VESTIGES OF UPLAND FIELDS IN CENTRAL VERACRUZ: A NEW PERSPECTIVE ON ITS PRECOLUMBIAN HUMAN ECOLOGY

By

ANDREW SLUYTER

B.A., The University of British Columbia, 1987

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF
THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF ARTS

in

THE FACULTY OF GRADUATE STUDIES
(Department of Geography)

We accept this thesis as conforming
to the required standard

THE UNIVERSITY OF BRITISH COLUMBIA

July 1990

ABSTRACT

Typically, Mesoamericanists do not credit that part of Veracruz State bounded by the Sierra de Chiconquiaco, the Cotaxtla River, and the lower slopes of the escarpment of the Sierra Madre Oriental with having played a key role in Precolumbian social history. The region's sub-humid climate and savanna vegetation would seem to have precluded intensive agriculture and dense population. However, evidence of intensive maize cultivation there by the Late Preclassic is now apparent in some 2,200 ha of wetlands. More central to this thesis, evidence of intensive agriculture throughout some 1,000 km^2 of gently sloping piedmont west of the wetlands is also apparent. There, deeply incised streams separate upland areas. On the interfluvial surfaces, linear concentrations of stones closely follow slope contours and form contiguous networks of upland fields over hundreds of hectares. Analogues and the ecological context suggests a water and soil management technology. Direct evidence for cultivars and a chronology is still lacking, but ethnohistorical data and plant ecology suggest cotton, maize, agave, and a Precolumbian origin. Furthermore, archaeological and iconographic data suggest a relationship between these lowlands and the emergence of the highland centre of Teotihuacan, Mesoamerica's first metropolis. To elaborate this hypothetical connection, further work is necessary on the nature and timing of human ecological change in both Central Veracruz and the Valley of Mexico.

CONTENTS

FIGURES

ACKNOWLEDGEMENTS

"No man [*sic*] is an island, entire of itself."
--John Donne

Clearly, I did not complete this thesis in a vacuum, and therefore I take pleasure in acknowledging the contributions of others. My parents, Nick and Leni, and my brothers, Nick and Matthew, have supported my academic aspirations since their tenuous beginning. Dr. Alf Siemens provided the initial and continuing stimulation for my research in the Veracruzan lowlands. Beyond the debt I owe him which is already so obvious in the references, his intimate knowledge of the region, intellectual eclecticism, and *joie de vivre* have been a fount of inspiration. I am also grateful to my other committee members, Drs. Cole Harris and Derek Gregory, particularly the former for his insightful comments as second reader. Tarah Wilson's help with ground survey during June 1989 was invaluable, and I lovingly appreciate her continued encouragement and support even while busily engaged in her own academic endeavours. Dr. Phil Wagner, Ian Joyce, and Brian Debou proved stimulating and pleasant companions during an overland odyssey from Vancouver to Veracruz in May 1989. Their friendship and involvement in the initial stage of the field work ensured a propitious beginning. The University of British Columbia provided financial support through a University Graduate Fellowship, and the Department of Geography supplemented this award with a Teaching Assistantship. Others, too many to name--including faculty, staff, fellow students, and Mexicans--played lesser roles but also have my thanks.

INTRODUCTION

Typically, Mesoamericanists do not credit that part of Veracruz State bounded by the Sierra de Chiconquiaco, the Cotaxtla River, and the lower slopes of the escarpment of the Sierra Madre Oriental with having played a key role in Precolumbian social history (figure 1). In sharp contrast, neighbouring regions do appear to have stimulated the dramatic change from egalitarian rural society to hierarchical urban society during the Preclassic and Early Classic periods (figure 2). From 1200 to 100 BC the prototypical Olmec occupied San Lorenzo and several other monumental centres just to the south. From AD 1 to 800 the first metropolis, Teotihuacán, emerged and collapsed in the central highlands only 200 km to the west, its builders influencing societies throughout Mesoamerica. Partially contemporaneously, El Tajín flourished from AD 600 to 1200 just north of the Sierra de Chiconquiaco. And two centuries later the Aztecs built Tenochtitlán in the Valley of Mexico, expanding their tribute domain to encompass most of northern Mesoamerica by 1521. Yet in Central Veracruz the only large Precolumbian site appears to have been Zempoala, the former Totonac capital. And it, moreover, dates from no earlier than AD 1200.

Not only this apparent lack of early monumental centres, but *a priori* conceptions of environments that

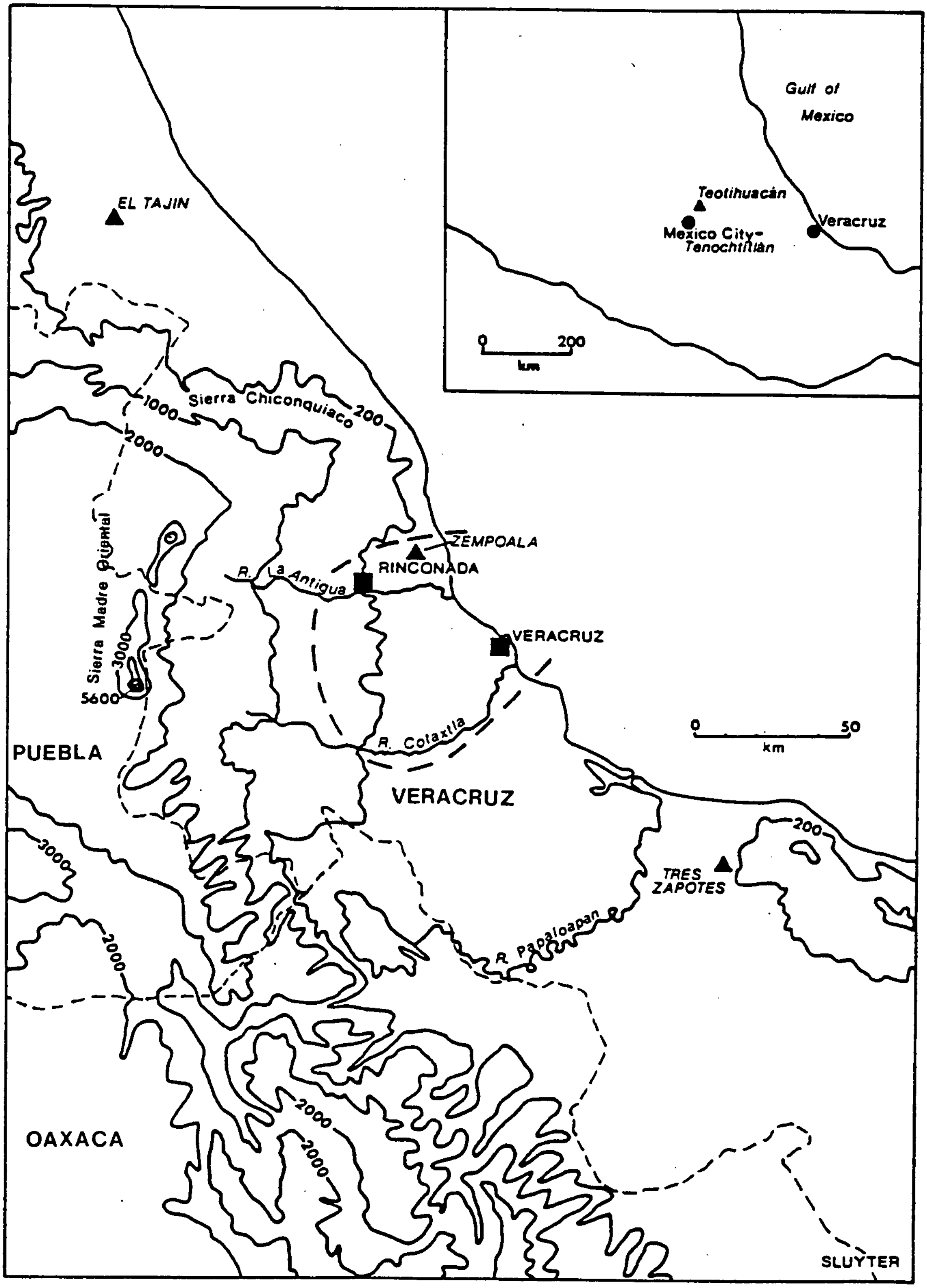


Figure 1. The dashed line delimits Central Veracruz.

TIME	PERIOD	CLIMATE	MESOAMERICAN MONUMENTAL CENTRES
1,600			ZEMPOALA; TENOCHTITLAN
1,200	POST-CLASSIC	PLUVIAL	
800			EL TAJIN; CLASSIC MAYA
400	CLASSIC	DRY	TEOTIHUACAN; CENTRAL VERACRUZAN RIDGED-FIELDS (El Yagual)
AD BC			
400			
800	PRE-CLASSIC	PLUVIAL	TRES ZAPOTES LA VENTA SAN LORENZO
1,200			
1,600			
2,000	ARCHAIC	DRY HYPSI-THERMAL	EMERGENCE OF SEDENTARY AGRICULTURAL VILLAGES
2,400			CERAMIC POTTERY APPEARS

Figure 2. Mesoamerican chronology (after Coe 1962, fig.2; Davies 1982, 12; Siemens et al. 1988, table 1).

could have sustained dense population have long discouraged a comprehensive research effort in Central Veracruz. Several influential Mesoamericanists consider the climate, vegetation, soils, and hydrology to have been effective barriers to any dense population before the Totonacs constructed an irrigation system at Zempoala (Sanders 1953, 41-2; Palerm 1955, 33; Palerm and Wolf 1957, 15-16; Wolf 1959, 13; Sanders 1971, 552-54; Palerm and Wolf 1972, 72-73).

> Most of the area is true savannah, the most difficult vegetation for the primitive farmer to cope with, and also the rains in general are undependable. It seems doubtful if he ever really successfully coped with his environment. The only incentive for heavy settlement, would be on the basis of irrigation agriculture, and...in a small section of this area [, at Zempoala during the Middle Postclassic,] this incentive was presented (Sanders 1953, 67).

Certainly, Central Veracruz's climate is sub-humid, making rainfed agriculture problematic (García 1970, figs. 10 and 15). The temperature of these tropical lowlands is high throughout the year, but precipitation is seasonally low (figure 3). Each summer as the thermal equator swings north, the trade winds and the intertropical convergence zone cause the advection and convection of humid air, bringing abundant rain to the lowlands and the higher, more temperate slopes to the west. Each winter, however, the thermal equator swings south, and the dominant subtropical high promotes subsidence and drying. The windward slopes of the escarpment continue to receive precipitation,

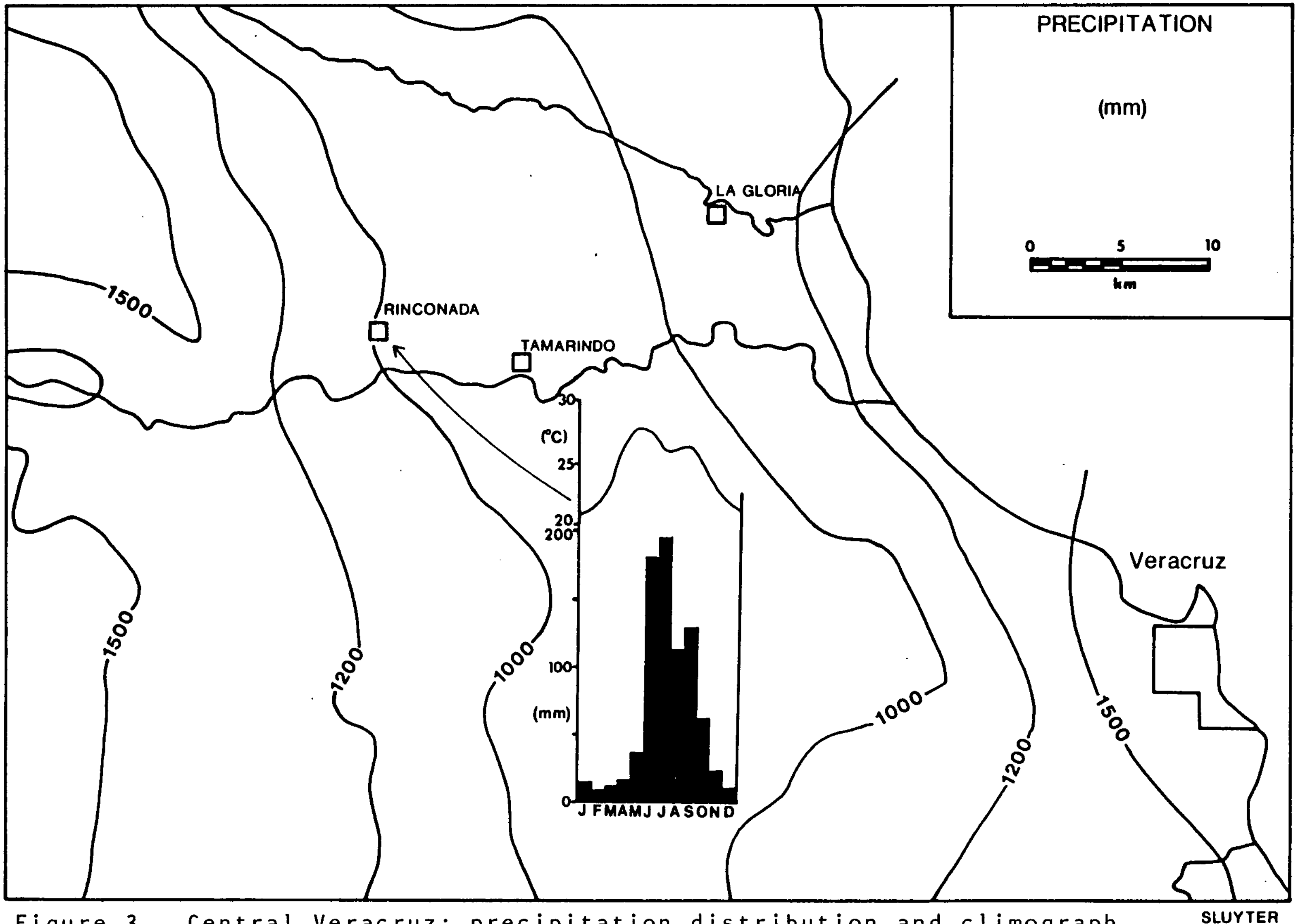


Figure 3. Central Veracruz: precipitation distribution and climograph for Rinconada (after García 1970, figs. 11 and 16).

orographically as the humid trade winds blow in from the Caribbean, frontally as cyclones periodically sweep in from the north. Meanwhile, the lowlands receive little orographic precipitation and parch in the rain shadow of the Sierra de Chiconquiaco, the _nortes_ adiabaticly drying and warming as they descend the leeward slopes of this range (Vivó Escoto 1964, 192-93; García 1970, 6-7).

