CLASSIC PERIOD AGRICULTURAL INTENSIFICATION AND DOMESTIC LIFE AT EL PALMILLO, VALLEY OF OAXACA, MEXICO

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INTRODUCTION

The historical relationship between population and agricultural resources is at the core of many key and long-standing anthropological debates (e.g., Boserup 1965; Brookfield 1972; Brown and Podolefsky 1976; Cohen 1977; Grigg 1979; Johnson and Earle 1987; Morrison 1996, with CA comments; Netting 1993; Turner et al. 1977; Turner et al. 1993). In Mesoamerica, the arguments have focused on the distribution and relative importance of land and water as a basis for understanding and accounting for ancient population distributions and sociopolitical developments (e.g., Sanders 1972:112-113; Sanders and Price 1968). These debates have been especially lively in the Valley of Oaxaca, a key demographic and political region situated in the Southern Highlands of Mesoamerica (Palerm and Wolf 1957) (Figure 1). William Sanders and his colleagues, drawing on their investigations in the Basin of Mexico, have asserted that land quality and water resources are the most important factors for explaining prehispanic population distributions (Sanders et al. 1979; Santley 1980:137-138). They apply their model more broadly, arguing the same factors were at play elsewhere, including the Valley of Oaxaca (Sanders and Nichols 1988). In contrast, archaeologists working in the Valley of Oaxaca regard this explanation for settlement distributions, and ultimately social change, as overly narrow. Other factors (politics, economics, ideology) are stressed as equally or, at times, more important in determining settlement size and location (Blanton 1978; Blanton

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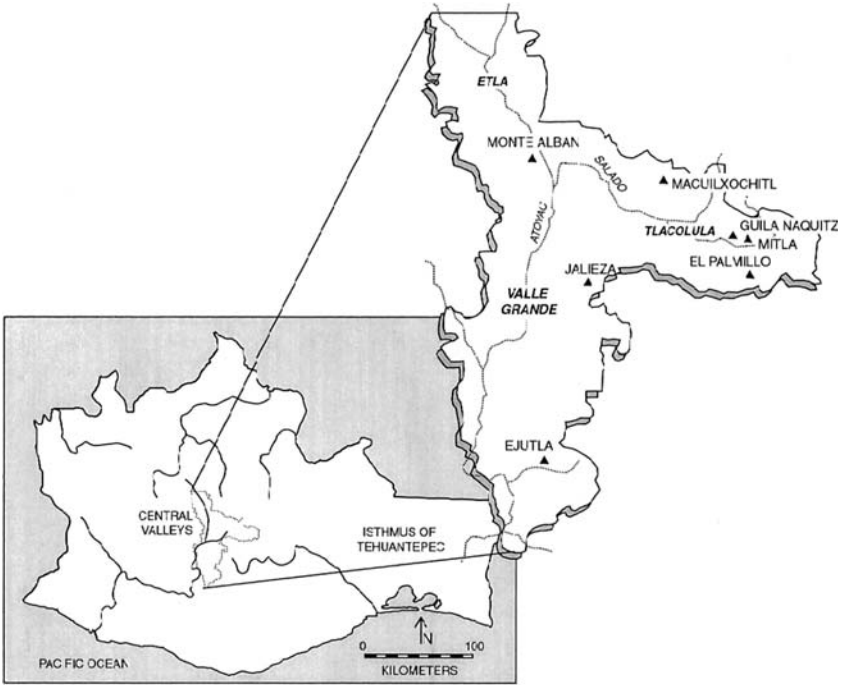

Figure 1. Map of the Valley of Oaxaca showing places mentioned in the text.

et al. 1982, 1993; Feinman et al. 1985; Kowalewski et al. 1989; Nicholas et al. 1986).

During systematic regional surveys of the Valley of Oaxaca and neighboring regions (Blanton et al. 1982; Feinman and Nicholas 1990b, 1996; Kowalewski et al. 1989), pre-hispanic settlements were not found to have been consistently concentrated near the richest valley bottomlands or adjacent to the most dependable and abundant water sources. Rather, ancient sites were dispersed throughout a wide range of ecological zones, including agriculturally marginal areas (Blanton et al. 1982, 1993; Feinman et al. 1985; Feinman and Nicholas 1990a; Kowalewski 1980; Nicholas 1989; Nicholas et al. 1986). Of course, the specific patterns of settlements varied considerably from phase to phase. Such marked diachronic differences in site location and density along with the location of some large sites at significant distances from the region's richest land and most reliable water sources provide empirical justification for questioning whether land and water alone are adequate to retrodict settlement distributions for most settings and times. For ancient Oaxaca, a series of studies (Feinman and Nicholas 1987, 1990a, 1992; Kowalewski 1980; Nicholas 1989; Nicholas et al. 1986) have been undertaken comparing empirically

	Oaxaca	**Mesoamerica**
1500		
1300		
	Monte Albán V	Late Postclassic
1100		
900		
	Monte Albán IV	Early Postclassic
700		
	Monte Albán IIIb	Late Classic
500		
	Monte Albán IIIa	Early Classic
300		
AD 100	Monte Albán II	Terminal Preclassic
BC 100		
	Monte Albán Late I	
300		Late Preclassic
	Monte Albán Early I	
500		
	Rosario	
700		Middle Preclassic
	Guadalupe	
900		
	San José	
1100		Early Preclassic
1300	Tierras Largas	
1500		

Figure 2. Valley of Oaxaca chronology.

derived settlement distributions against the spatial patterns of land and water resources. In response to earlier works that gave priority to land and water resources (e.g., Sanders et al. 1979), these Oaxaca-focused analyses have illustrated that the distribution of land and water cannot provide the explanation for the placement (or size) of archaeological settlements across the landscape (Nicholas 1989).

Of the valley's three arms, Tlacolula is the driest and least agriculturally reliable subvalley for maize agriculture (Kirkby 1973; Nicholas 1989). Yet during regional survey, crews recorded denser populations in this sector of the valley for the Classic period (A.D. 200 – 800; Figure 2) than in several other parts of the region (Kowalewski et al. 1989:208; Nicholas 1989) (Figure 3). Many of the Tlacolula sites are located on ridge summits and hilltops, far from the best farmland in the area. Access to good arable land and accessible water alone cannot explain the settlement density of Tlacolula during the Classic period (or during the subsequent Postclassic period, A.D. 800 – 1521).

In the Formative period (c. 1300 B.C. – A.D. 200), when early villages were first established in the Valley of Oaxaca, the dry eastern Tlacolula subvalley was relatively sparsely settled (Blanton et al. 1993:55-59; Kowalewski et al. 1989:64-64).

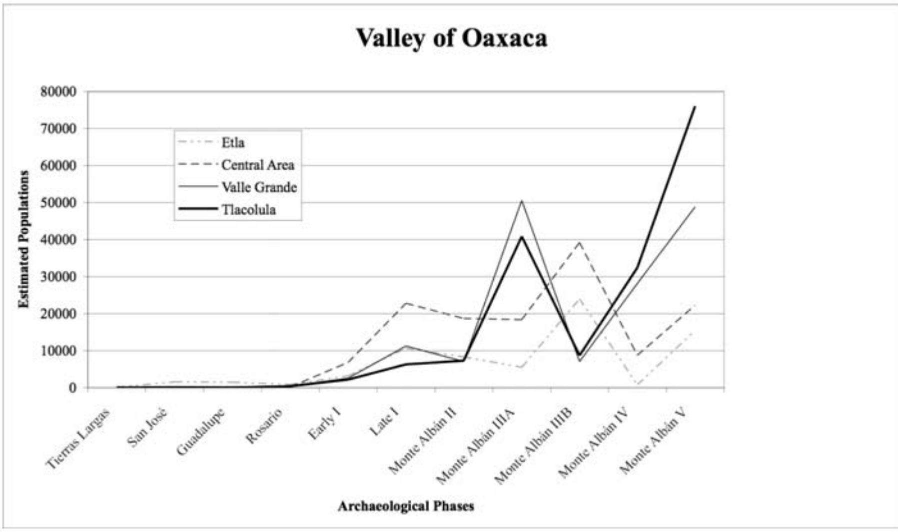

Figure 3. Estimated regional populations in the three arms and central area of the Valley of Oaxaca.

Populations continued to be comparatively depressed in Tlacolula at the time when the early hilltop city of Monte Albán was established around 500 B.C. in the center of the valley. During the centuries following its foundation, new communities were established and grew rapidly in the immediate vicinity of the expanding capital (Blanton et al. 1993:73-74). As a consequence, the population of the Tlacolula arm, especially the eastern portion of that arm, remained sparse compared to the rest of the valley.

By the Classic period, however, the population of Tlacolula increased rapidly, surpassing many other valley sectors (Nicholas 1989:497). By the Postclassic (c. A.D. 800 – 1520), Tlacolula was the most densely occupied subvalley (Kowalewski et al. 1989:312) (see Figure 3). According to 16th century documents, two of the valley's most important Postclassic communities were Macuilxochitl and Mitla, both located in eastern Tlacolula (Asensio 1905 [1580]; Canseco 1905 [1580]). The regional survey confirmed that these two sites also were two of the most extensive Postclassic settlements in the Valley of Oaxaca (Kowalewski et al. 1989:317). If land and water sources in Tlacolula are lacking in comparison to other parts of the valley, then what factors fueled this pattern of growth in the driest part of the valley?

The apparent imbalance between large populations and limited agricultural resources in Tlacolula raises a suite of questions about settlement in the driest part of the valley and how the resident population supported its food requirements. One possible explanation that we (and our colleagues) have previously proposed is the importance of domestic craft production and exchange in sustaining these Tlacolula populations (Blanton et al. 1993; Feinman et al. 2001; Finsten 1983, 1995;

Kowalewski et al. 1989). During the regional surveys, more surface indications of craft activities were recorded in Tlacolula, especially at hilltop terrace sites, than in the other valley arms or subvalleys. Given the distance of these hilltop population centers from productive well-watered land on the valley floor, we have suggested that specialized crafts were produced in order to exchange for foodstuffs. Nevertheless, subsistence dependence is a risky strategy, especially since so many of the large Classic period Tlacolula sites were positioned on ridgetops, indicating that defense may have been an important consideration in their location.

