations of their function.

## Conclusion

Agricultural terracing around the sites of Cuexcomate and Capilco was a local adaptation to the processes of population growth and colonization of new land that took place throughout the central Mexican highlands in the Late Postclassic period. In contrast to some models of Aztec society that emphasize the monolithic economic power and control of the Aztec empire (e.g., Davies 1987), our data suggest that rural society must also be understood first on a local, household level. Although the causes of the Late Postclassic population surge in Morelos and the Basin of Mexico have yet to be determined, its effects on agricultural production are clear in the archaeological record. This intensified cultivation was carried out, not in the context of centralized production by des-



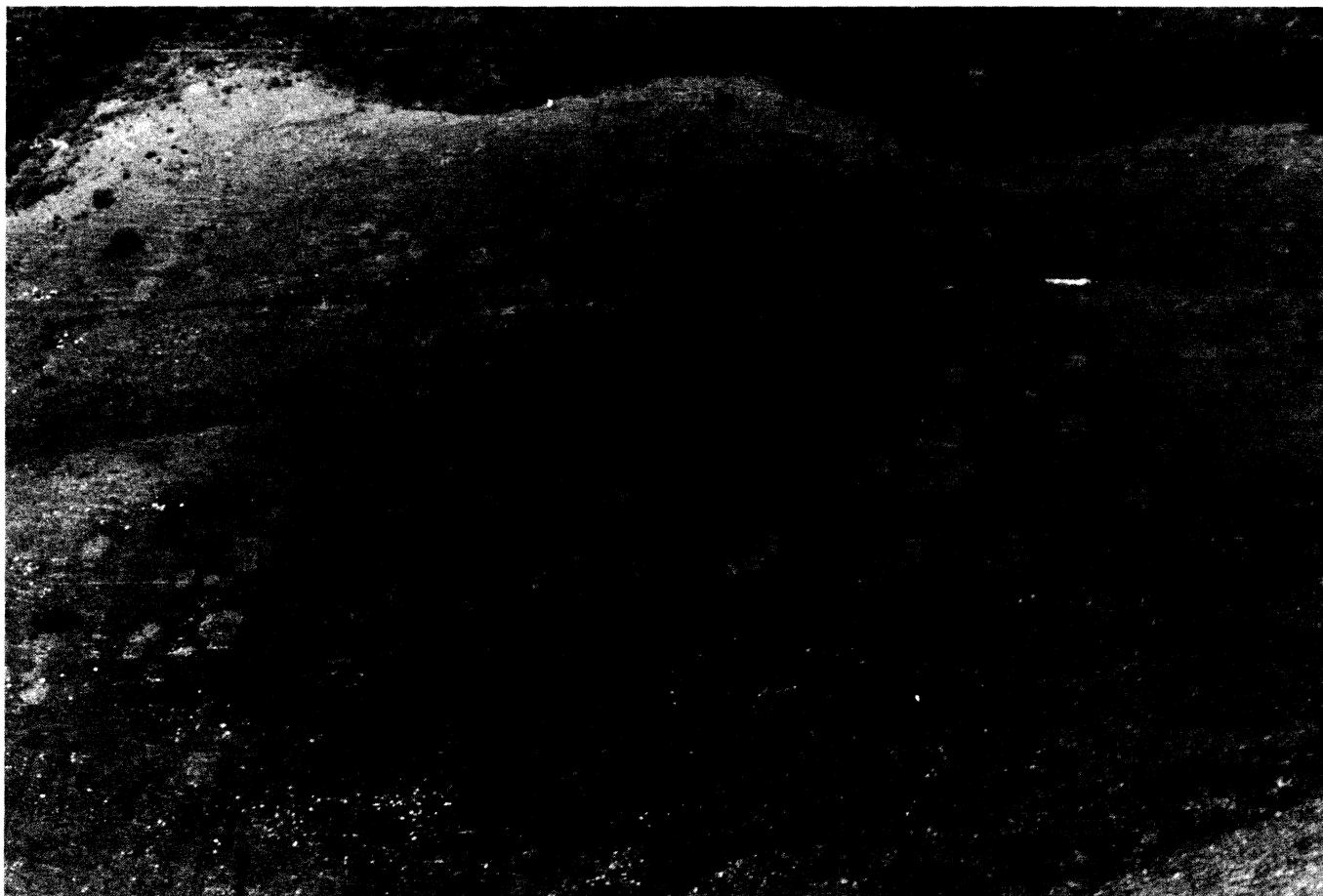


Figure 8. Low-altitude oblique aerial photograph of houses and contour terraces on the Loma de Santa Clara, Buenavista Lomas area. The white squares are Cuauhnahuac phase house remains on the ridge-top, and the short linear features are stone terrace walls. North is to the right.

potic states, but in a setting of household-level construction and use.

### Acknowledgments

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