This sub-humid climate contrasts dramatically with that of the El Tajín and Olmec regions to the north and south. Based on mean annual precipitation and potential evapotranspiration, Central Veracruz has an annual water deficit of 715 mm, El Tajín a surplus of 50 mm, and the Olmec region a surplus of 772 mm (Thornthwaite 1964: data from Soledad de Doblado, Papantla, and San Andrés Tuxtla). This contrast defines lowland Central Veracruz as a sub-humid enclave along an otherwise humid coast, although the transitions are not as sharp as figure 1 indicates (Sanders 1953, 28-29). To the south, the country between the Cotaxtla and Blanco rivers is transitional. To the west and north, the lowland _tierra caliente_ gradates into _tierra templada_ around 800 m.

Pollen cores from the Valley of Mexico indicate possible climate change since the Pleistocene glaciation. Although from another context and no substitute for a local paleoclimatic study, they do suggest a general pattern of Mesoamerican climatic fluctuation: wetter, cooler, pluvial periods during the Preclassic, Postclassic, and

Postcolumbian periods, with dryer, warmer, thermal periods during the Archaic and Classic (figure 2) (Coe 1962, 25-7). Central Veracrüz, then, might have been hotter and dryer during the first millennium AD than at present, implying an even less congenial environment for agriculture.

This sub-humid climate results in a natural vegetation of savanna interspersed with stands of deciduous tropical trees (Gómez-Pompa 1973, 77-85 and 121-26; Rzedowski 1978, 190 and 201). And, as Sanders suggests, Precolumbian farmers with stone and wood tools might have had difficulty clearing and tilling land under such conditions, although data from the Petén suggest just the opposite (Cowgill and Hutchinson 1963, 276-77). During the wet season this vegetation is lush and green. But as the long dry season deepens, the grass yellows; the thickets of shrubs and stands of low trees lose their leaves; and the sporadic cacti take on a new significance, providing the little green in an otherwise drab landscape. Only the depths of the major river gorges, far below the surface of the gently sloping piedmont plain, and the wetlands among the coastal hills retain enough moisture to support lush vegetation all winter. Modern agriculture is rapidly altering this landscape as subsistence cultivation of maize (Zea mays) retreats before papaya (Carica papaya) and mango (Mangifera india) plantations and before increasingly ubiquitous fields of sugar cane (Saccharum officianarum).

Such modern cropping indicates the basic fertility of the calcareous rendzinas which predominate around Rinconada and the black vertisols--locally known as praderas, or meadow soils--which predominate more generally (figure 4). However, the vertisols are clayey, stiff, and massive when wet--making tillage with hand tools difficult (Strahler and Strahler 1987, 399). In addition, the conglomerates underlying much of this area result in stoney soils--again, making manual tillage difficult (figure 5). Sander's low opinion of the Precolumbian productive potential of the soils over much of this area, therefore, certainly seems reasonable (Sanders 1953, 36).

Moreover, much of this modern agriculture is dependent on costly irrigation projects. Generally the torrential streams which rise in the Sierra to the west are deeply incised into the piedmont plain which gently slopes down from the foothills to the coast. The narrow flood plains, difficult of access and small in area, cannot support much agriculture. And without pumps or large dams the deeply incised streams cannot supply irrigation agriculture on the extensive interfluvial uplands. Yet near Zempoala an arm of the Río Actopan is untypical in this regard. The Río Agostadero is a small but perennial stream and well suited for supplying an irrigation system which uses only small diversion dams and canals (Sanders 1953, 37).

Given this *a priori* conception of the relationship between people and land in Central Veracruz, a Precolumbian population employing intensive agriculture could only have

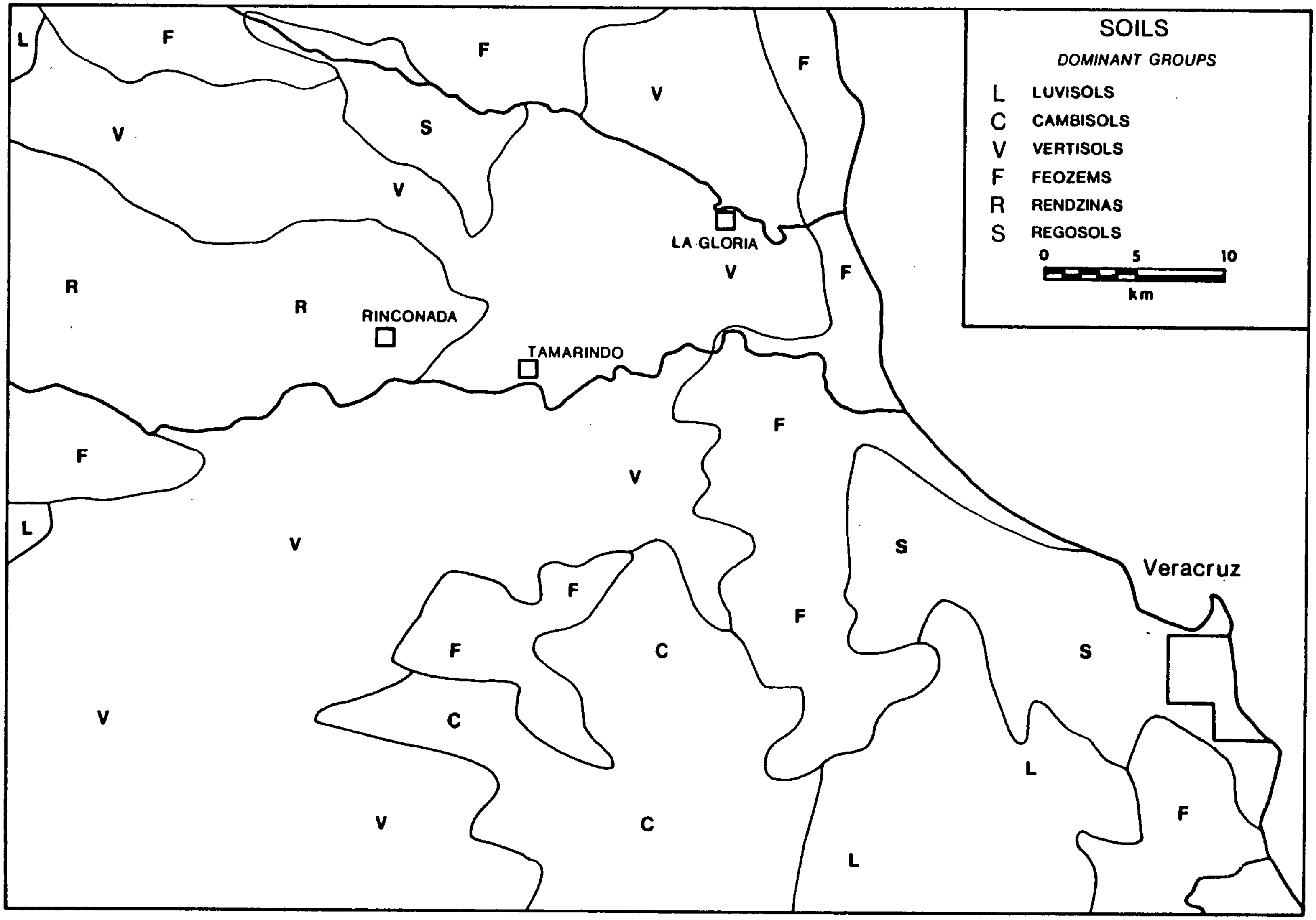


Figure 4. Central Veracruz: soils (after SPP 1981).

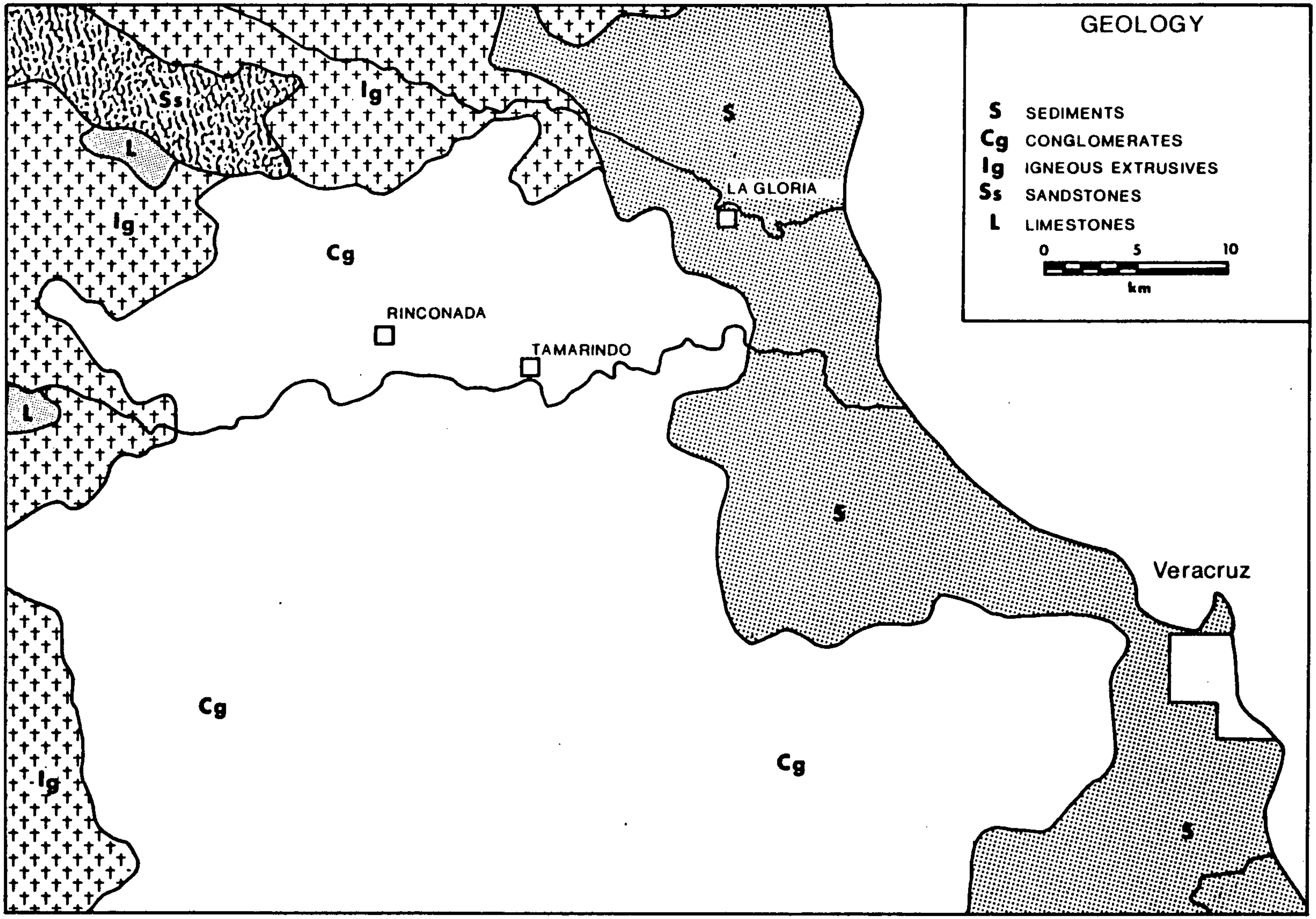


Figure 5. Central Veracruz: geology (after SPP 1980).

SLUYTER

occurred at Zempoala. Only there, in a limited area, could a densely settled and socially stratified society based on surplus production emerge. The remainder of the region would have had a low population density based on extensive swidden agriculture throughout the gallery forests of the limited alluvial plains along the major perennial streams (Sanders 1953, 51-3; Palerm and Wolf 1957, 15; Sanders 1971, 552-54).

> Farming for one annual crop, [and] the restricted size of the [riverine] gallery forest and its longitudinal form of growth did not favor high population densities or large population centers [in Central Veracruz]. The grasslands which surrounded these forests and could not be used agriculturally tended to isolate them. Political units were fragmented; their axes were always formed by the rivers.... Lands [with smaller permanent streams at Zempoala] came into use later when application of small-scale irrigation allowed...urban centers like those of the Highlands.... No case of autochthonous self-generated political development is known, however; all seem to be secondary formations with centers of origins in the Highlands (Palerm and Wolf 1957, 15-16).

In this view, the peripheral role of these lowlands in Precolumbian social history seems certain. A region constrained by low agricultural potential could neither have supported a dense population nor produced an agricultural surplus. And, therefore, unlike the Valley of Mexico, such a region was unlikely to have stimulated social change in other parts of Mesoamerica (Sanders 1953, 74-8).