Now, several years removed from the aforementioned debates and with new data at hand, it is time to reconsider the question of Classic period and later populations in Tlacolula. Was production for exchange a key component of domestic strategies in this dry part of the valley? We see two other possible alternatives, one largely methodological, the other interpretive. Methodologically, as we all are aware (Hassan 1981:63-75), it is not a simple matter to derive population estimates from surface settlement pattern findings. The population figures that we estimated for Tlacolula were derived using procedures (Blanton et al. 1982:10-11; Feinman et al. 1985:336) comparable to those followed elsewhere in the region and highland Mesoamerica (Parsons 1971:23; Sanders 1965:50). Nevertheless, is it possible that estimated populations for this eastern arm of the valley were inflated? Much of the Tlacolula population was concentrated in defendable and elevated terrace sites. Were these settlements short-term military redoubts rather than hilltop towns? Although our own interpretations never were in line with such a view, until recently we lacked the empirical basis to assess this alternative.

More significantly, over the past decade or so, new empirical findings from central Mexico (Evans 1990; Parsons and Parsons 1990) have begun to question the overwhelming and universal importance that has been given to maize agriculture in prehispanic Mexico. Is it possible that both the initial attempts to use land and water resources to predict settlement patterns (e.g., Sanders 1972; Sanders and Price 1968) as well as the counterefforts designed to assess such views (e.g., Kowalewski 1980; Nicholas 1989) have given too much weight to maize? As some are coming to suspect for central Mexico (Parsons and Darling 2000a; Parsons and Parsons 1990:6), perhaps the importance of maize as an agricultural staple throughout the Valley of Oaxaca has been overemphasized. Were other kinds of agricultural production and intensification feasibly employed in the dry Tlacolula arm?

A basic assumption of most prior research on all sides of the issue has been that maize agriculture, largely reliant on flat land and available water, formed the foundation of prehispanic subsistence systems for populations throughout highland Mesoamerica (Sanders and Price 1968:9, 87), including the Tlacolula arm of the Valley of Oaxaca (Kirkby 1973; Kowalewski 1980; Nicholas 1989:452). Accordingly, the potential (based on the availability of water and flat land) to intensify maize production in Tlacolula was viewed as limited. Given this focus on maize, the hypothesis that populations in drier parts of the valley may not have relied as heavily on maize or other traditional resources, instead exploiting local xerophytic plants that are known to have economic uses both as food and economic raw materials, has not been satisfactorily assessed.

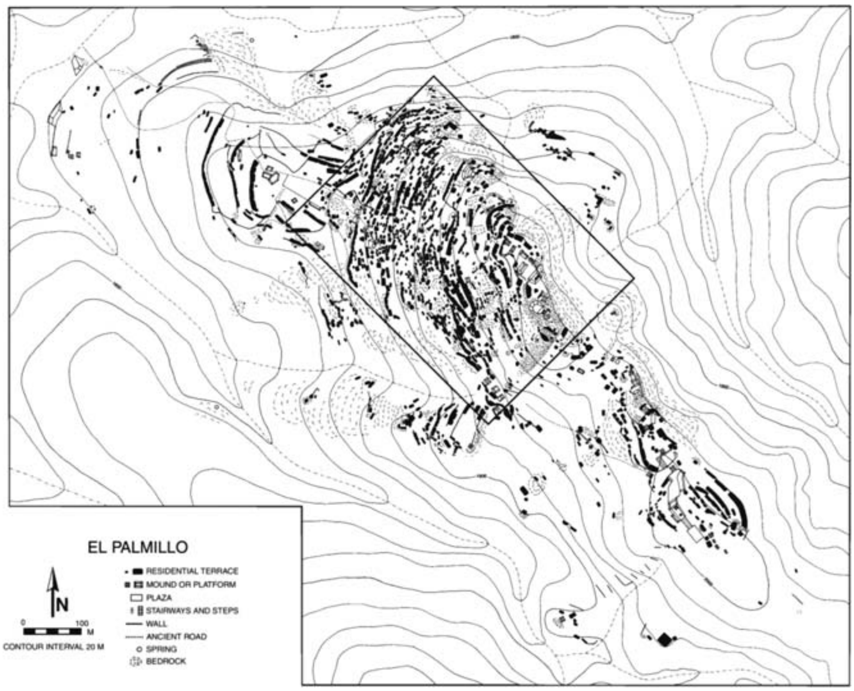

Figure 4. Map of El Palmillo, showing the distribution of terraces on the slopes and monumental architecture on the ridgetop. The area inside the box is enlarged in Figure 5.

In this chapter we draw heavily on recent archaeological and botanical findings from the site of El Palmillo, a large Classic period hilltop terrace settlement in eastern Tlacolula (Figure 4). New data are presented that allow us to inform the series of alternatives that have been advanced above to account for the relatively high prehispanic population density in Tlacolula during the Classic (and by extension the Postclassic) period. To begin, we provide a brief background to the Valley of Oaxaca and our investigations at El Palmillo. Then, in light of the El Palmillo research, we return to the question of population estimates, the previously proposed interpretation of specialized craft production for exchange, and the hypothesis that perhaps much previous research has depended too heavily on maize agriculture at the expense of other resources and their intensification.

THE VALLEY OF OAXACA

Surrounded by the rugged mountains of the Sierra Madre, the Valley of Oaxaca is the largest expanse of flat arable land in the Southern Highlands of Mexico (Kirkby 1973). This Y-shaped valley comprises three smaller subvalleys – the Valle

Grande to the south, Etla to the north, and Tlacolula to the east – that are formed by the drainage basins of the Atoyac and Salado Rivers (see Figure 1). The valley floor is approximately 1500 meters above sea level, so frost is rare and the temperature is mild. These conditions change as one ascends the surrounding slopes that reach heights of 3000 meters above sea level. Rainfall in the valley ranges between 400 to 800 millimeters, but other water sources, especially the Atoyac River and its tributaries, also are present and afford some opportunities for small-scale irrigation.

The terrain in the Valley of Oaxaca can be classified into three broad ecological zones – alluvium, piedmont, and mountain (Kowalewski 1980). Yet it is not solely the geophysical morphology of the landscape but more importantly accessibility to water that determines the potential agricultural productivity of the area (Kirkby 1973; Messer 1978; Nicholas 1989). The Valle Grande, the largest of the three subvalleys, receives slightly more rainfall annually than the others so dry farming (rainfall dependent) is generally more successful in that area. The Valle Grande also contains land that can easily be cultivated through irrigation, drainage works, or by tapping the high watertable (especially in the alluvial zones). The smaller Etla subvalley has the best irrigation potential and therefore the most secure agricultural base. Tlacolula to the east has the most arid and marginal lands (for maize) in the valley, receiving less rainfall than the other two arms. With less irrigation potential, maize farming in much of Tlacolula is often risky (Kirkby 1973; Kowalewski 1980; Nicholas 1989). Generally, as one moves to the east in Tlacolula, the conditions for maize deteriorate.

The moderate climate and abundant natural resources (edible plants and water) made the Valley of Oaxaca an ideal location for human occupation. Several Archaic period (9000 – 2000 B.C.) rockshelters have been found in the eastern part of the valley. Botanical material recovered from excavations at Guilá Naquitz (a small cave site dating to 8750 – 6670 B.C.) document a range of wild indigenous plants that the early inhabitants of the valley utilized for food (Flannery 1986). Residence patterns changed with the shift to agriculture at the end of the Archaic. The first permanent agrarian-based settlements date to the mid-second millennium B.C. (Blanton et al. 1982, 1993; Flannery 1983b; Kowalewski et al. 1989). Settlements are found throughout the valley by the Tierras Largas phase (1400 – 1150 B.C.), yet most of the region's population was concentrated in Etla (Blanton et al. 1993:56; Kowalewski et al. 1989:55). The remaining population was dispersed across the other valley arms, with only one settlement in Tlacolula.

Settlement patterns changed little in the valley until the Late Formative (Monte Albán Early I, 500 – 300 B.C.), when Monte Albán, the new capital, was settled on top of a cluster of high hills in the previously underutilized center of the valley. Situated roughly 400 meters above the valley floor, Monte Albán is the earliest terraced hilltop settlement in the region (Blanton 1978). Monte Albán's population grew quickly, as did the population in nearby areas. Demographic changes occurred at a slower tempo in Tlacolula (Feinman et al. 1985:345).

By the Classic period (A.D. 200-800), however, demographic patterns shifted, so that population densities in Tlacolula became as high or higher than in other parts of the valley (see Figure 3). Many of the largest Classic period centers in the entire region were the terraced hilltop sites located in the Tlacolula subvalley (Feinman and

Nicholas 1990a, 1996; Kowalewski et al. 1989:241). These sites account in large part for the rapid population rise in that part of the valley during the Classic period. Population densities remained high in Tlacolula up to the arrival of the Spanish in the early 1500s (Feinman and Nicholas 1990a; Kowalewski et al. 1989:312).

As noted above, the archaeological findings of dense populations in Tlacolula during the Classic and Postclassic periods, higher than found in other, wetter parts of the valley, are worth considering in more depth. Many of the terrace sites in Tlacolula, which account for much of the estimated population, are located at the edges of the valley, in piedmont locations far from the more productive valley floor. With populations at many of these hilltop sites estimated in the thousands, they frequently exceeded the agricultural potential (based on maize farming) of their immediate sustaining areas. One such Classic period site in the Tlacolula subvalley is El Palmillo.

EL PALMILLO

Located high in the eastern piedmont of the Tlacolula subvalley, El Palmillo did not receive any attention from archaeologists until 1980 when it was visited and mapped as part of the regional survey of the Valley of Oaxaca (Kowalewski et al. 1989:241). The site was revisited in 1997 as part of a program of intensive mapping and terrace-by-terrace surface survey at several hilltop sites in eastern Tlacolula (Feinman and Nicholas 2000a, 2004b). With over 1400 terraces recorded and mapped at the site during the intensive mapping work (see Figure 4), El Palmillo clearly is one of the largest hilltop terraced sites in the entire valley.