However, a consideration of data from recent fieldwork in Central Veracruz prompts a reevaluation of the role of this region in Mesoamerican social history. Vestiges of wetland and, more central to this thesis, upland fields suggest that Precolumbian farmers did cope with their seemingly uncongenial environment and that intensive agriculture was widespread. Furthermore, a reconsideration of data from ethnohistorical and archaeological sources suggests that Precolumbian Central Veracruz was densely settled and that during the Late Preclassic its inhabitants might have played a role in the dramatic transition to hierarchical urban society at Teotihuacán.

FIELD EVIDENCE

The Wetland Fields

Aerial photographic interpretation, ground survey, and excavation have revealed some 2,200 ha of field complexes scattered throughout the wetlands among the coastal hills of Central Veracruz (figures 6 and 7) (Siemens 1980, 1983a, 1983b, 1983c, and 1985; Siemens et al. 1988). Siemens has thoroughly discussed the morphology and function of this Precolumbian agricultural technology. But briefly, farmers formed the fields by channeling the shallow wetland margins and heaping the spoil into planting platforms toward the deeper centres. As the water level fell during the dry season, the channels aided drainage and allowed earlier planting, first on the margins, then toward the centres. As the dry season progressed, farmers impounded water within the channels to retain moisture within the root zone. Annual flooding and _chinampa_-like mucking of platforms with channel dredgings and hydrophytes preserved fertility (Robertson 1983, 133-36). In addition, wetland fish, waterfowl, and fruits probably supplemented the dietary staples. Whatever the difficulties of investigating paleointensification, the wetland fields certainly appear to be more intensive than the swidden cultivation Sanders, Palerm, and Wolf proposed for much of this region.[1]

More difficult than interpreting the morphology and

Figure 6. Central Veracruzan wetland fields. Top: dark green hydrophytic vegetation has occupied the former channels, outlining the former planting platforms. Bottom: water still remains in some channels at the end of the dry season. (May 1989.)

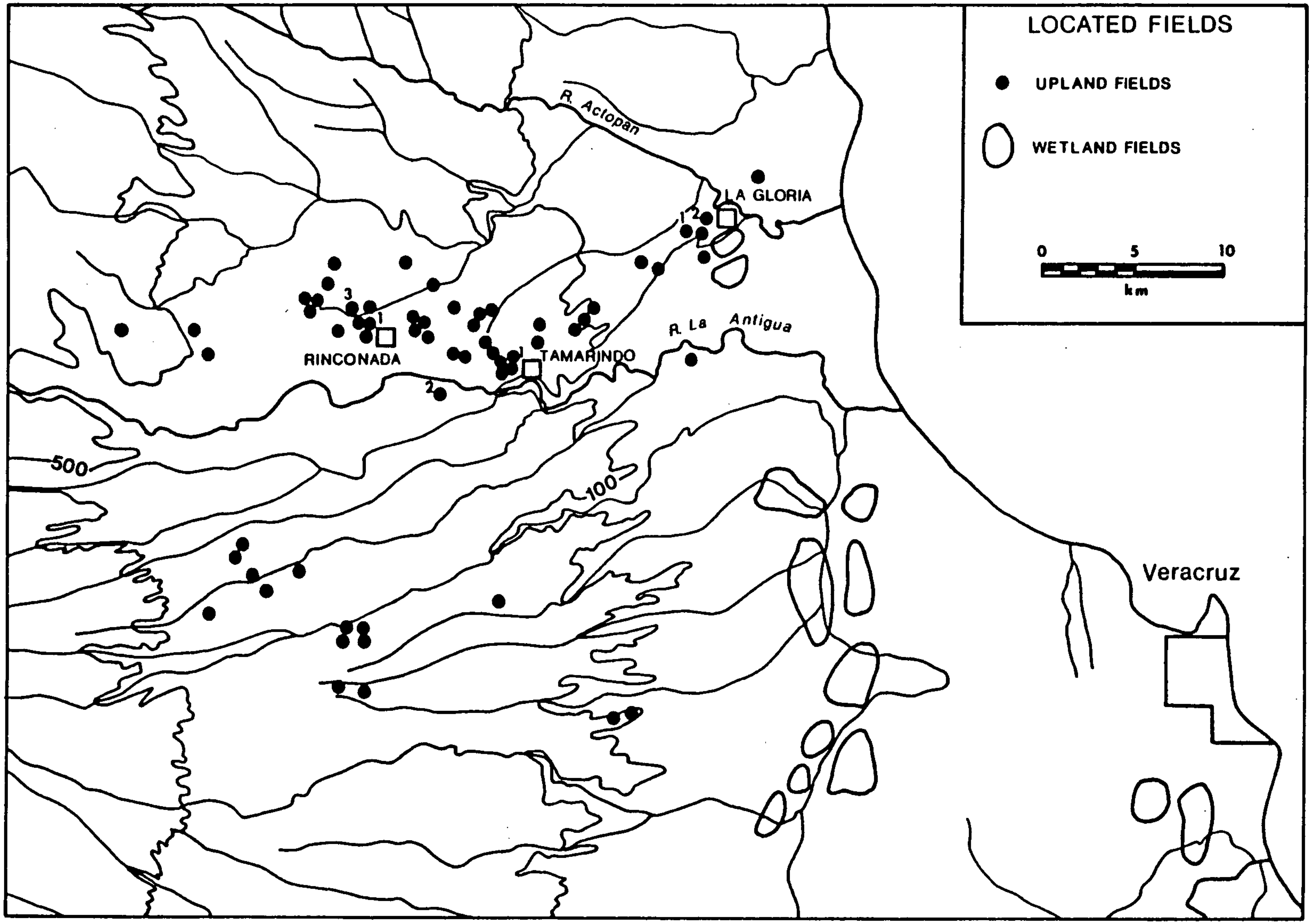


Figure 7. Central Veracruz: wetland and upland field complexes located with vertical and/or oblique aerial photography. No indication of the area covered by field surfaces is intended (after Siemens 1980, fig. 1; Siemens, Navarrete, and Sluyter 1989, fig. 7).

SLUYTER

function of the vestigial wetland fields, however, is dating them and determining the cultivars involved. Nonetheless, excavations in the Veracruzan wetlands have yielded maize phytoliths and pollen. Associated ceramics indicate cultivation during the Late Preclassic and Early Classic (Siemens et al. 1988, 107 and table 1). Although based on a limited sample and a ceramic sequence without adequate absolute dating, this timing is notable. It coincides with the first few centuries of Teotihuacán's emergence and expansion. And, significantly, the Veracruzan wetland agriculture might also have anticipated that highland centre's emergence by several centuries.

The Upland Fields

Aerial photographic interpretation and ground survey have also revealed field complexes scattered throughout some 1,000 km^2 of uplands west of the wetlands (figures 7 and 8) (Siemens 1985, 143; Siemens, Navarrete, and Sluyter 1989; Sluyter 1990). From the air, these upland fields appear as light lines against the dark soil of newly ploughed land on gentle slopes (figure 8). The lines vary from 3-5 m in width and generally form rectilinear networks with 5-25 m intervals. These upland fields also suggest intensification and a considerable investment of labour in aid of increased productivity. Considering their possible areal extent, these upland fields might prove to have been a central component in the Precolumbian agricultural

Figure 8. Central Veracruzan upland fields. Top: newly ploughed fields north of Tamarindo. Bottom: a newly ploughed field amid irrigated sugar cane fields southwest of La Gloria. (May 1989.)

economy. Of course, in hypothesizing any such agricultural intensification, the same cautions apply to these uplands as to the wetlands.[1]

Approached on the ground the lines exhibit no appreciable relief, being comprised of a surface scatter of stones smaller than 20 cm in diameter. Only in one observed instance, at the Gasoducto site near Tamarindo, are larger stones involved, giving the linear feature a slight relief and making it discernable at ground level. There, excavation revealed 30 cm long limestone slabs set upright in the surface, oriented normal to slope direction, and supported by smaller stones placed downslope (Siemens, Navarrete, and Sluyter 1989, figure 10). However, despite ground surveys of cleared fields and adjacent areas around Rinconada, Tamarindo, and La Gloria, no other such slab-type features are yet apparent. Farmers are actively clearing stones larger than 20 cm from the level fields to facilitate tractor ploughing. Steeper areas bordering ploughed fields, such as at A on figure 9, are not mechanically cultivated but are subject to slash and burn for maize and rough pasture. Cattle, fire, and torrential summer rains all contribute to severe erosion and the obliteration of any Precolumbian vestiges. Except for the thus far unique Gasoducto site, then, the lineal variations in the density of field stone distribution are largely imperceptible at ground level.

Further complicating study of the upland fields, the stone patterning only becomes visible after farmers have cleared and ploughed. The patterns soon disappear as crop growth obscures the ground. The dominant modern crops are introduced sugar cane and mango with some maize, none of which typically show height or colour differentiation due to archaeological features (Riley 1987, 279). The upland pattern, therefore, only briefly reveals itself in fragments which regularly shift location as farmers fallow old fields and clear new ones. This ephemeral characteristic hinders an appreciation of the morphology and areal extent of individual complexes.

Despite these difficulties, an assesment of the morphology and environmental relationships of the upland fields is central to any understanding of their genesis and function. Therefore, mapping individual complexes is a necessary sequel to mapping the regional distribution. Interpretation of commercial 1:8,000 vertical air photographs from July 1973 revealed upland field complexes covering tens of hectares near the villages of Tamarindo and La Gloria. The extent and accessibility of these fields suggested their suitability for mapping. Also, the La Gloria fields border a complex of wetland fields, suggesting contemporaneity and an ecological relationship. An aerial reconnaissance flight in May 1989 confirmed extensive upland fields in these areas and yielded low-level oblique air photographs. These in combination with ground surveys in June 1989 and May 1990, the 1:8,000 vertical air photographs, and 1:5,000 topographic maps allowed mapping of these complexes (figures 9-12).[2] In addition, the field complexes apparent on the available 1:8,000 vertical photographs allowed topographic overlays of patterning at La Gloria 1-2, Tamarindo 1, and Rinconada 1-3 (figures 13-18: see figure 7 for locations).

Morphology

These planimetric views reveal some salient morphological traits. Most obviously, the linear concentrations of stones consistently follow slope contour, suggesting terracing. This characteristic is clearest at La Gloria, particularly at A and B in figure 10 (enlarged in figures 13 and 14). There, sharp changes in line direction reflect equally sharp changes in slope direction. Just as clearly, the curvilinear patterning near the centre of Rinconada-1 remains normal to slope direction around the upper drainage basin of a small ephemeral stream (figure 16). Figure 19 is an oblique view of this same area from the northwest and shows the pattern more clearly. At Rinconada-2 an interfluvial upland slopes gently east-west; its surface is patterned with north-south trending lines (figure 17). Near the top of the upland's escarpments, steeper slopes fall off north and south toward the La Antigua and Santa María Rivers; there, lines trending east-west dominate. The pattern is more complex at Rinconada-3, but equally as consistent (figure 18). The

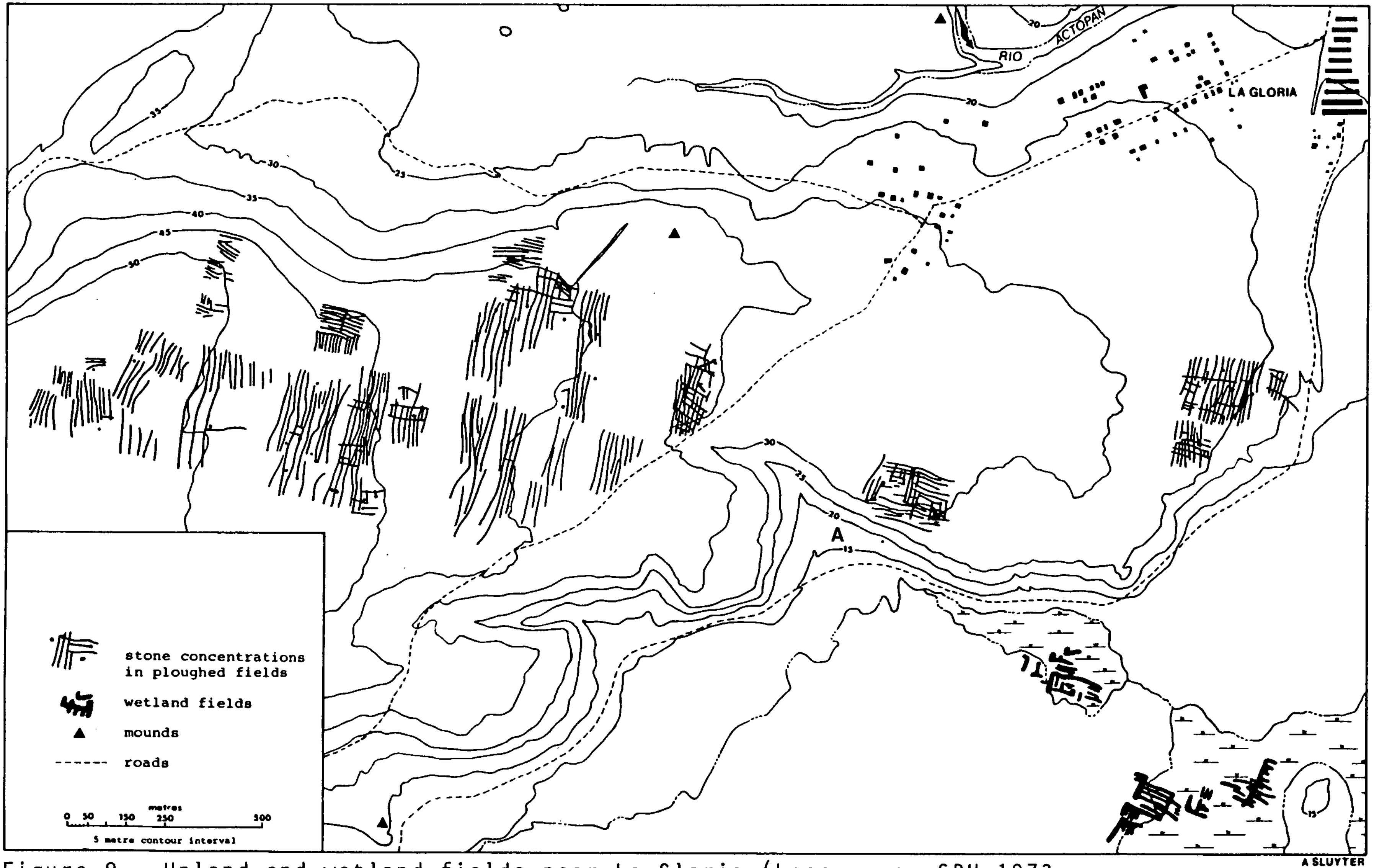


Figure 9. Upland and wetland fields near La Gloria (base maps: SRH 1973, sheets 23 and 30).