Situated between 1760 and 2010 meters, the site occupies the apex and steep slopes of a high piedmont ridge overlooking the modern town of Santiago Matatlán. To the north and east the rocky hill descends sharply, making access to the site from those sides virtually impossible. The southern and southeastern slopes are cut by deep gullies interspersed with steep slopes. The western face is more accessible, although to reach the top requires an arduous climb.

The ridgetop is divided in two halves by a low saddle. The northern hill, the site's highest point, has steeply sloping sides and extensive natural bedrock outcrops. Most of the site's monumental architecture, which often incorporates the natural bedrock, was constructed on this ridge. Terraces are densely packed on the western face descending the northern hilltop. The lower, southern part of the ridge is flatter with fewer outcrops. There is less public architecture to the south, consisting largely of low platforms, and many fewer terraces.

Although access into the core of the site is easiest on the western face, passage is impeded by strings of terraces with high stone retaining walls. In some places as many as 10 terraces shared a single unbroken wall. As much as 2 to 4 meters high in places, these retaining walls form an imposing gauntlet for anyone attempting to reach the site center, even today. Although from the outset our working hypothesis has been that most of the terraces were in fact residential (Feinman et al. 2001, 2002), the high retaining walls also served a defensive function, preventing unrestricted access to the core of the site. Some of the terrace strings near the base of the hill abut steep impassable bedrock on either end. Narrow roads and stairways do run between some of these terraces and up onto the site, so that access could have been monitored in some manner (e.g., Hirth 1982:323).

Based on survey findings (Feinman and Nicholas 2004b), El Palmillo was initially settled during Monte Albán Late I (300 – 200 B.C.), when there was a significant but dispersed settlement of about 4 hectares at the higher reaches of the site, especially on the ridgetop saddle and southern apex. In Monte Albán II (200 B.C. – A.D. 200), settlement shifted to the northern part of the ridge and its descending slopes, and the area of settlement more than doubled.

As noted previously, the Early Classic (Monte Albán IIIa, A.D. 200 – 500) was a time of intense settlement expansion in the eastern part of the Valley of Oaxaca, when many terrace sites were densely settled. El Palmillo reached its greatest extent in the early Classic, extending over 90 hectares and including all habitable areas on both ridgetops and the descending slopes. Most of the 1400 terraces on the site were occupied in Monte Albán IIIa and IIIb/IV (A.D. 200 – 900).

Although occupation at the site continued until the arrival of the Spanish, the settlement was smaller during Monte Albán V (c. A.D. 900 – 1520). Although some settlement remained on the ridgetop, the last prehispanic community was focused on the lower slopes; some of these lower areas continued to be occupied at least until the outset of the colonial period.

How did the residents of El Palmillo sustain themselves in the arid environment of Tlacolula? Two year-round springs and two small seasonal streams are located at the base of the hill, and several smaller springs are dispersed across the site's outcropping bedrock. Yet none of these sources are near large tracts of farmable land. The nearest areas of well-watered farmland are located on the valley floor (Kirkby 1973; Nicholas 1989), several kilometers west of the site. With maize agriculture unreliable (as it is in the vicinity of the site today), did El Palmillo's residents grow other crops or largely receive foodstuffs through exchange? What was the role of specialized craft production? What items (if any) were crafted for trade? Were there resources other than the traditional seed crops (maize) that were important in the diet? What were these plants and their uses? Were economically useful plants present on site in quantities that would indicate prehispanic intensification? In part to address these questions regarding how the residents of Oaxaca's terrace sites supported themselves in seemingly marginal environments, we began excavations in 1999 on a series of El Palmillo terraces.

Because many of the vestigial plant species on site are (or were until recently) considered economically useful (as food or sources of other commodities such as fiber) by the current inhabitants of Matatlán, we completed a botanical survey of El Palmillo (Middleton et al. 2001). To evaluate whether the plant community on site might be a relict of prehispanic gardening (e.g., Bohrer 1991; Folan et al. 1979; Martínez y Ojeda 1996), we also undertook a botanical census of a nearby hill that was similar in elevation, slope, and orientation. This adjacent hill serves as a "control site."

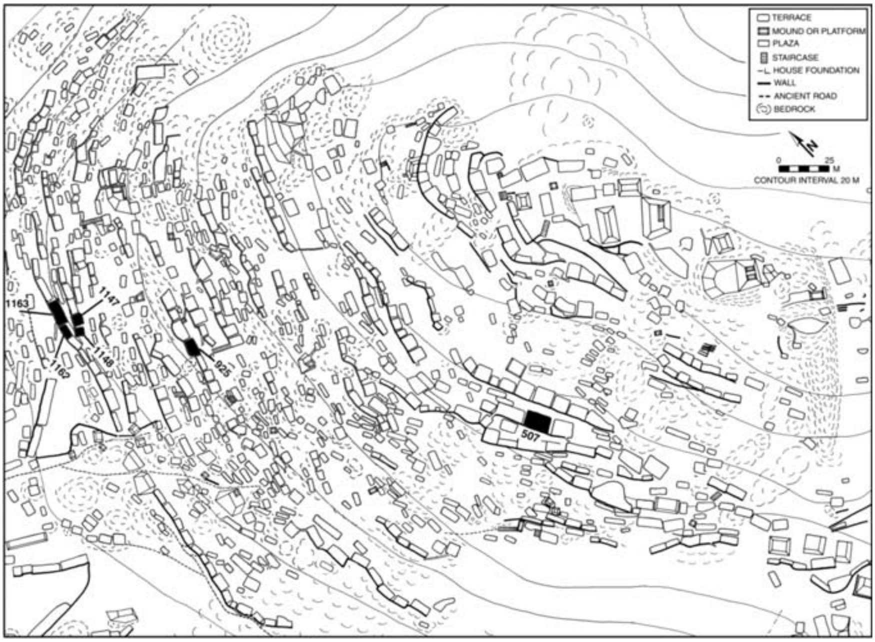

Figure 5. Location of the excavated terraces at El Palmillo.

RESIDENTIAL TERRACE EXCAVATIONS

Because our interests concerned domestic activities and how terrace site residents supported themselves, we chose to begin our excavations near the bottom of the hill, far from the civic-ceremonial structures on the ridgetop. We exposed an area of approximately 500 square meters on four adjacent terraces near the base of the hill in 1999 and 2000, 160 square meters on another terrace approximately 100 meters farther upslope in 2001, and an additional 215 square meters on a single terrace about 100 meters below the site's summit in 2002 (Figure 5). The four lower terraces shared two high stone retaining walls. The two upper terraces also were parts of strings of terraces, although we excavated only one terrace in each string.

Our excavation strategy was to open large contemporaneous surfaces, or "living floors," following natural stratigraphic levels whenever possible. These broad horizontal exposures were excavated in a series of contiguous 2 x 2 meters units gridded across the terraces. All deposits were screened with 1/8 or 1/4 inch mesh (depending on context) to recover by-products and residues of manufacturing and other activities. Soil samples for flotation and for chemical analysis of residues were taken from all floor deposits and from other selected contexts (e.g., Metcalfe and Heath 1990; Widmer 1991). Light fractions were collected to recover plant remains, and heavy fractions were saved for microdebitage analysis.

Figure 6. Residential complex on Terrace 925.

During the excavations, we found that architectural and other domestic features (rooms, patios, oven, burials) occupied virtually all the available flat space on the terraces (Figure 6). Little, if any, of the flat space created behind retaining walls was available for gardens or the cultivation of crops. The basic architectural layout on the terraces was a residential complex consisting of three or four rooms around an open central patio, similar to the plan of residential complexes on several Classic-period terraces excavated by Marcus Winter (1974) at Monte Albán. At El Palmillo, the complexes included a long rectangular room constructed with foundations of flat shaped stones and plastered floors that was situated at the back, upslope (east) edge of the terrace. These rectangular east rooms generally were linked with one or more smaller, square rooms or structures to the south and north, forming arrangements of rooms around a patio that was open to the west (the front, or downslope edge of the terrace). The central patios were plastered, although the plaster was often poorly preserved, indicating they were unroofed and exposed to the elements. The

Figure 7. Crew excavating large oven at El Palmillo.

interment of individuals in household contexts was a common practice among pre-hispanic Mesoamerican people (Feinman and Nicholas 2000b; McAnany 1995; Middleton et al. 1998; Winter 1974). At El Palmillo we recovered the remains of 81 individuals (including males, females, and children) on the six terraces, mostly in the patios, beneath house floors, or in terrace walls. Most of the adult interments and a few of the children were buried with one or more ceramic vessels. A few adults were buried with jade beads, but generally most interments contained few grave goods. Overall, the burial population is composed of young and old, and we have an almost balanced ratio of identifiable males to females. These findings would seem to conform to the expectations for household composition, much like that found for the terraces at Monte Albán (Winter 1974).

A variety of fire installations (especially small hearths and ash pits) were unearthed on the excavated terraces. A small kiln on one of the lower terraces was used to fire ceramics. Although several ash pits on other terraces may just be small refuse dumps, some ash pits had been used to fire small quantities of pottery. On the lower terraces we also uncovered two large ovens that appear to have been utilized to roast maguey (Figure 7). When uncovered, they were filled with dark black ash, charcoal, and fire-cracked rock, and closely resemble ovens used today in Santiago Matatlán for cooking maguey hearts in the process of making mescal (Middleton et al. 2001; see also Flannery and Marcus 1983; Serra Puche et al. 2000), a postcolonial alcoholic beverage. Similar prehistoric agave roasting ovens have been reported in the American Southwest (Fish et al. 1992; Van Buren et al. 1992).

Based on ceramic associations, the excavated terraces at El Palmillo were constructed early in Monte Albán IIIa (c. A.D. 250 – 350). After initial construction, the terraces and the residential structures on them were periodically rebuilt and renovated. Some of these rebuilding episodes involved considerable movement of earth and stone as front terrace walls were raised and tremendous amounts of fill were brought in behind these walls, increasing the area of flattened space on the terraces. The residential complexes often were rebuilt in the same basic configuration but were repositioned just a bit up the slope. At junctures between major episodes of reconstruction, room floors often were replastered. These modifications to the terraces did not occur on an individual basis but rather involved the organization and cooperation of the residents from several adjacent terraces.

The findings from the terrace excavations at El Palmillo are in line with both Winter's (1974) studies at Monte Albán and earlier systematically recorded observations from regional and intensive surveys in the Valley of Oaxaca (Blanton et al. 1982; Feinman and Nicholas 1990b, 1996, 2004; Finsten 1995; Kowalewski et al. 1989). Each of these works points to a heavy residential use of terraces at these hilltop Oaxaca sites. In fact, if the density of residential complexes on the excavated terraces at El Palmillo is representative of other terrace sites in the region, we would propose that, if anything, prior population estimates for most Oaxaca terrace sites are likely to be a bit conservative. These hilltop sites were compact settlements, often with tightly packed and clustered terraces. Although postabandonment farming does not appear to have been a major problem at El Palmillo, it likely was more destructive at other, more accessible terrace sites. Consequently, at certain locales, the number of terraces could have been slightly greater than was estimated during the systematic surface walkovers.

Furthermore, the persistent pattern of terrace rebuilding over centuries at El Palmillo has revealed that these terrace sites were hill towns rather than short-term military redoubts. The presence of women and children in graves would seem to support this interpretation. The deciphered meaning of the Zapotec "hill glyph" as a signifier of place (Batres 1902; Caso 1947; Marcus 1983) also would seem to tie in to the residential character of these elevated terrace communities. Hill glyphs also are present in Mixtec codices from Oaxaca (Furst 1978:254-255). So the recognition that hills may be associated with important residential communities may have a degree of local confirmation. Yet if Classic period settlements, like El Palmillo, had sizable populations that lived at these sites for centuries, we are left to consider how the residents of this dry sector of the valley fulfilled their basic food needs.

SPECIALIZED CRAFT PRODUCTION AND EXCHANGE

More than two decades of research has illustrated that specialized craft production was an important domestic activity in prehispanic Mesoamerica (Balkansky et al. 1997; Charlton et al. 1991; Feinman 1999a; Feinman and Nicholas 1993, 1995; Otis Charlton et al. 1993; see also Costin 1991). As noted previously, the importance of such activities at terraced settlements, especially in drier sections of the Valley of Oaxaca, long has been suspected (Finsten 1983, 1995; Kowalewski et al.

1989). Because many of the items manufactured at these sites were produced in volumes greater than can be accounted for by household or local consumption (Feinman et al. 2001, 2002), it is likely that these goods were produced for exchange (Feinman 1999a; Feinman and Nicholas 1993, 1995, 2000b, 2004a).

Nothing that we have uncovered at El Palmillo leads us to change our preexisting hypothesis that craft production was a key component of the site's economy. An important activity at El Palmillo was the production of chipped stone tools. Using the abundant sources of local chert, the inhabitants of El Palmillo produced a variety of tools, including abraders, generalized bifaces and unifaces, perforators, projectile points, and a variety of scrapers. These formal tools and other finished chert artifacts account for approximately 2% of the total chert assemblage (just under 40,000 pieces from excavated deposits). The low proportion of tools compared to flakes and debris (and the overall ubiquity of chert at the site) would seem to indicate that stone tools were manufactured for exchange, at least to other parts of El Palmillo and more likely also to other sites in the region. Chert (or other suitable) resources for chipped stone tools are not uniformly available in the Valley of Oaxaca (Whalen 1986); therefore, it seems possible, if not likely, that chert tools, cores, and nodules may have been prepared and exported off site.

The distribution of the recovered chert tools and debris was not uniform on the excavated terraces, indicating minor variations in activities among the settlement's residents (Haines et al. 2004). The highest quantity of chert debris was recovered from one of the lower terraces, in locations that appear to have been used as outdoor work areas. This debris included a large amount of production debris (flakes, chips, etc.), some of which had been utilized as expedient tools. In contrast, there was less production debris and so higher proportions of formal tools on the upper terrace. Lithic reduction and tool production for exchange appears to have been more actively engaged in by inhabitants of the lower terraces, while the upper terrace residents used these stone tools in other craft specializations.

An abundant class of chert scraper at the site, scraper or pulping planes (*raspadores*), long have been associated with maguey (*Agave* spp.) and the extraction of fiber from that plant's pulpy leaves (Hester and Heizer 1972; Robles 1994; see also Bernard-Shaw 1990; Fish et al. 1992) (Figure 8). Large ceramic spindle whorls, in the size range typically used to spin maguey fibers (Parsons and Parsons 1990:177; Parsons 1972:61), also are fairly common, especially on the lower terraces. Many of the bone tools recovered during the excavations, including battens, needles, perforators, and spindle whorls, are associated with sewing and weaving. Consequently, it appears that the production of maguey fiber (*ixtle*) and textiles also was important at El Palmillo. Later Aztec accounts list maguey textiles as an important tribute item (Anawalt 1981; Barlow 1949; Berdan 1987); thus during the Postclassic period maguey fiber was manufactured for exchange in Mesoamerica. Given the prehispanic value of textiles, it seems likely that at least some of the textiles produced at El Palmillo were made for the purpose of exchange.

Other items recovered during the excavations at El Palmillo were imported to the site, some from great distances. Excavations on the upper terrace yielded hundreds of obsidian blades and blade fragments as well as several greenstone objects,

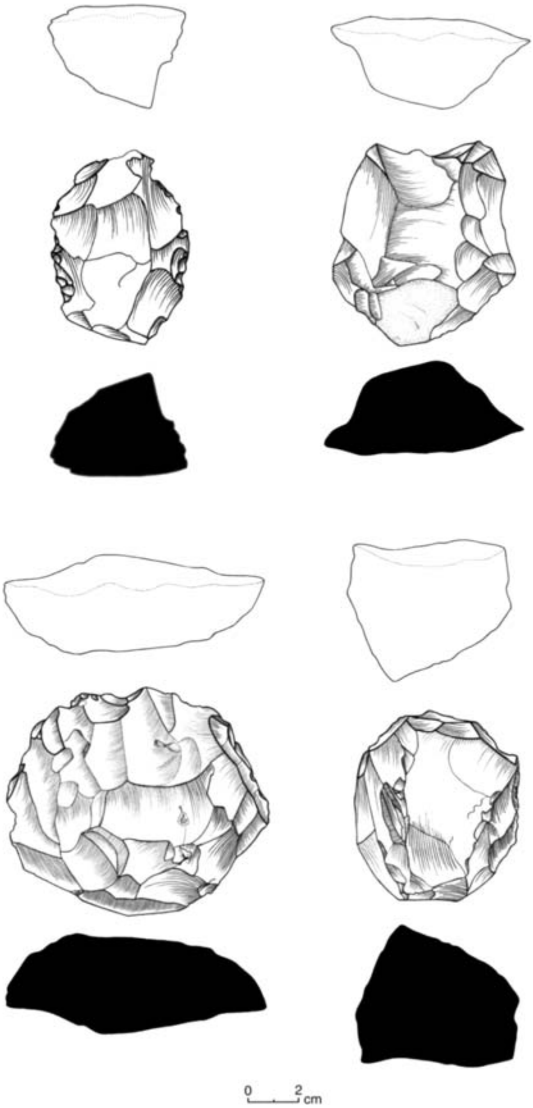

Figure 8. Examples of scraper planes (*raspadores*) from El Palmillo.

from nonlocal sources (there are no known obsidian sources in Oaxaca). Worked marine shell from the Pacific Coast also was brought to the site in small quantities. Goods produced at El Palmillo likely were exchanged for these nonlocal products (and perhaps certain raw materials). Although we cannot document or identify whether or which crops were imported to the site or how much, we suspect that local goods and products were exchanged for edible items produced elsewhere, likely including maize. Yet until we have a better understanding of what local plants, if any, were available, it is difficult to evaluate the overall importance of exchange for subsistence needs.

PLANTS AND INTENSIFICATION AT EL PALMILLO

Maize has traditionally been considered one of the dominant prehispanic cultigens in Mesoamerica (Kirchhoff 1943; Sanders and Price 1968:9; Wolf 1959). Nevertheless, the location of settlements in areas where maize farming could be considered only marginal (or worse) opens questions regarding whether maize was a staple crop for all inhabitants of the Valley of Oaxaca. Rainfall in eastern Tlacolula today is barely sufficient for maize cropping, and crops fail frequently in dry years (Druijven and Kruithof 1992; Kirkby 1973; Kowalewski 1982). According to colonial era accounts (del Paso y Troncoso 1905 [1579-1581]:149-150), maize was seldom consumed in the Tlacolula subvalley near Mitla and Matatlán. Corn was not present in sufficient quantities to support the inhabitants of the area (Horcasitas and George 1955:21). Given the absence of a conjunction between reliable water sources and flat farmland near the base of El Palmillo, it seems doubtful that maize could have been grown in sufficient quantities to support the thousands of occupants that likely inhabited the site during its Classic period apex.

Under semiarid conditions, certain kinds of terracing can provide a more suitable environment where maize and other crops may grow successfully (Donkin 1979; Downum et al. 1985, 1993:81; Fish et al. 1984; Smith and Price 1994). Yet at El Palmillo there was little free, flat space on the terrace surfaces where crops could have been cultivated. It is possible to erect small dams or retaining walls across depressions or gullies (*barrancas)* in the bedrock to create small plots of land (*lama-bordo;* Spores 1969) that take advantage of soil and water run off (e.g., Donkin 1979 Wilken 1987), and several possible *lama-bordos* have been noted near the base of the hill. Yet the available plots and farmable crevices are far too small to have produced crops in the quantities needed to support the population of El Palmillo.