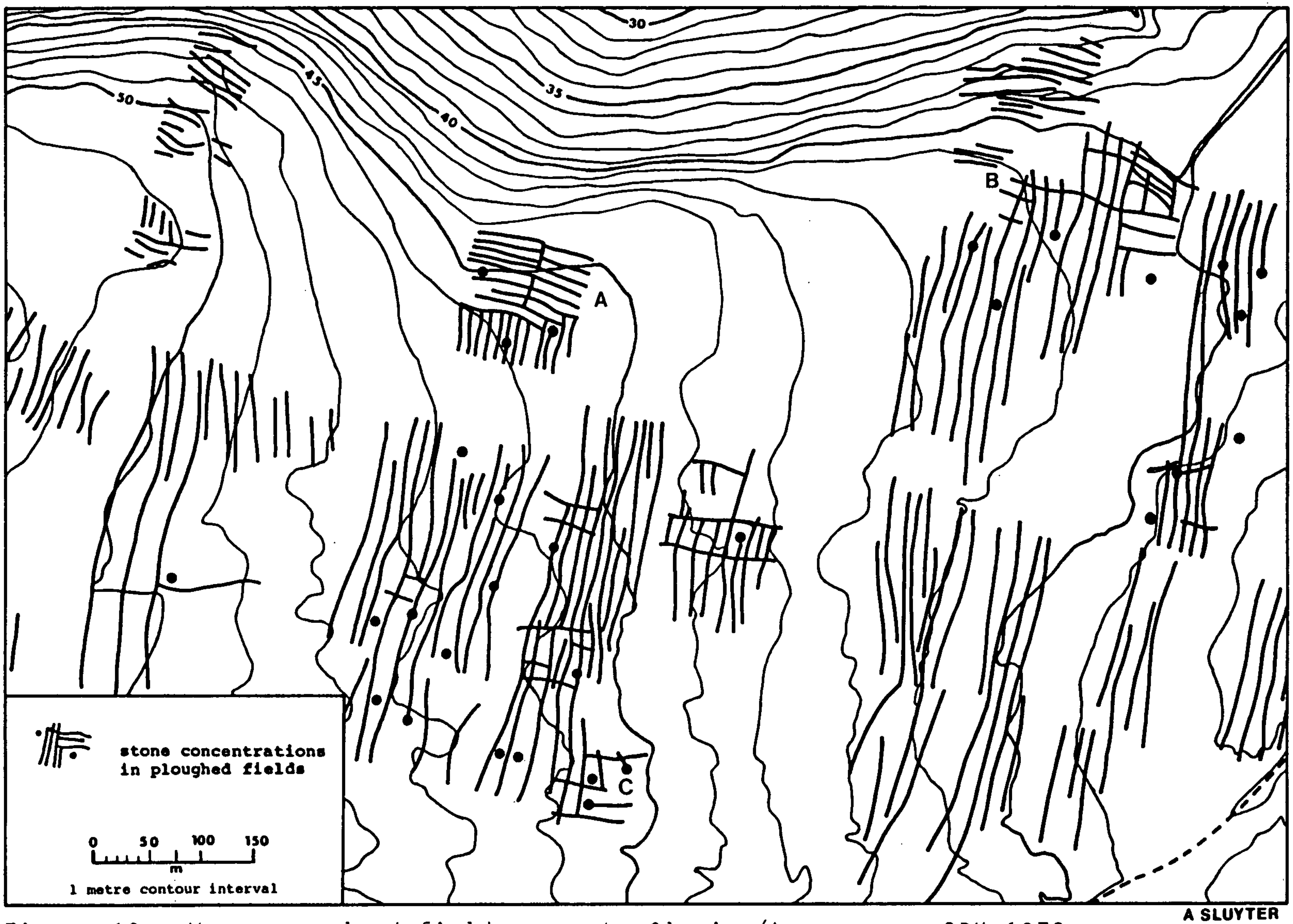


Figure 10. Western upland fields near La Gloria (base maps: SRH 1973, sheets 23 and 30).

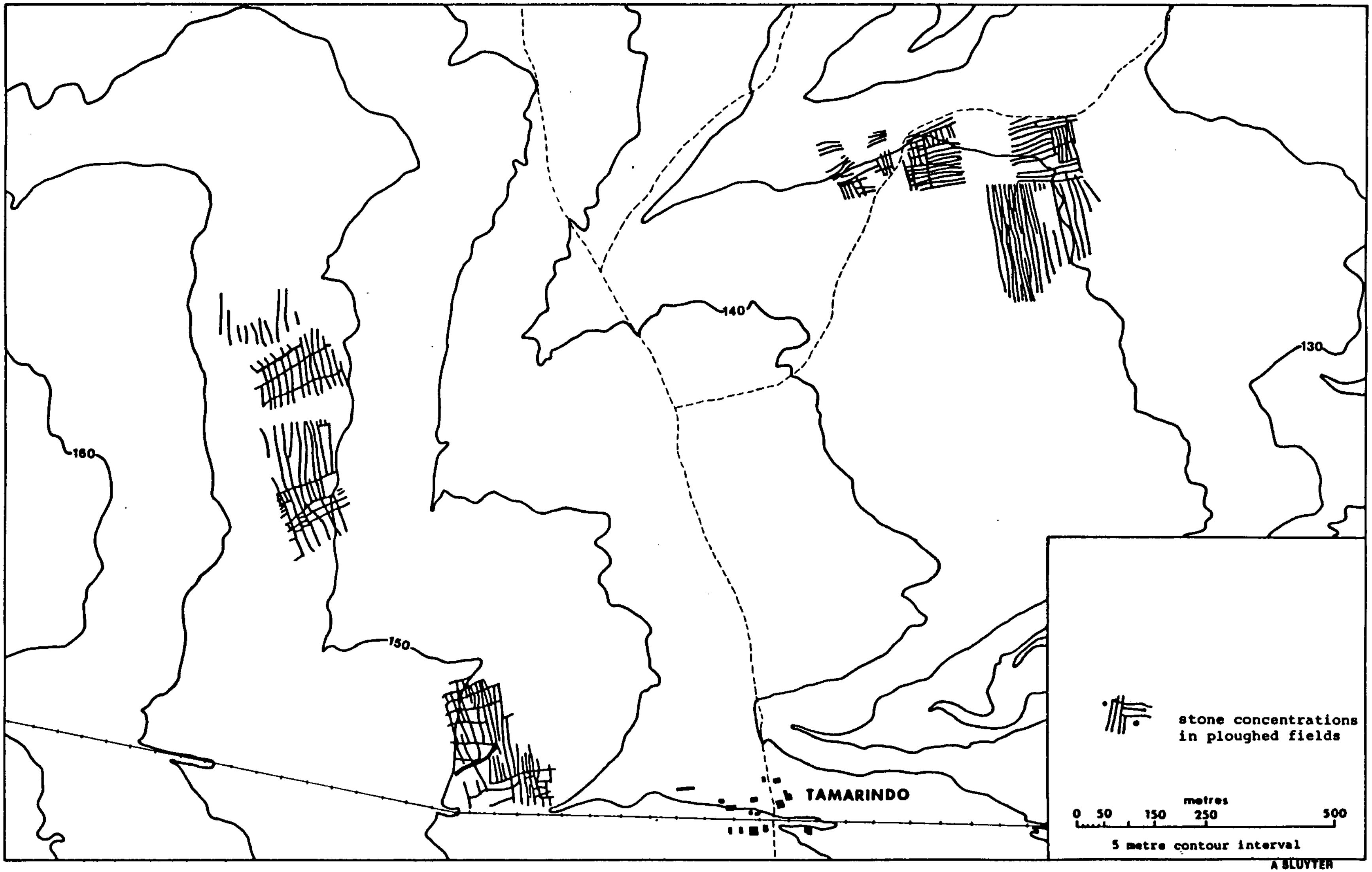


Figure 11. Upland fields near Tamarindo (base maps: SRH 1973, sheets 42, 43, 49, and 50).

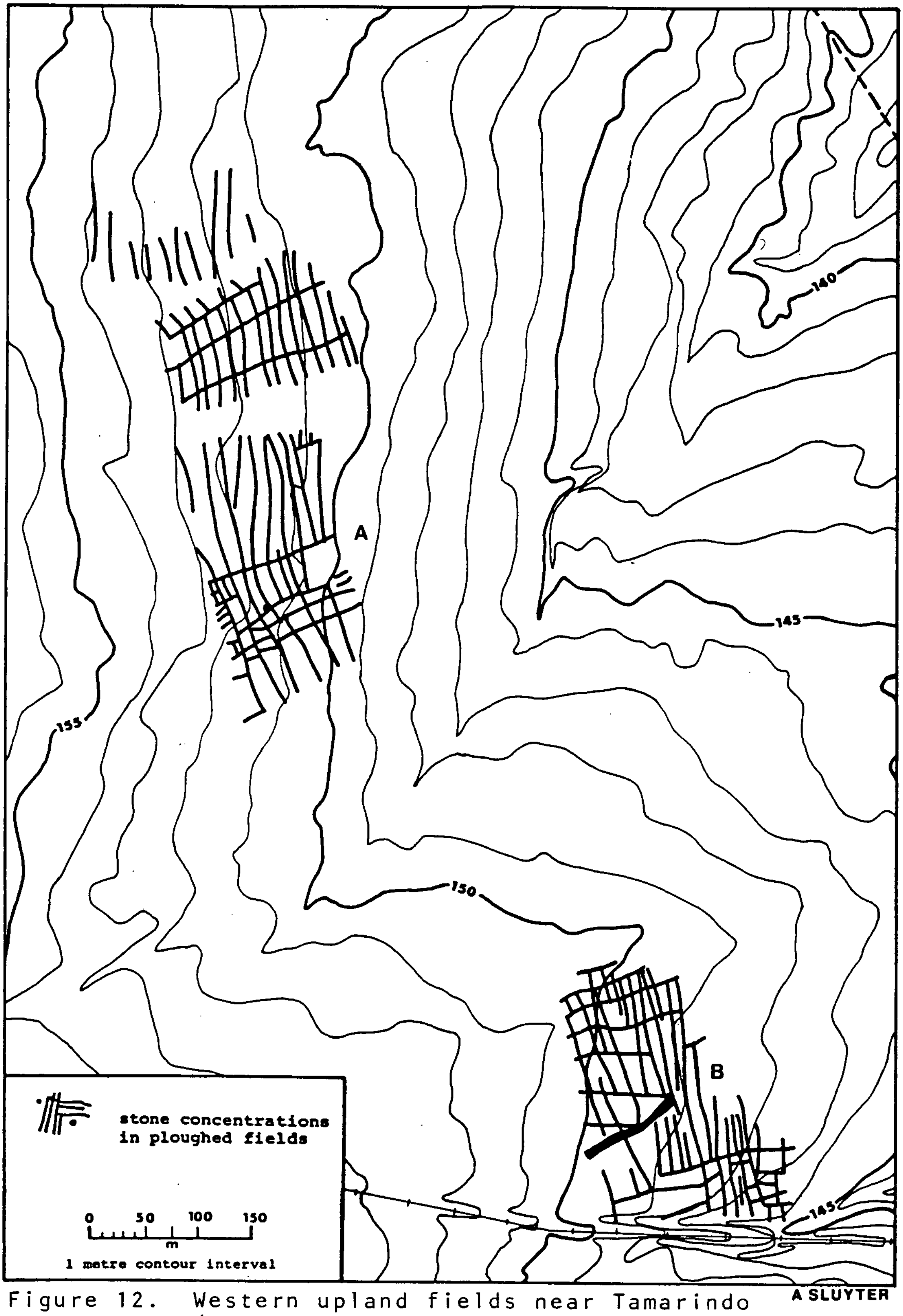


Figure 12. Western upland fields near Tamarindo (base maps: SRH 1973, sheets 42, 43, 49, and 50).