Although most of the flattened space on the terraces was occupied by domestic architecture, plants adapted to rocky terrain could have been fostered and cultivated along the terrace walls and edges. Terrace walls at the site currently support dense xerophytic (drought tolerant) vegetation, particularly during the wet season. Xerophytic plants such as cacti and maguey could easily have been planted on the sloping retaining walls of the residential terraces in the past, providing not only some privacy (Parsons 1936:9) but also reinforcing the walls and preventing erosion (Ortiz de Montellano 1990:97; Patrick 1985; Wilken 1987:105). Most of these sloping and rocky spaces are less amenable to growing seed crops, but they seem to provide little obstacle for cacti and succulents (Cook 1949:25).

The use of xerophytic plants as food, medicine, and sources of fiber has a long history in the Valley of Oaxaca (Flannery 1983a, 1986; Flannery and Spores 1983; King 1986; Smith 1978, 1986). Archaic period (c. 9000 – 2000 B.C.) occupants of the Valley of Oaxaca relied on a variety of xerophytic plants as part of their diet, including seeds from nanche (*Malpighia* sp.) and prickly pear (*Opuntia* sp.), biznaga (*Ferocactus recurvus*), maguey (*Agave* spp.), and susí nuts (*Jatropha* sp.) (Flannery and Spores 1983:22). *Opuntia* spp. remains also are found at later Formative period (c. 1500 – 200 B.C.) villages (Whalen 1981:192).

A botanical study by Martínez y Ojeda (1996) confirmed the presence of many of these same plants on the grounds of the archaeological zone at the long-inhabited site of Yagul (Bernal and Gamio 1974), also in eastern Tlacolula and no more than 20 kilometers from El Palmillo. We also had previously observed that most of these same economically important xerophytic plants were more common at El Palmillo than on the neighboring hills and in the rest of the terrain of Santiago Matatlán. Thus we reasoned that the current plant populations at El Palmillo (and other archaeological sites in the region) may reflect residual or vestigial growth from prehispanic cultivation.

The Botanical Survey

To assess our hypothesis that the present plant community at El Palmillo is a relict of prehispanic activities at the site, we completed botanical surveys of El Palmillo and a nearby "control" hill that was similar in altitude and topography (Middleton et al. 2001). The control hill lacked surface indicators of ancient settlement and thus served to document a native plant community that was markedly less affected by prehispanic human activity. Several local informants assisted with the identification of the principal plant species. Our local informants often were aware of plants that were unique to one hill or the other, although this was checked during the botanical survey. The informants also provided local Spanish and Zapotec names for the plants, as well as local knowledge regarding economic uses. We identified as many plants in the field as possible and collected specimens of both identified and unidentified plants at El Palmillo for later identification and storage at The Field Museum. In Chicago, we were able to make additional plant identifications relying on the collections and resources at the museum (see Table 1 for a list of identified plants at El Palmillo and their economic uses). Several illustrated publications also were especially helpful in this endeavor (García-Mendoza et al. 2004; Martínez y Ojeda 1996, 2004; Pesman 1962; Reyes Santiago et al. 2004; Werling 2001).

The main species at both El Palmillo and the control site include a variety of economically useful plants that are present throughout the immediate area and form the backbone of the local natural floral community (see Martínez y Ojeda 1996). Most are native to the area; remains of many of the plants have been recovered from Archaic period deposits (Smith 1986). Common are *Dodonaea viscosa* (jaras), *Ipomoea murucoides* (pájaro bobo), *Lippia berlandieri* (salvia de castilla), *Lantana camara* (zapotillo), and two species of *Mammillaria* (both commonly called chilillo), all of which have medicinal properties. *Lantana camara* and *Mammillaria spp.* also produce edible fruits, as do *Myrillocactus schenckii* (garambullo), *Stenocereus treleasei* (tunillo), and both species of *Opuntia (pilifera* and *pumila)* found at El Palmillo. Two species of maguey (*Agave karwinskii* and *A. potatorum),* both of which are used for food and fiber, were observed at both locales.

Figure 9. Palmillo plants (*Yucca periculosa*) on the site.

During the botanical survey, we documented several economically useful species that are present only at El Palmillo (and not on the control site) or that are considerably more common at El Palmillo than in the surrounding region (Middleton

Figure 10. Uncultivated maguey plant (*Agave marmorata*) on the site.

et al. 2001). In contrast, there are no economically significant species present on the control hill that were not also observed at El Palmillo. One of the most visible species present only at El Palmillo is *Yucca periculosa* (locally called palmillo). Various species of *Yucca* have been used for fiber and food in both Mexico and the southwestern United States (Anawalt 1981; Ebeling 1986:472-474, 675; Martínez y Ojeda 1996:66; Sheldon 1980) (Figure 9).

The most significant difference between El Palmillo and the control site, however, is in the distribution of maguey (*Agave* spp.) varieties (Figure 10). Of eight different species of maguey recorded at El Palmillo, six species (*Agave angustifolia, A. americana, A. kerchovei, A. macroacantha, A. marmorata,* and *A. rhodacantha)* are not found in the control area (Middleton et al. 2001). Although the remaining two species (*Agave karwinskii* and *A. potatorum)* are present on the control site and throughout the area, they are more common at El Palmillo than elsewhere. All of these varieties were used for food and/or fiber in the past, and most still are today.

Different varieties of maguey often prefer very specific locales and conditions (Gentry 1982). Sánchez López (1989:34) lists eight species of *Agave* for the Tlacolula subvalley. These are the same eight species present at El Palmillo, yet no community in Sánchez López's study had more than three to five species of *Agave*. Patrick (1985:544) reports a similar checkerboard pattern for different *Agave* varieties in contemporary southern Tlaxcala; although local inhabitants recognize as many as a dozen varieties, no more than four or five are found in any one community. Given the range of *Agave* species that still grow at El Palmillo, we suspect that some

Figure 11. Nopal plant (*Opuntia pilifera*) on the site.

of the maguey species at El Palmillo were taken to the site from nearby areas and were fostered or husbanded on site in prehispanic times for their economic and food value; similar practices have been documented in the American Southwest (Bohrer 1991; Hodgson 2001; Hodgson and Slauson 1995; see also Folan et al. 1979)

Based on the marked abundance of *Agave* spp., *Opuntia* sp. (Figure 11), and other economically useful botanical resources that are more prevalent at El Palmillo than elsewhere in the surrounding region, we believe that the site's plant community is a relict of the prehispanic habitation of the hill. At present, we cannot completely rule out that the clustering of economically valuable plant resources on El Palmillo reflects postcontact period use, but that seems highly unlikely. No other hills in the area that also lack modern occupation have this suite or range of economically useful plants. Some of these hills are closer to the modern village or the colonial period hacienda near Matatlán than El Palmillo is. Nothing we have observed leads us to believe that El Palmillo's locale has been used to foster these plants subsequent to its prehispanic abandonment.

Given the economic and dietary usefulness of the identified xerophytic plant community, we propose that these plants were an integral part of the economy and subsistence base of El Palmillo. Below we focus on three economically important xerophytic plants – maguey, yucca, and nopal – that are especially abundant at El Palmillo. With nopal we include a discussion of cochineal. Nopal (*Opuntia pilifera*) is one of the major host plants for the parasitic insect that produces cochineal, a red dye that was very important in Postclassic and colonial Mexico (Anawalt 1981; Baskes 2000; Berdan and Anawalt 1997; Donkin 1977; Hamnett 1971).

Maguey

Maguey (*Agave* spp.) has long been recognized as a highly versatile and economically important plant in highland Mexico, where its use has been well documented ethnohistorically (Beals 1975; Malinowski and de la Fuente 1982; Parsons 1936; Parsons and Parsons 1990) and prehispanically (Anawalt 1981; Callen 1965, 1967; Cook 1949; Ebeling 1986; Evans 1990; Gonçalves de Lima 1956; King 1986; MacNeish 1967; Ortiz de Montellano 1990; Smith 1967, 1986; Smith and Kerr 1968). Maguey, however, generally has not been considered a staple food but rather seen as a marginal dietary supplement that was not intensively used (e.g., Colunga-GarcíaMarín et al. 1993). Yet the Aztec did place important iconographic and cosmological significance on maguey (Martín del Campo 1938; McCafferty and McCafferty 1991; Ortiz de Montellano 1990; Quiñones Keber 1989; Taube 1993).

A sixteenth century account by Francisco Hernández highlights what a significant resource maguey was for the indigenous populations:

> "As a whole it [maguey] can be used as fuel or to fence fields. Its shoots can be used as wood and its leaves as roofing materials, as plates or platters, to make paper, to make cord with which they make shoes, cloth and all kinds of clothes…From the sap…they make wines, honey, vinegar and sugar…From the root, they also make very strong ropes which are useful for many things. The thicker part of the leaves as well as the trunk, cooked underground…are good to eat and taste like cidra (a citruslike fruit) with sugar…This plant, by itself, could easily furnish all that is needed for a simple, frugal life since it is not harmed by storms, the rigors of the weather, nor does it wither in drought. There is nothing which gives a higher return" (Hernández 1959 [1577], vol. 1, pp. 348-349).

More recently Walter Hough was generous in his praise of this plant:

> "When one recognizes the benefits the agave confers on man, there seems good ground for the generalization that without this plant the great population and the civilization of the high plateau of Mexico would have been impossible" (Hough 1908:578).

Maguey's economic utility is enhanced by its long maturation period – between 7 and 25 years. As a consequence, different parts of the plant can be harvested at different times of the plant's lifecycle to produce a wide variety of products. The sap can be processed into a range of liquids and beverages, the flesh can be roasted and eaten, the pulpy leaves can be stripped to produce fibers or mashed into medicinal poultices, and what remains can be burned for fuel.

Maguey sap, or *aguamiel*, is one of the most versatile dietary components of agave (Evans 1990; Hough 1908; Parsons and Darling 2000b; Parsons and Parsons 1990). When fresh, *aguamiel* is a thin, watery liquid with a pleasant sweet/tart flavor that can be drunk raw and in arid areas may serve as a substitute for water (Evans 1990:125). *Aguamiel* is not only refreshing but also nutritious; the sap contains protein, carbohydrates, and a variety of vitamins and minerals including calcium, iron, and vitamin C.

Aguamiel can be fermented into a nondistilled, mildly alcoholic beverage called pulque. One liter of this nutritious drink contains roughly 600 calories and supplies important minerals, amino acids, and vitamins (Parsons and Darling 2000b:83). Studies conducted in the 1940s among Otomí villagers revealed that pulque contributed as much as 12% of their total calories (second only to tortillas) and 48% of their total vitamin C (Anderson et al. 1946:888, table 2). Taken in moderation, pulque's nutritional value makes it a reasonable substitute for meat (Gentry 1982:11).

A fermented beverage (most likely pulque) was consumed in Oaxaca in the sixteenth century (del Paso y Troncoso 1905 [1580]:145), and the Postclassic consumption of pulque is documented in the Codex Vindobonensis (a Mixtec document from Oaxaca) (Furst 1978:201-203). Similar images also are present in the Codex Nuttall (Nutall 1975:plate 82). The drink could have been an important dietary staple for earlier prehispanic people as well (Evans 1986:305; Martín del Campo 1938). In Oaxaca today, pulque has largely been replaced by mescal, which is produced by distillation that was introduced by the Spanish, although small-scale pulque production is still practiced in some Oaxacan villages, including Matatlán.

Aguamiel also can be boiled down into a sugar that can be formed into cakes for easy portability; these cakes are highly caloric and can be stored for long periods of time (Evans 1990:126-127; Parsons and Darling 2000b:83). The heart and leaves can be roasted and eaten. The highly nutritious flesh contains roughly 350 calories and 4.5 grams of protein per 100 grams (about a 3.5 ounce serving) (Fish et al. 1985:112).

At El Palmillo, several classes of evidence point to the importance of maguey as a food source. Two large ovens similar to present-day maguey ovens in Matatlán (Feinman et al. 2001) were excavated on the lower terraces. Soil sampled from the El Palmillo ovens is compositionally similar to soil collected from ovens in Matatlán (Middleton et al. 2001; see also Serra Puche et al. 2000). In addition, coarse fibers that are magueylike were found adhering to sooted stones and ceramics from the El Palmillo ovens. We suspect these ovens were used for roasting maguey hearts for consumption.

The artifact assemblages from the excavated terraces at El Palmillo contain a range of tools almost identical in form to tools used today for processing maguey into food and fiber. To collect maguey sap, a hollow cavity is cut into the heart of the plant. The sap flows from the fleshy leaves into the cavity and is collected daily. The cavity must be scraped several times a day to remove the thin crust of oxidized tissue that regularly forms and will stop the flow of sap if not removed. Today, sharpened metal disks are used to scrap the interiors, but in the past obsidian, basalt, or chert scrapers similar to those discovered at El Palmillo were probably used (Alvarez Palma et al. 1998:23-26; Evans 1990:121-122).

But as Hernández noted so many years ago, maguey provides more than just food. The most important economic product from maguey is fiber (*ixtle*) (Figure 12), which has been used since prehispanic times in Oaxaca (King 1986) and elsewhere in highland Mesoamerica (Smith and Kerr 1968) to make ropes, nets, baskets, mats, and sandals. By the time the Spanish arrived, spinning and weaving maguey fibers into cloth had become very important household activities across the highlands (Anawalt 1981; Brumfiel 1991a, 1991b; Durán 1994 [1581]; Gibson 1964; Hicks

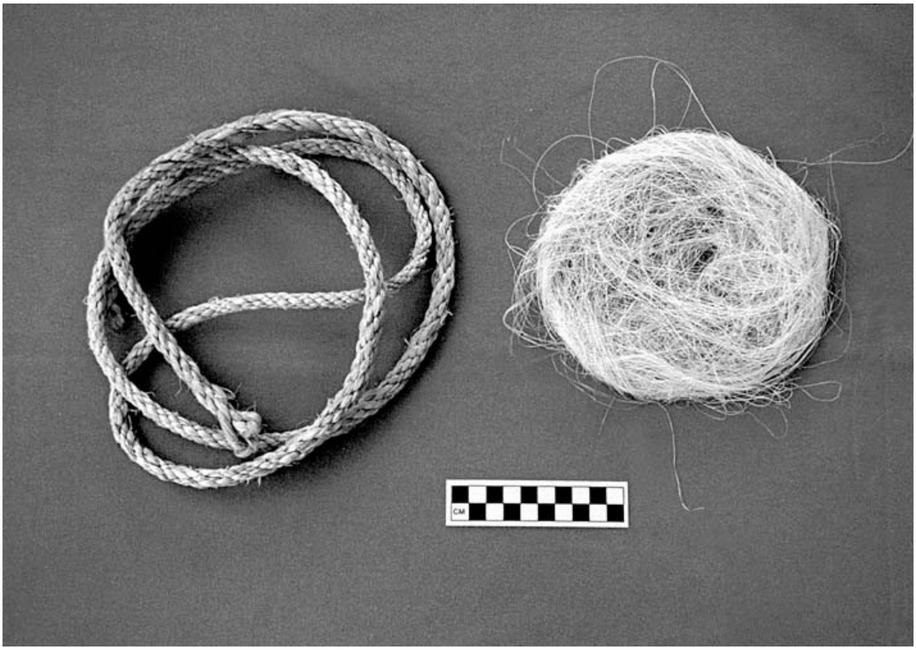

Figure 12. Modern rope made from maguey fiber and a bundle of *ixtle* fibers.

1994; Nichols et al. 2000; Sahagún 1961 [c. 1570]). Maguey fibers, once extracted from the heavy pulpy leaves, are light and easily transportable, and it is likely that a portion of the raw fibers produced also were traded in an unfinished form (Berdan 1987:248). Although maguey fiber has continued to be an important economic good into historic times in highland Mexico (Beals 1975; Cordry and Cordry 1940; Kelly 1944:106; Palma Cruz 2000; Parsons 1936; Patrick 1985), today in Oaxaca and elsewhere in Mexico *ixtle* largely has been replaced by synthetic fibers (Johnson 1977; Palma Cruz 2000:101).

Two types of fiber can be extracted from maguey, *penca asada fina* (fine fiber made from the inner leaves of the plant) and *penca grande* (coarse fiber made from the heavier outer leaves). These fibers can be spun into thread and then woven into textiles. Maguey leaves (*pencas)* can produce between 60 and 88 grams of fiber (Parsons and Parsons 1990:157, table 13). Based on an average of 75 grams of fiber per leaf, and 20-30 leaves per plant, roughly 2000 grams of dried fiber can be extracted from a single agave plant (Parsons and Darling 2000b:84). This would be enough fiber to produce approximately 10 square meters of cloth, fulfilling the maguey clothing needs for one person for about three years (Parsons and Darling 2000b:85).

The range of tools recovered at El Palmillo indicate that the inhabitants of the site were actively engaged in both fiber and textile production, seemingly also in domestic contexts. Extraction of the fibers is a labor-intensive process that requires the leaves to be sheared from the plant, and then either roasted or placed in a rotting pit to allow the flesh to soften; the fibers are then extracted by washing and scraping the leaves (Parsons and Parson 1990). We recovered many obsidian blades and other cutting tools on the excavated terraces, which could have been used to cut the leaves free of the plant (Evans 1990; Nichols et al. 2000). The scraper planes (*raspadores*) could have been used to remove fibers from maguey leaves.

Ceramic spindle whorls used to spin fibers into thread were recovered from all the excavated terraces at El Palmillo (Feinman et al. 2002) (Figure 13). Different types, or grades, of thread can be produced based on the size and weight of the spindle whorl and the dimension of the central hole (Evans 1990; Nichols et al. 2000; Parsons and Parsons 1990; Parsons 1972, 1975). According to Parsons and Parsons (1990:328-330) mid-weight whorls (between 11—23 grams) can be used to spin the fine *penca asada fina* fibers into a fine thread; heavier and larger whorls (above 23 grams) are unsuited for the finer fibers and instead were most likely used to spin thread from the heavier *penca grande*, resulting in a heavier, coarser thread. Spindle whorls recovered at El Palmillo included sizes suitable for spinning both fine and coarse threads. Bone awls, needles, and battens used in weaving also were recovered from both the upper and lower terrace areas at El Palmillo (Feinman et al. 2002).

The preponderance of *Agave* spp. at El Palmillo and the range of ceramic, stone, and bone tools used for processing this xerophytic plant point to an active fiber and textile industry at El Palmillo. In addition several stone bark beaters recovered during the excavations may have been employed to make maguey fiber paper (Gon-

Figure 13. Ceramic spindle whorls from El Palmillo.

çalves de Lima 1956:195). The residents of the excavated terraces at El Palmillo likely produced goods from maguey fiber for exchange to other parts of the site, to other sites in the vicinity, and possibly beyond. Yet maguey was more than just an economic raw material providing fiber that could be worked into a large range of products; maguey stalks also served as a combustible for fires and the hearts and leaves provided important sources of nutrition, from protein-rich liquids to storable solid foods.

Yucca

El Palmillo derives its name from the large stands of *Yucca periculosa* plants that dot the hill (with the densest clusters at the site's apex). These plants are more conspicuous at El Palmillo by their absence at the control site and in the rest of Matatlán's terrain (Middleton et al. 2001). Palmillos also are present at other archaeological sites in the region (Yagul [Martínez y Ojeda 1996] and the Mitla Fortress), but do not appear to be as abundant at those sites as at El Palmillo.

Although there are fewer references to yucca than maguey in early documents and other reports, yucca has a long history of exploitation in parts of highland Mexico, especially in central and north-central regions (Sheldon 1980), and the southwestern United States (Bell and Castetter 1941; Ebeling 1986). Some Mexican species of yucca provide edible fruits and flowers (Martínez y Ojeda 1996:66; Sheldon 1980:386), and at least one species is a source for a fermented liquor (Ebeling 1986:675). Native Americans in the southwestern United States also processed the fruits and seeds into dried products that could be stored over the winter (Ebeling 1986:472-474). Given the abundance of *Yucca periculosa* at El Palmillo, it likely was at least a minor dietary component for the site's residents.