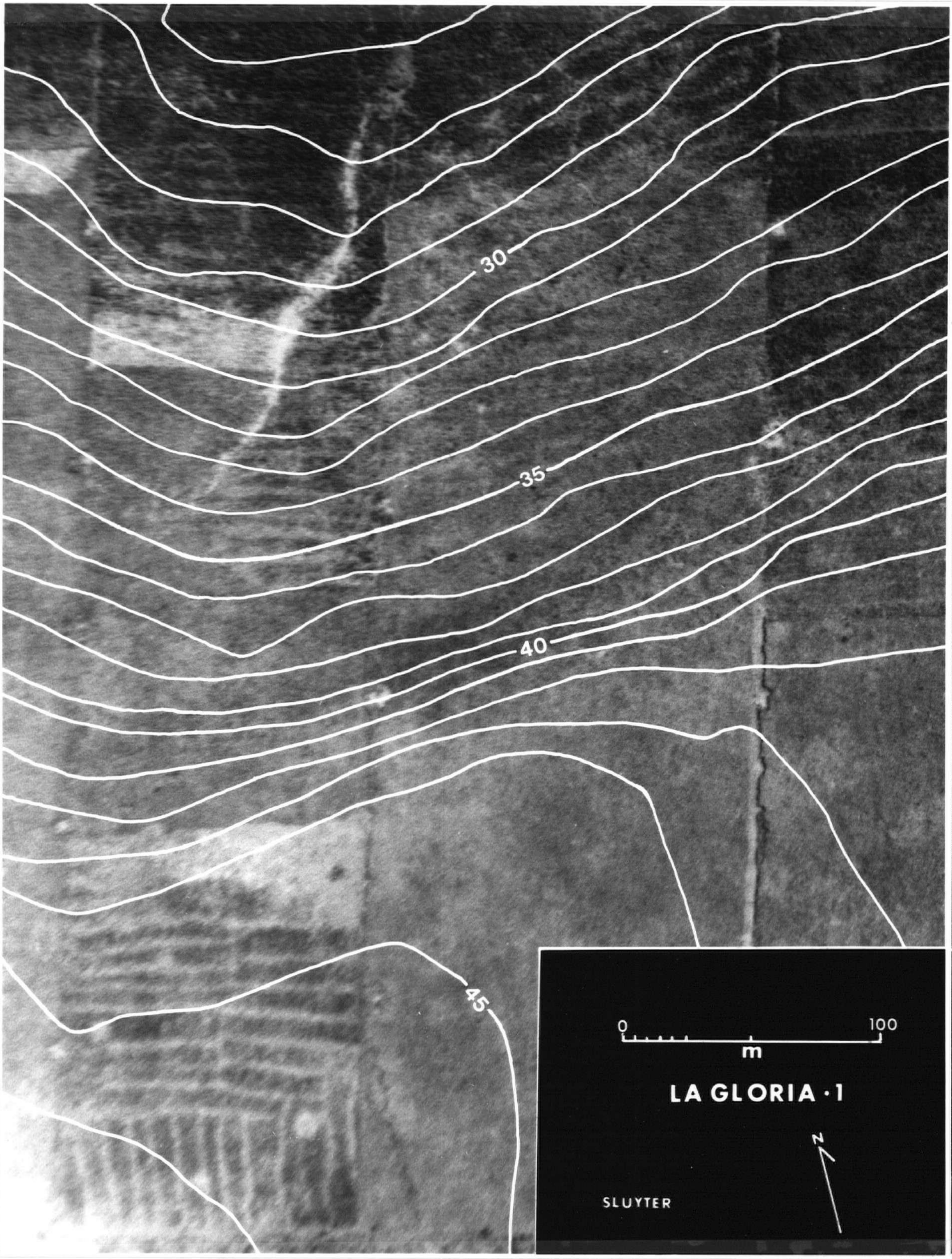


Figure 13. Topographic overlay of a vertical air photograph showing upland fields at La Gloria-1 (photo: SRH 1973, F23-15; map: SRH 1973, sheet 23).

Figure 14. Topographic overlay of a vertical air photograph showing upland fields at La Gloria-2 (photo: SRH 1973, F23-15; map: SRH 1973, sheet 23).

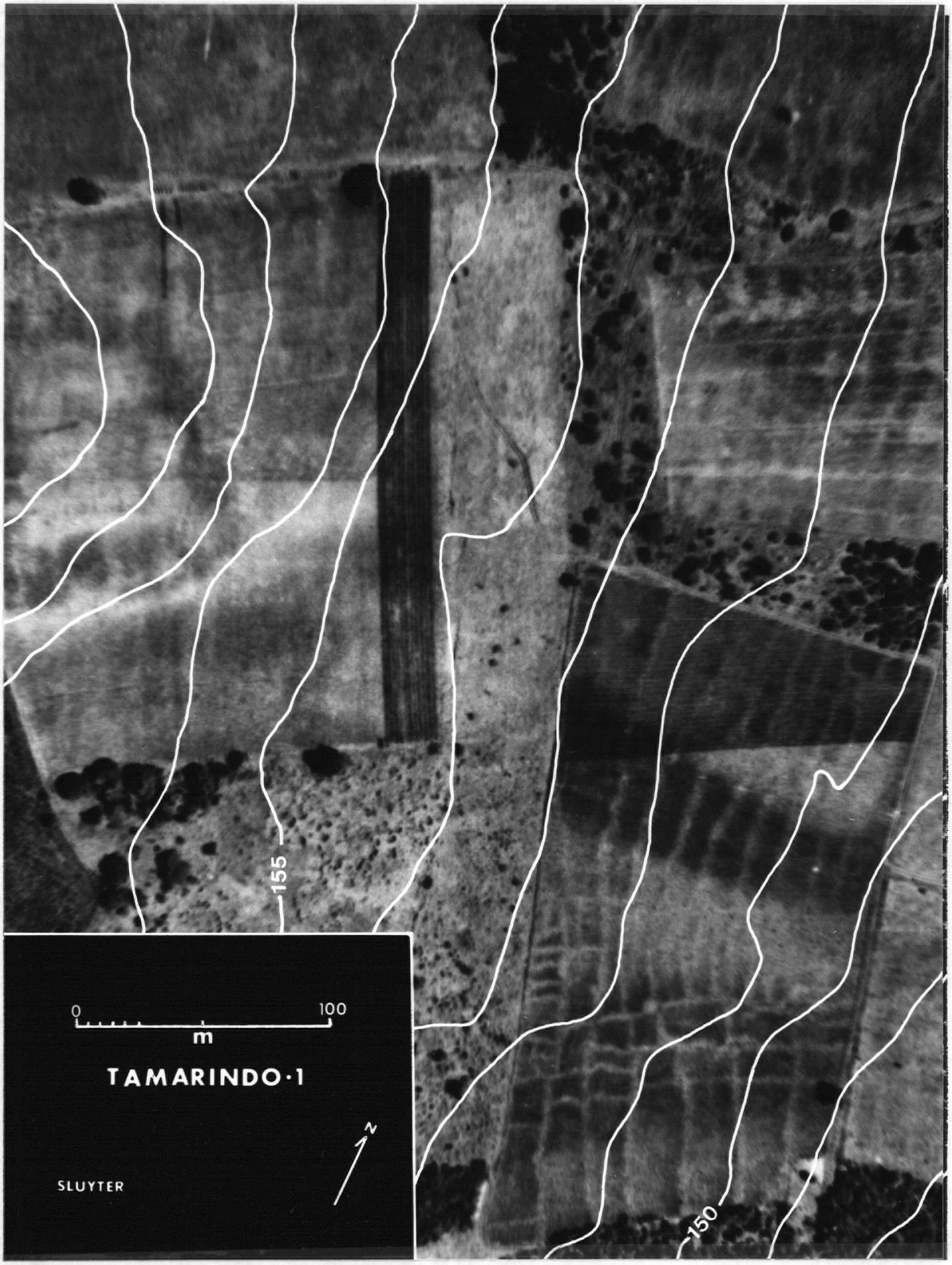


Figure 15. Topographic overlay of a vertical air photograph showing upland fields at Tamarindo-1 (photo: SRH 1973, F14-29; map: SRH 1973, sheet 49).

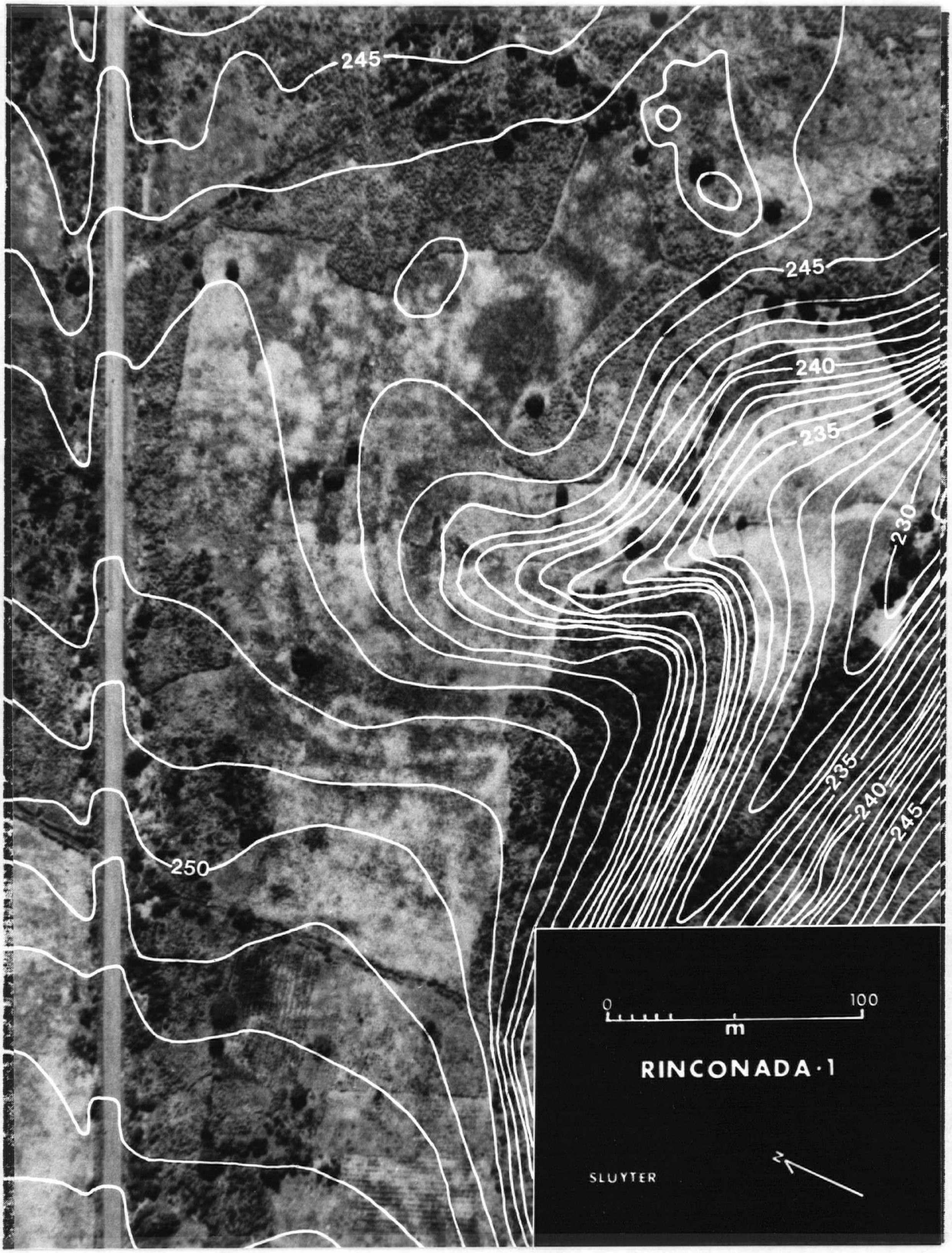


Figure 16. Topographic overlay of a vertical air photograph showing upland fields at Rinconada-1 (photo: SRH 1973, F7-20; map: SRH 1973, sheet 41).