Most references to prehispanic uses of yucca concern the plant's fibers. Weaving yucca fibers was an important industry, and textiles made from yucca were widely used among the Aztecs to make mantles (*tilmatli*), women's skirts (*cueitl*), cord (*mecatl*), and cord jackets (*mecaxicolli*) (Anawalt 1981:27, 33, 45). Yucca fibers also could be woven tightly to produce fine cloaks or fashioned into loose, net-like constructions (Berdan 1987:245; Sahagún 1961 [c. 1570], Book 10:75). In the precontact southwestern United States yucca fibers were woven into rope, cord, baskets, mats, cloth, and sandals (Ebeling 1986:472-474). Yucca fibers are still used today in north-central Mexico to make a range of products, but especially cordage that serves a range of uses (Sheldon 1980:383-385).

Today in Oaxaca "palm" fronds are woven into mats (*petates*) (Beals 1975, 1979); brooms, baskets, and other utilitarian objects woven from palm or palmlike plants are found in the markets of Matatlán today. Most of the production today takes place in several towns in eastern Tlacolula (Cook 1983). Weaving *petates* from palm during the colonial period also is reported in historical records of the area (Schmieder 1930; Taylor 1972:103). In their modern market studies of Oaxaca, neither Beals (1975, 1979) nor Cook (1983) explicitly identifies the species of the palm used, so it is unclear whether goods were made only from imported palms (family Arecaceae) that are not native to the Valley of Oaxaca or from yucca, which to the untrained eye looks superficially similar to palm. At least some prehispanic *petates* were likely made from yucca.

There is no direct archaeological evidence for yucca at El Palmillo, but the documented use of this species in highland Mexico subsequent to contact provides a circumstantial case for yucca exploitation. Bone awls and stone tools resembling those used by the modern inhabitants of palm-weaving villages (Cook 1983; see also Osborne 1965) have been encountered in some quantity at El Palmillo. Although we do not know what fiber they were worked on, the abundance of yucca at El Palmillo today in conjunction with a set of tools that may have been used to process the plant provide some support for yucca weaving at El Palmillo during the Classic period.

Nopal and Cochineal

Opuntia pilifera (nopal), which is far more frequent at El Palmillo than in the surrounding hills, has a variety of economic uses; virtually all parts of the plant (fruit, juice, flesh, and sap) can be consumed in some form (Meyer and McLaughlin 1981; Russell and Felker 1987). According to Oviedo y Valdés (1526, cited in Donkin 1977:11), the edible fruits (tuna) resemble "large figs," and early accounts refer to them as "higuera de las Indias" (Indian figs). These fruits can be processed into a type of preserve (*miel, melcocha, queso de tuna)* by allowing the juices to evaporate; alternately the juices can be extracted and allowed to ferment to make an alcoholic beverage that the Aztecs called *nochoctli* (Donkin 1977:12).

Nopal flesh also can be prepared in a variety of ways for both consumption and economic purposes. Joints from the plants can be cooked with chiles (*Capsicum* spp.) (Donkin 1977:12), or the pad can be peeled and eaten. Today in Matatlán the pads are a key dry-season food, especially for village inhabitants of lesser means. Sap from nopal (*zumo)* can be drunk when water is scarce or mixed with other substances as a salve for burns (Donkin 1977:12). Historic documents record the Spanish applying poultices of pulped nopal to broken bones (Donkin 1977:12). *Opuntia* spp. also are the host plants for an economically important insect that produces the vibrant red dye, cochineal.

Cochineal was highly prized by both the Spanish (Donkins 1977; Evans 1990; Gibson 1964:354; Lee 1947-1948) and the Aztecs (Durán 1994 [1581]; Evans 1990). The dye is produced from the dried bodies of the female scale insect, *Dactylopius coccus* Costa (Baranyovits 1978:88; Lee 1947-1948:450). The desiccated remains closely resemble small seeds or grains (Baranyovits 1978; Lee 1947-1948), which led to the colloquial term *grana* (grain) being used to describe the raw dye. The name cochineal is a derivation of the Spanish term for the dye "*grana cochinilla*" (*coccinus* in Latin meaning "scarlet in color") (Brunello 1973:84). The Aztecs referred to the nopal plant as *nopal nocheztli*, "the cactus which produces the blood fruit," and to the raw dye simply as *nocheztli* (Baranyovits 1978:87; Lee 1947-1948:452).

Once these tiny insects are harvested from the plants and dried, they retain less than 70 percent of their original body weight, or an average of 10.74 milligrams each (Baranyovits 1978:89). It can take as many as 70,000 insects to produce one pound of cochineal dye (Lee 1947-1948:451). In prehispanic times, cochineal was processed into flat cakes (*nocheztlaxcalli*); illustrations in the Codex Florentine reveal the production and display of cakes for sale (Sahagún 1963 [c. 1570], Book 11:239, plate 804). Cochineal in this form, however, is inconvenient for trading over long distances (Donkin (1977). Spanish merchants preferred the dried “granular” form of the dye (Baranyovits 1978; Donkin 1977; Lee 1947-1948), although this may have had more to do with verifying that the dye had not been adulterated than with ease of transport.

To maintain their monopoly over the cochineal market, the Spanish encouraged the misconception that the dye was botanical in origin (Baranyovits 1978:88; Lee 1947-1948:451). Yet although the dye is not botanical, it is plant dependent. *Dactylopius coccus* are host plant specialists that feed solely on plants of the genus *Opuntia* (Cactaceae) (Baranyovits 1978). Two of the common host plants, *Opuntia pilifera* (nopal) and *O. pumila* (cardo) are found at El Palmillo, and nopal is especially abundant on site.

Historic accounts document the careful tending of *Dactylopius coccus* colonies to protect them from their many predators. While not arduous, cochineal production was labor intensive, so that most of its production was carried out at the domestic scale by peasant farmers (Baskes 2000:10; Donkin 1977:13). To maximize cochineal production, prehispanic cochineal farmers or *nopaleros* (Humboldt 1811, vol. 3:77-78) collected and transplanted the insects manually to different pads or nopal plants. To increase their colonies, *nopaleros* would often plant additional cactuses, forming orchards or nopalaries (Donkin 1977:17).

Cochineal had many uses among prehispanic populations, the most well documented of which is for dying textiles. In the Codex Vindobonensis, 12 deities are depicted drinking pulque, nine of which are dressed in red (Anawalt 1981:134; Furst 1978:201-203). Prehispanic scribes used cochineal for painting codices (Donkin 1977:20), and artisans used it to color wood, stone, and ceramics (Franco Brizuela 1977; Lee 1947-1948:453).

The dye was popular with native women who used it as a cosmetic (Donkin 1977:20; Lee 1947-1948:453). Spanish physicians in the sixteenth century used a mixture of ground cochineal and vinegar to treat wounds, clean teeth, and as a cure for head, heart, and stomach ailments (Donkin 1977:21; Lee 1947-1948:472). It also was highly prized in Europe as a bright, color-fast, red dye for fabrics (Baranyovits 1978:87). Cochineal is superior to dyes found in the Old World and was the preferred red dye until the late nineteenth century when it was largely replaced by easier to obtain synthetic dyes (Baranyovits 1978). Yet it was still easy to obtain in the markets in Tlacolula and Oaxaca into the 1930s (Parsons 1936:45), and small-scale production continues today in a few villages.

By 1572 cochineal production in Oaxaca was important enough to the Spanish export economy to warrant the establishment of a separate weighing and registration office in the valley (Lee 1947-1948: note 116). Cochineal was Mexico’s second most valuable export commodity (after silver) for much of the colonial period (Baskes 2000:9. For Oaxaca, however, it was the region’s most important economic product by the mid-eighteenth century (Hamnett 1971:59: Taylor 1972:14), when as many as one-third of the province’s households were involved in some aspects of its production (Baskes 2000:12). As much as 40% of the cochineal was produced in the central valleys, including the district that encompassed Matatlán (Baskes 2000:17). Colonial documents include mention of several peasant cochineal producers from Matatlán (Baskes 2000:84; Taylor 1972:65).

Although Oaxaca was a major supplier of cochineal both historically (Baskes 2000; Donkin 1977; Gibson 1964:354; Lee 1947-1948; Taylor 1972) and prehispanically (Durán 1994 [1581]:182, 204), direct archaeological indicators for cochineal use are not well identified. The earliest evidence of *Dactylopius* as a source of dye comes from Peruvian textiles (Fester 1943; Yacovleff and Muelle 1934). Cochineal's history and its first use in Mexico is still debated. Although Rodríguez et al. (2001:76) propose that the insect originated in South America and was transported to southern Mexico by sea no earlier than 1450 B.C., others suggest the insect is indigenous to southern Mexico (Baskes 2000:9).

At present, Classic period cochineal production at El Palmillo can only be inferred from the dense concentrations of its host plant, *Opuntia pilifera* (nopal), on site. There is no question that cochineal was important in Oaxaca in the Postclassic period; this red dye was one of the major tribute items exacted from Oaxaca by the Aztec (Berdan and Anawalt 1997:108; Schmieder 1930:19). Its role in Classic period Oaxaca is less clear. Although we have found bright red pigment on figurines and urns at El Palmillo and other Classic period and earlier sites in Oaxaca, we have not yet established if cochineal was the source of this red dye (but see Franco Brizuela 1997). Yet arguments for a Classic period cochineal industry at El Palmillo are strengthened by the archaeologically documented presence of the spinning and weaving of maguey and other fibers (Feinman et al. 2001, 2002), materials on which the dye would have been applied. Given its later importance in Postclassic and colonial Oaxaca, cochineal likely was a key economic good at El Palmillo during the Classic period.