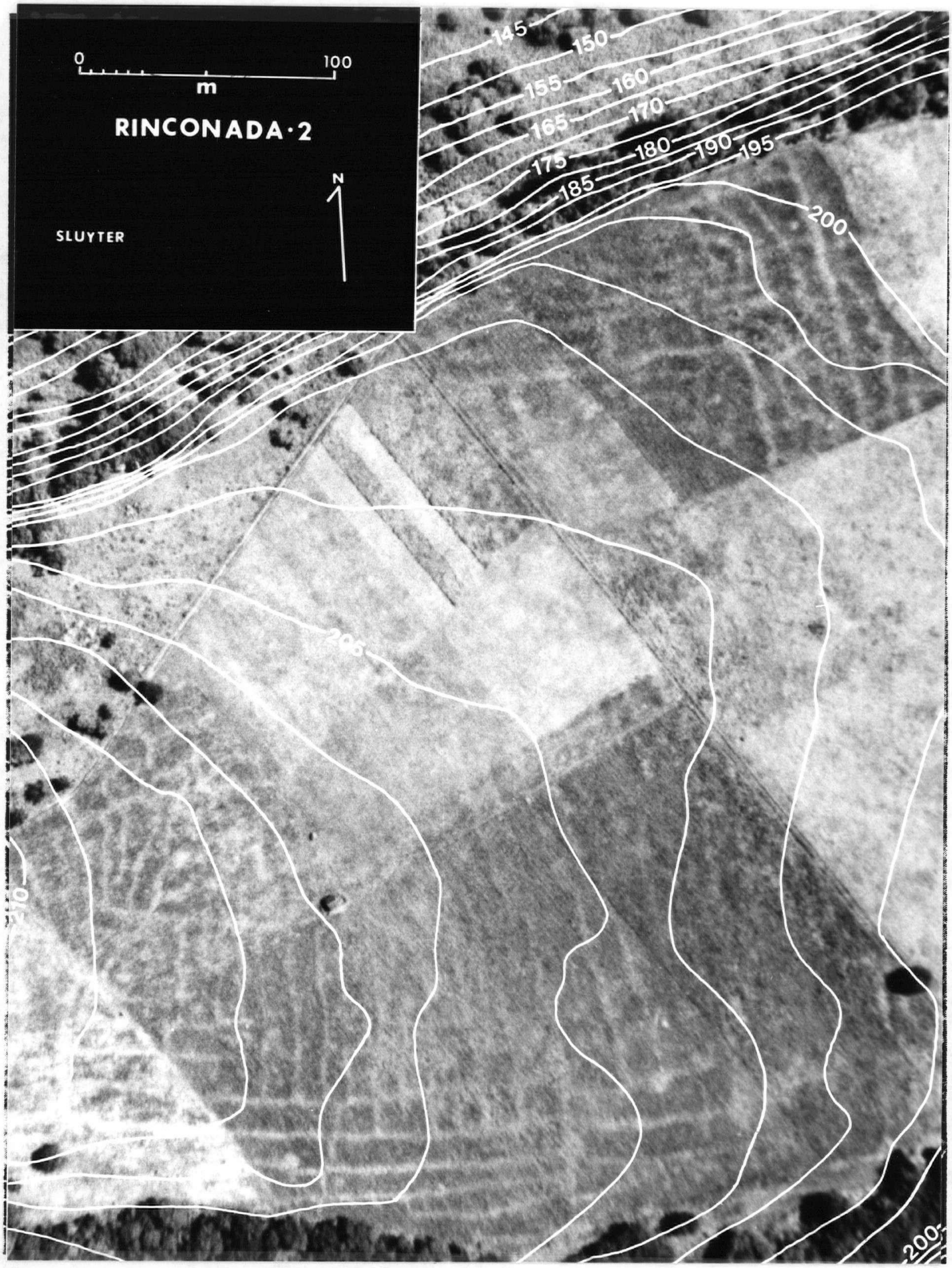


Figure 17. Topographic overlay of a vertical air photograph showing upland fields at Rinconada-2 (photo: SRH 1973, F8-25; map: SRH 1973, sheet 56).

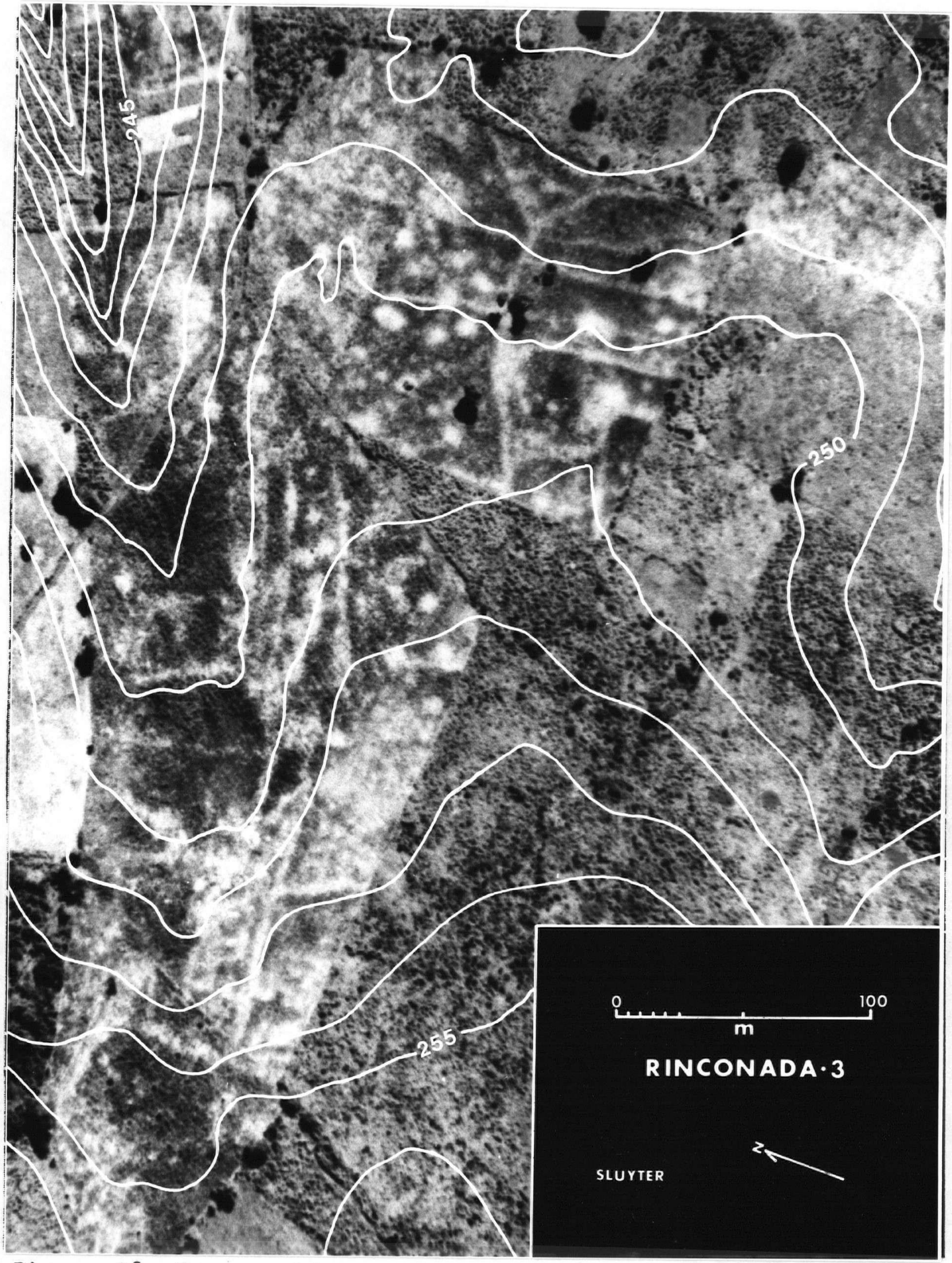


Figure 18. Topographic overlay of a vertical air photograph showing upland fields at Rinconada-3 (photo: SRH 1973, F7-24; map: SRH 1973, sheet34).

Figure 19. Oblique air photograph of upland fields at Rinconada-1 (photo by A.H. Siemens, August 1980).

lines trend east-west, normal to the north-facing slope; then they turn and follow the east-facing slope in the upper-right quadrant. At Tamarindo, again, this same characteristic is apparent at A (figures 12 and 15); the stone lines consistently follow slope contours.

This contouring, however, is not always precise. In some places, as in C at La Gloria, the majority of lines trend parallel to slope direction (figure 10). But such cases are few. In other places, such as B at Tamarindo, the alignment is consistently diagonal to slope direction (figure 12). Perhaps, the one metre contour interval reveals detailed changes in slope which were neither apparent nor critical to Precolumbian farmers. Simple surveying techniques on shallow slopes cannot delineate precise contours. And the technology involved might not have required the exact contouring apparent in Asian and Andean stone-faced irrigation terraces.

Moreover, other orientational motivations might have dominated. At La Gloria a consistent orientation of 13-15 degrees azimuth is apparent (figure 9). At Tamarindo an orientation of 349-351 degrees is equally consistent (figure 11). In both cases the alignments follow gross slope direction. Perhaps Precolumbian farmers ignored micro slope variations in order to conform to some macro organizational scheme, conceptually similar to the North American township and range survey. Interestingly, 15 degrees azimuth is a dominant orientation among Classic and

Postclassic Mesoamerican monumental centres (Aveni 1980, Appendix A). And 348-353 degrees azimuth is the characteristic orientation of the Preclassic Olmec centres (Carlson 1975, 753).

Typically, terracing would also display a correlation between slope angle and line interval, steeper slopes requiring narrower field surfaces (Donkin 1979, 32; Wilken 1987, 115). However, profiles of upland fields do not reveal such a relationship between interval and slope (figures 20-22). The distance between the centre-lines of linear stone concentrations ranges from 5-25 m on slopes of 0.75-4.0 degrees in a seemingly random fashion. Perhaps the slope range is too narrow or the sample too small to reveal a consistent correlation. More likely, other factors confound the issue. A particular farmer working with a particular stone concentration while considering particular edaphic conditions would create a particular line interval, perhaps less tied to slope angle than initially seems likely. Moreover, as apparent in figures 13 and 14, the stone lines on the steeper slopes are the most deteriorated; therefore, their interval might appear greater than it originally was because only some of the lines remain visible.

Because of the ephemeral and deteriorated condition of these features, field length is also difficult to gauge. Still, fields appear as short as 15 m in places, such as Tamarindo-1 (figure 15). But they are much longer at La

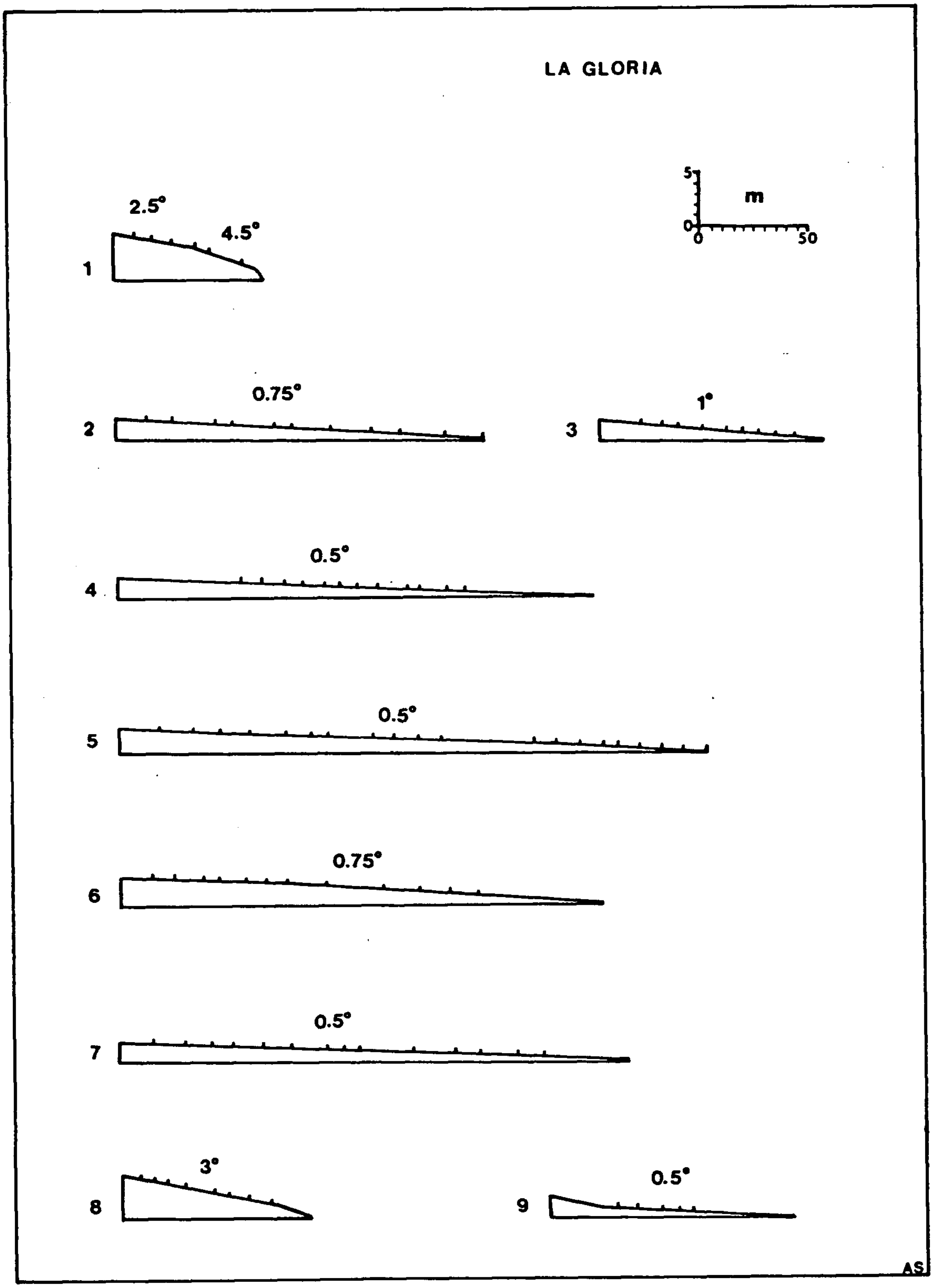


Figure 20. Interval profiles from La Gloria upland fields.