CONCLUSIONS

Based on our research at El Palmillo, we offer new perspectives on the relationship between population and agrarian resources in the dry eastern Tlacolula arm of the Valley of Oaxaca. In this study, multiple lines of evidence have been interwoven to illustrate that the Classic period inhabitants of the site relied economically on a complex of xerophytic plants that served subsistence needs as well as raw materials for specialized production and exchange. While this agricultural strategy may largely have entailed the fostering and dispersal of locally available plant resources, it also likely involved the relocation and concentration of valued plant varieties that were not initially available on the site itself.

Recently, studies focused on the arid highlands of central Mexico, particularly during late prehispanic Aztec times, have identified maguey as a critical food and economic resource (e.g., Evans 1990). Our study not only extends the seeming importance of these drought-resistant resources south to the Valley of Oaxaca, but it stretches archaeological evidence for a lifeway focused on these resources back to the earlier Classic period. We also have outlined some of the key plants that may have supplemented maguey, at least in ancient Oaxaca.

More significantly, the role or maguey, yucca, nopal, and associated plants provides a key vantage for understanding Classic period Oaxaca, as it helps us see how such large populations were supported on lands that were rather marginal for maize. Our findings have done nothing to alter our view that land and water still cannot be used to retrodict a region's prehispanic population distribution in the manner that Sanders and his colleagues asserted. Yet at the same time, we see that considerations of the relationships between people and agricultural resources must be envisioned more recursively (Feinman 1999b; Fisher et al. 1999; Lees 1992) than most, if not all, scholars tended to think or model decades ago. Labor strategies, the suite of available technologies and resources, as well the opportunities for exchange all have important effects on "agricultural potential."

Although this research has provided some clues regarding how the inhabitants of terraced hilltop sites (such as El Palmillo) in dry Tlacolula managed to feed and support themselves in a marginal environment for maize, it also raises some new questions. For example, since maguey and other xerophytic plants have been exploited in Oaxaca as early as the Archaic period and through intensification were capable of providing a significant resource base for later, larger populations, then why was this subvalley not more densely settled prior to the Classic period? At the same time, we still do not know what led to the early Classic period demographic spurt in Tlacolula. It is important to remember that this growth did not occur in a context in which other parts of the valley were overpopulated or entirely filled in, spurring people to move into drier, less "desirable" areas (Feinman et al. 1985; Nicholas et al. 1986). One possibility is that population growth in Tlacolula and the intensification of xerophytic plants for food and economic raw materials were partly spurred by new exchange opportunities as all arms of the valley were consolidated under the hegemony of centrally situated Monte Albán. Such an interpretation dovetails with the ample indicators of craft activities found at Oaxaca terrace sites, especially at those in drier sectors of the region.

In sum, the intensification of xerophytic plant communities now appears to have been a central aspect of the prehispanic highland Mesoamerican economy. If our interpretation of this intensification regime is borne out, then an interdependence with maize-producing communities and active networks of exchange to move goods across the region also likely were key parts of this ancient economic puzzle.

Table 1. List of common identified plants at El Palmillo.

Scientific Name	**Family Name**	**Common Names**	**Economic Uses**
Acacia farnesiana (L.) Willd.	Fabaceae	huizache de cerro (S.)	
Agave americana Linnaeus	Agavaceae **	maguey de pulque (S.)	pulque, mescal
Agave angustifolia Haw.	Agavaceae	espadín (S.)	preferred species for mescal
Agave karwinskii Zucc.	Agavaceae	lechugilla (S.)	mescal, fiber possible but not preferred
Agave kerchovei Lem.	Agavaceae	maguey de coyote (S.)	ixtle amarillo, not eaten due to bitter flavor

Agave macroacantha Zucc.	Agavaceae	javaline (S.)	mescal
Agave marmorata Roezl	Agavaceae	dob yet (Z.)	mescal, pulque
Agave potatorum Zucc.	Agavaceae	tobalá (S.)	mescal, quijote is mixed with masa to make tortillas
Agave rhodacantha Trel.	Agavaceae	dob bao (Z.)	mescal
Arbutus sp. Linnaeus	Ericaceae	madroña (S.)	edible fruit
Arctostaphylos sp. Adans.	Ericaceae	manzanita (S.)	fruit, tea for cough, treatment of kidney stones
Asclepias sp. Linnaeus	Asclepiadaceae	hierba de lagartija, pluma de gallina (S.)	
Azrtecaster pyramidatus Rob. and Greenm.	Asteraceae	romero de campo (S.)	brooms
Bursera galeottiana Engl.	Burseraceae	copal rojo (S.)	incense, glue
Bursera glabrifolia (H.B.K.) Engl.	Burseraceae	copal blanco (S.)	incense (preferred), fruit medicine for diabetes
Byrsonima crassifolia (Linnaeus) Kunth	Malpighiaceae	nanche (S.)	edible fruit
Cnidoscolus urens (Linnaeus) Arth.	Euphorbiaceae	mala mujer (S.)	medicine (circulation, mild pain killer)
Croton ciliato-glanduliferus Ortega	Euphorbiaceae	agua de pollo (S.)	sap is dangerous to eyes
Dodonaea viscosa Jacq.	Sapindaceae	jaras, jarilla (S.)	medicine
Euphorbia cotinifolia Linnaeus	Euphorbaceae	palo sordo (S.)	
Eysenhardtia polystachya (Ortega) Sarg.	Fabaceae	cuatle (S.)	medicine (kidney stones), cures leather
Ferocactus recurvus (Miller) Borg.	Cactaceae	biznaga (S.)	medicine (cuts, rashes), sweets
Fouquieria splendens Engelm.	Fouquieriaceae	ocotillo (Z.)	
Gonolobus sp. Decne.	Asclepiadaceae	hoja santa de campo (S.)	medicine for skin problems
Gossypium sp. Linnaeus	Malvaceae	algodón de campo (S.)	clothing, forage
Hechtia podantha Mez.	Bromeliaceae	lechuguilla (S.)	fiber
Hibiscus tenorii Fryxell	Malvaceae	flor de chilillo (S.)	ornamental flower
Ipomoea murucoides Roem. & Schult.	Convolvulaceae	pájaro bobo (S.)	medicine (variety uses), sap for clearing surface of water
Jatropha oaxacana J.Jiménez Ram. & R. Torres	Euphorbiaceae	nuez de campo (S.) susí (Z.)	medicine (rashes), edible nut
Lantana camara Linnaeus	Verbenaceae	zapotillo (S.)	fruit, medicine (granadillas), tea
Larrea tridentata (DC) Colville	Zygophyllaceae	batidor (S.)	
Lippia berlandieri Schauer	Verbenaceae	salvia de castilla, orejita de ratón (S.)	medicine for muscle/ear ache
Malpighia galeottiana A. Juss.	Malpighiaceae	nanche silvestre (S.)	edible fruit
Mammillaria collinsii (Britton & Rose) Orcutt	Cactaceae	chilillo (S.)	fruit, medicine (cuts, rashes)
Mammillaria karwinskiana Martius	Cactaceae	chilillo (S.)	fruit, medicine (cuts, rashes)
Mentzelia hispida Willd.	Loasaceae	pegajosa (S.)	medicine for bone pain
Mimosa aculeaticarpa Ort.	Fabaceae	uña de gato (S.)	
Myrtillocactus schenckii (J.A. Purpus) Britton & Rose	Cactaceae	garambullo (S.)	edible fruit
Opuntia pilifera F.A.C. Weber	Cactaceae	nopal (S.)	edible fruit
Opuntia pumila Rose	Cactaceae	cardo (S.)	edible fruit
Pellaea sp. Linnaeus	Pteridophyta	hierba de susto (S.)	medicine (anxiety)
Plumeria rubra Linnaeus	Apocynaceae	flor de mayo (S.)	ornamental flower

Prosopis laevigata (Willd.) M.C. Johnst.	Fabaceae	mesquita (S.)	fire wood
Pseudosmodingium multifolium Rose	Anacardiaceae	pirul de cerro (S.)	
Ptelea trifoliata Linnaeus	Rutaceae	arbol de zorillo (S.)	
Quercus sp. Linnaeus	Fagaceae	encine (S.) yega yu (Z.)	medicine (loose teeth)
Quercus sp. Linnaeus	Fagaceae	encino (S.) bla ta zi (Z.)	cures leather
Randia echinocarpa Moc. & Sessé ex DC.	Rubiaceae	durazno de campo (S.)	edible fruit
Salvia hispanica Linnaeus	Lamiaceae	flor de elote (S.)	seeds
Senecio praecox (Cav.) D.C.	Asteraceae	arbol de ixtle (S.)	medicine (broken bones)
Senna atomaria (L.) Irwin & Barneby	Fabaceae	chinchillo	
Senna pallida (Vahl.) Irwin & Barneby	Fabaceae	hierba de peine (S.)	paint
Senna polyantha (Moc. & Sessé ex. Colla.) Irwin & Barneby	Fabaceae	guaje de chivo (S.)	
Solanum sp. Linnaeus	Solanaceae	hierba loca (S.)	medicine (rashes)
Stenocereus marginatus (DC.) A. Berger & Buxb.	Cactaceae	organo (S.)	edible fruit
Stenocereus pruinosus (Otto) Buxb.	Cactaceae	pitayo (S.)	edible fruit
Stenocereus treleasei (Vaupel) Backeb.	Cactaceae	tunillo (S.)	edible fruit
Tecoma stans (L.) Juss. ex. Kunth	Bignoniaeceae	hierba de chichi (S.)	medicine (children's fevers)
Wigandia caracasana H.B.K.	Hydrophyllaceae	hoja de san pablo (Z.)	seasoning in barbocoa
Yucca periculosa Baker	Agavaceae	palmillo (S.)	fiber, edible flower
Zanthoxylum limoncello Plachan & Oerstead	Rutaceae	limón de campo (S.)	

* S = Spanish, Z = Zapotec.
** The family name Agavaceae is accepted in Mexico and appears in the literature. North American herbariums prefer a more traditional nomenclature, which classifies the genus *Agave* under the family Amaryllidaceae.

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