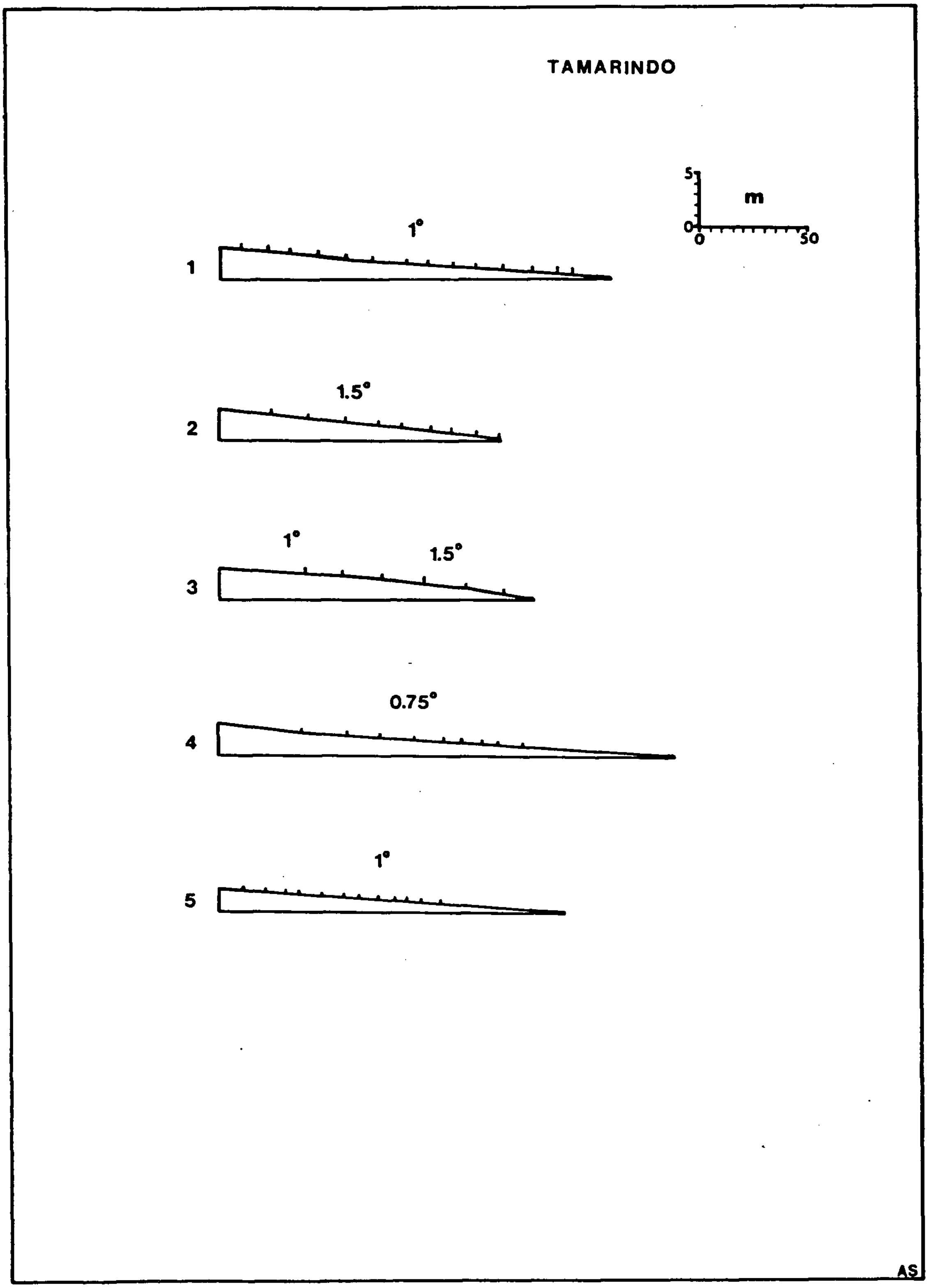


Figure 21. Interval profiles from Tamarindo upland fields.

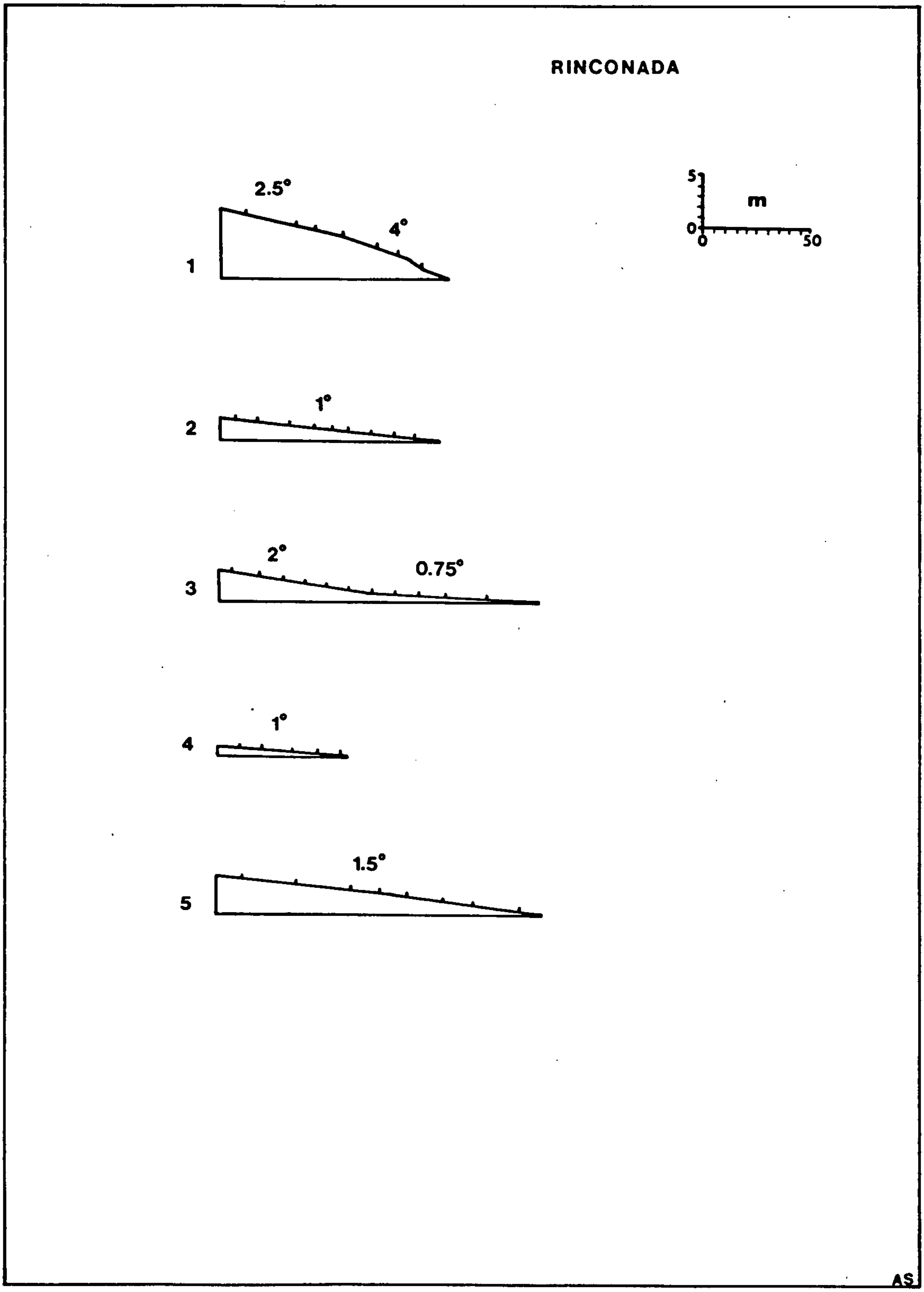


Figure 22. Interval profiles from Rinconada upland fields.

Gloria, where series of lines run normal to slope for 500 m without perpendicular lines interrupting (figure 10).

In addition, because of their ephemeral nature, determining the areal extent of field complexes as a whole is equally problematic. The fragments of complexes which are apparent approximately range from 3 ha to 50 ha, for the nearly contiguous western La Gloria fields. Yet the consistent orientation of the fragments visible at La Gloria and Tamarindo suggests unity. Quite likely, other upland fields underlie the intervening spaces now covered in crops and savanna, forming a contiguous, oriented whole. Only continued aerial survey over a number of consecutive years can confirm or deny this hypothesis. If correct, however, the entire La Gloria complex would cover at least 150 ha and the Tamarindo complex at least 300 ha.

Associated with the linear stone concentrations are circular ones. They are particularly evident at La Gloria-1, La Gloria-2, and Rinconada-3, where they range from 5-10 m in diameter (figures 13, 14, and 18). Regularities in the density and spacing of these stone circles are not apparent. A much larger feature, on the order of 100 m in diameter, occurs at Tamarindo-1 in the upper-left quadrant (figure 15).

Analogues

The morphology of the vestigial upland fields suggests some analogues. Each human ecological context is unique, and, by definition, analogues cannot provide exact models for genesis and function. But analogues can provide hypotheses for testing. Accordingly, then, the upland fields' characteristic contouring suggests several sloping-field terracing technologies which in turn suggest possible functions.

The _metepantli_, or _bancal_, of the Mexican Central Highlands provides the most propinquitous, thoroughly studied analogue. The _metepantli_ is a sloping-field terrace which controls soil erosion and runoff on shallow slopes. It certainly dates from AD 500-600 and quite possibly from as early as the Preclassic. Farmers still frequently employ _metepantli_ on slopes throughout the Mesa Central (West 1968, 365-66; Sanders, Parsons, and Santley 1979, 251; Denevan 1980, 626; Patrick 1985, 544-45). Although isolated _metepantli_ occur, more often flights of them cover entire hillsides, shallow channels distributing runoff to each field (figure 23) (West 1968, 367; Charlton 1970, 280-81). Near Apan, Hidalgo, fields vary in length from 15-150 m, and they vary in width from 12-30 m on slopes of 3-6 degrees to less than 3 m on slopes of 15 degrees (West 1968, 367). Near San Antonio Acuamanala, Tlaxcala, _metepantli_ generally only occur on slopes of less than 5 degrees (Patrick 1985, 539). But these figures vary depending on local cultural, edaphic, and climatic conditions (Wilken 1987, 109).

Wilken describes modern _metepantli_ construction in

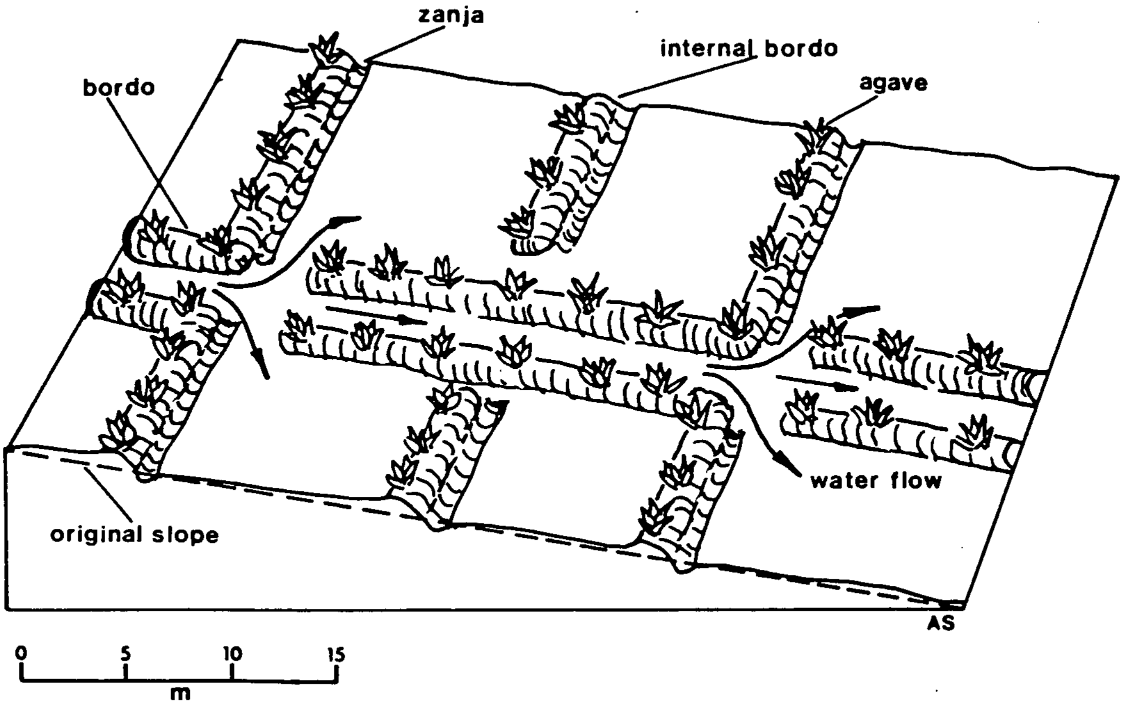


Figure 23. A generalized schematic of a metepantli field system.

Tlaxcala (1987, 106-7). Using shovels and picks, farmers excavate a ditch, or *zanja*, 0.8 m wide by 0.6 m deep along a contour line. Using the excavated material, they then build a 1 m thick by 0.4 m high bank, known as a *bordo* or *melga*, directly upslope of the ditch. Last, they plant young *maguey* (*Agave cantala*) at 3 m intervals along the bank to act as a living terrace wall. Usually the *bordo* incorporates any available stones and continues upslope along the ends of the field to enclose it (Sanders, Parsons, and Santley 1979, 245). As figure 23 also illustrates, the wider *metepantli* sometimes have internal *bordos-zanjas* to further control erosion. As colluvium accumulates, the farmer builds the bank higher, but fields never achieve an entirely horizontal planting surface (West 1968, 367; Charlton 1970, 281; Wilken 1987, 105-6).

Because beans (*Phaseolus* spp.) and barley (*Hordeum vulgare*) require less soil depth and moisture than maize, farmers can strategically vary their crops within and between fields (Charlton 1970, 287-91). In new fields with little soil accumulation, maize occupies the lowest, deepest part of the field and barley or beans the upper part. As soil depth increases, the entire field may exclusively support maize. And as newer *metepantli* located further upslope capture the bulk of the runoff and colluvium, the lowest fields will again come to support only barley and beans (Charlton 1970, 281; Sanders, Parsons, and Santley 1979, 248). Eventually, decreasing soil fertility and water availability force a field's abandonment: the *magueys* reach the end of their ten year life cycle; breaches in the banks develop into miniature *barrancas*; the soil progressively erodes away; and only "traces of the original terrace can be detected in the...*tepetate* surface," a layer of compacted volcanic ash underlying the soil in the Valley of Mexico (Sanders, Parsons, and Santley 1979, 247-49). In time farmers might reclaim these denuded areas by breaking up the *tepetate* and forming new *metepantli* (Charlton 1970, 279).

In addition to augmenting soil depth in the main field for grains and beans, the *metepantli's* bank provides a microenvironment for xerophytic cultivars (West 1968, 367). They are both a crop and a living terrace wall. *Maguey* grows well in the drained *bordo* soil and provides fiber, thatch, fuel, food, medicine, and the fermented drink, *pulque* (Patrick 1985, 542-43). Other *bordo* cultivars include mesquite (*Prosopis* spp.) and fruit trees such as *tejocote* (*Crataegus mexicana*) and *capulin* (*Prunus capuli*) (Wilken 1987, 105).

The parallels between the *metepantli* and the upland field vestiges are striking. Field widths, lengths, and slopes are similar. As well, cultural contexts and the sub-humid climates are similar, although the Central Mexican highlands are temperate rather than hot (SPP 1983). Suggestively, figure 24 shows a newly constructed *metepantli* on a 3 degree slope near Querétaro. The farmers

Figure 24. A metepantli bordo near Querétaro. Note the field stones incorporated into the earth bank. The field slopes down from right to left. (May 1989.)

have incorporated many of the field stones into the *bordo*. If eventually abandoned, the *magueys* will reach the end of their life cycle. Breaches will develop in the bank. The *bordo's* soil will progressively erode away, and only a linear concentration of stones will remain. Eventually, subsequent ploughing could attenuate the stone strip into a pattern similar to the Veracruzan vestiges.

Another context suggests a second but little unstudied analogue (Siemens-Sluyter pers. comm. 7/89). Near Taxco, Guerrero, a series of embankments occupy a 0.07 ha field (figure 25). A farmer has cleared field stones ranging from 4-12 cm in diameter into banks nominally 1 m wide and 0.3 m high, locally known as *pretiles* (Siemens-Sluyter pers. comm. 6/90) or *terraplenos*. The 40 m long slope averages 6 degrees with an irregular interval between banks of 6-12 m. They range up to 16 m long and curve slightly upslope at midfield, apparently to direct runoff toward the field's sides and ameliorate the erosional effects of sheet flow.

Reconnaissance so far has been confined to fields along roads and to casual inquiries, but it indicates that these features might only occur in this one small field. Therefore, unlike the *metepantli*, which has a long history and wide distribution, the *terrapleno* has limited utility as an analogue. Nonetheless, the similarity to the upland field vestiges suggests the *terraplenos'* significance. The upland fields might never have been more

Figure 25. Terraplenos near Taxco, Guerrero. (May 1990.)

substantial than this Guerrero analogue, subsequent ploughing and erosion attenuating the embankments of stones into 3-5 m wide concentrations with no relief. Like Central Veracruz, this area also has a hot, sub-humid climate (SPP 1983). And like the Central Mexican metepantli, maize appears to be the principal crop. However, unlike the mainly earth metepantli bordos, the completely stone terrapleno embankments do not support xerophytic crops.

Although thus far a unique case, the upright slabs at Gasoducto do suggest the relic stone-slab terraces in the Río Bec area as yet a third analogue (Turner 1983a, 77-84). These Maya terrace walls consist of cut limestone slabs set upright into the slope. The lack of well-preserved instances prevents precise measurement, but the slabs seem to be approximately 60 cm long (Turner 1983a, figure 20). The width of the sloping fields on 4 degree slopes, comparable to the Veracruzan slopes, averages 42 m (Turner 1983a, 87). Thus the walls are approximately twice as high and the fields twice as wide in the Río Bec area as compared to the Gasoducto case. Interestingly, although no comparable feature is yet evident in Central Veracruz, the slab-type Río Bec walls are associated with more common broadbase walls (Turner 1983a, figure 17). These features consist of 30 by 15 by 10 cm, rough limestone blocks dry-laid in courses to form walls 0.8-1.4 m high and 0.3 m thick. Immediately upslope of and below these walls is a rubble fill of 10 cm stones. Turner has hypothesized that the Maya used these terraces to grow maize, beans, and squash (Cucurbita spp.) during the Classic, the terraces ameliorating soil erosion (Turner 1983a, 97 and 111-112).

A fourth suggestive analogue based on morphological similarities is the "waffle garden," or huerta con bordes, of the American Southwest (Denevan 1980, 633; Fish and Fish 1984, 151). They consist of stone alignments running both parallel and perpendicular to slope direction, forming grids with individual squares on the order of 2.5 m. At Beaver Creek, waffle gardens contiguously cover 8.5 ha of gently sloping land (Fish and Fish 1984, 148-156 and figures 3-4). Farmers formed the lines from field stones cleared from the planting surfaces. Fish and Fish hypothesize that the "waffles" functioned as baffles to trap water and silt, increasing infiltration, deepening soils, and replenishing nutrients. As compartments silted in, the farmers built new borders on top of the old ones. In the Ojo Caliente, New Mexico area, waffle garden quadrangles range from 1 m by 0.25 m to 3 m by 3 m square (Buge 1984, 29-32). Less commonly, 30 m square fields occur, usually isolated, occasionally in contiguous groups, always on slopes of less than 3 degrees. The farmers located their fields in the path of runoff, distributing the water via small, stone-bordered channels.

These features are not a close analogue. They are located in a semi-arid rather than a sub-humid area, with average annual precipitation below 400 mm. And, also, generally the distances between linear stone concentrations in the waffle gardens are smaller than in the upland fields. Nonetheless, unlike the first three analogues, the waffle gardens, like the upland fields, apparently had little relief. Therefore, these features do illustrate the possiblitities for water and soil management on shallow slopes using nothing more than extremely low stone alignments. The dryland farmers of the American Southwest were able to sustain crops using this technology under quite uncongenial climatic conditions.

More distant contexts provide less striking analogues. Nonetheless, they do offer insights into construction techniques and demonstrate that nonindustrial farmers can and do construct sloping-field terraces which substantially increase yields. In the West African savanna, development agencies are encouraging farmers to build rough low stone banks along slope contours, sometimes stretching for kilometers (Schutt 1988). Farmers do the work by hand and use a simple water level to locate contours. The household which farms a particular field constructs and maintains the walls in the course of regular farm work (Burnham 1980, 160). Benefits have manifested themselves in yield increases of 50-100% over one year (Barrow 1988, 115; Schutt 1988). In the Andes, farmers dig ditches along contour lines, piling the soil in a low bank above the ditch (Pajares and Vonk 1986). The banks, stabilized with grass or economic plants and faced with any available field stones, trap colluvium. Farmers use only handtools and simple plumb bob levels to construct their terrazas de formación lenta.

Possible Functions

The morphological similarities between the analogues and the upland fields suggest a sloping-field terracing technique, a way to manage soil and water on gentle slopes.[3]

However, given that the conglomerate substratum in the upland field area results in particularly stoney soils, the linear concentrations of stones might also represent an even more fundamental practice. They might be the result of stone clearance, one of the most onerous of the many tasks facing farmers. They must dig up heavy, awkward stones, transport them horizontally, and place them where they will do the least harm and the most good. Even in well-cleared fields, new stones continually crop up due to tillage, making clearance a remorseless undertaking (Szabo 1980, 4-5; Fowler 1981, 18). The dumping place might be a steep, stoney slope with little agricultural potential bordering the field (Fowler 1983, 131-44). Or if no such wasteland exists nearby, the farmer might choose to place the stones either in linear strips, in mounds, or in both (Szabo 1980, 10-11; Fowler 1981, 18).

Over a given area, the spacing and distribution of these mounds and lines reflects the size and weight of the stones as well as the technological and cultural context (Fowler 1983, 148). The ongoing nature of field clearance, the logistics of transporting heavy stones and the low energy availability in preindustrial agriculture all indicate a line and mound distribution that should be quite dense and ubiquitous in ancient fields. Certainly, the relict patterns of ancient British fields reflect this expectation (Fowler 1983, 126-48 and plates IIIa, IIIb, and V). In the Veracruzan case, the 5-25 m spacing of the lines at least partially reflects the logistics of transporting 20 cm stones to either side of a field.

Despite the hard work involved in clearance, the benefits of stoneless fields vis a vis stoney fields are equivocal. On the one hand, the main point of clearance is to facilitate tillage. Working the soil with tools removes surface vegetation and weeds which compete with crops for inputs, turns over and breaks up the soil to release nutrients, and aerates the soil to improve root development, drainage, and infiltration. Stones make tillage more difficult by deflecting and breaking tools (Szabo 1980, 8). As well, and perhaps as importantly, stones compete with crops for field space. Too many stones limit both the minimum horizontal spacing of plants and their underground development. Even among the earliest agriculturalists equipped only with dibble sticks and fire, with no hoes to break on stones, a certain maximum threshold of stoniness must have existed beyond which cultivation would have been uneconomical.

On the other hand, a certain degree of stoniness can be beneficial to cultivation. A layer of small stones can act as a mulch which decouples the soil-atmosphere interface, reducing moisture and heat losses from the soil (Wilken 1972, 555-56). Because the interstices between stones are larger than those between soil particles, too large for surface tension to span, the mulch prevents capillary action from raising soil moisture to the surface where it would evaporate. At the same time, the higher ratio of volume to surface area of stone over soil particles moderates temperature fluctuations. A stone mulch can also increase infiltration during precipitation, resulting in higher moisture and nutrient levels (Szabo 1980, 6; Buge 1984, 30-31). The stones absorb the rain's energy, decreasing soil compaction and surface sealing, allowing infiltration rather than runoff and erosion (Epstein, Grant, and Struchtemeyer 1966, 640). In addition, plants can exploit water pockets trapped below buried stones when the general soil moisture level has reached the wilting point (Evenari, Shanan, and Tadmor 1971, 260-61). Other considerations are that as stones weather, they slowly release nutrients into the soil (Szabo 1980, 7). And surface stones protect loose soil from colluvial and aeolian erosion.

Ultimately then, the cost-benefit equation of stone clearance is complex. Even the definition of the size and density of rock fragments which constitute a stoney soil is equivocal (Nikiforoff 1948). The desirable degree of stone clearance depends on cultural, technological, and environmental parameters. However, in many contexts the evidence argues for removal of the "large" stones and retention of the "small" stones.

Moreover, the benefits of stone clearance occur as much in the dumps as in the fields. Stones have an intrinsic value as building material, and linear or nucleated concentrations can serve other purposes besides dumps. Either feature can shelter plants from wind, particularly important for cereals which are susceptible to lodging (Wilken 1972, 557). In Britain, a common use of field stones was to construct walls which enclosed and defined property, controlled the movement of animals, and prevented neighbours' intrusions (Fowler 1981, 28; Fowler 1983, 145).

Most strongly, however, the morphology of the Veracruzan features and the analogues suggest a sloping-field terracing technology with parallel flights of low stone walls or banks ascending hillsides. Based on trips through the Central Veracruzan savanna country, a ninteenth century writer describes an intriguing landscape and confirms the possibility of such a function.

> This region has a peculiar charm for men of an enquiring turn. Traces of extinct tribes are here met with, of a dense agricultural

> population, who had been extirpated before the Spaniards invaded the country. When the tall grass is burnt down, we can see that the whole country was formed into terraces with the assistance of masonry; everywhere provision had been made against the ravages of the tropical rains; they were carried out on every slope, descending even to the steepest spots, where they are often only a few feet in width. In the flat valleys are countless remains of dams and reservoirs, mostly of large stones and clay, many of solid masonry, naturally all rent by the floods at the lowest part, and filled with earth. On the dry flat ridges the remains of large cities are found, forming for miles regular roads. The stone foundations of the houses may be recognized covered with heaps of rubbish and stones, large squares with symmetrically arranged stately edifices, the principle front adorned with temple pyramids, from 40 to 50 feet high; there are also traces of plaster and mortar, and of pavements. There where the union of two ravines with perpendicular rocky walls (and there are many such points) forms a projection protected on three sides, are castles of solid masonry, with ramparts and battlements; in the court-yards are extensive remains of palaces, temples and graves. All is now concealed by trees or tall grass; for many miles scarcely a hut is built, where formerly every foot of land was as diligently cultivated as the banks of the Nile or the Euphrates in Solomon's time. We know not whether a plague or hunger, or warlike tribes from the North, or some great convulsion of nature destroyed the numerous population, indeed we have not the slightest clue which would enable us to decide to what people these relics of great industrial activity belong (Sartorius 1961 [1858], 10).

This passage suggests that the upland fields might have been walls of the Río Bec broadbase type. However, Sartorius did dream of establishing an agricultural colony, and he might have exaggerated the relics of ancient productivity to encourage German immigration (see also Sartorius 1869). Yet the vestigial upland fields do attest his careful observation.

In addition, Hugo Finck, a contemporary of Sartorius, somewhat corroborates his description.

> The whole country [of Central Veracruz] is intersected with parallel lines of stones, which were intended, during the heavy showers of the rainy season, to keep the earth from washing away. The number of those lines of stones shows clearly that even the poorest land, which in our days nobody would cultivate, was put under requisition... (Finck 1870, 373).

Given the morphology of the upland field vestiges, Finck's "parallel lines of stones," even more than Sartorius' "terraces...of masonry," are intriguing and recall the Guerrero terraplenos. Finck's description, however, is too brief to provide details of either morphology or location.

Contouring stone and earth banks control soil depth, water distribution, and infiltration--with all the beneficial corollaries. The balance between the frictional and cohesive forces holding soil on a hillslope and the degradational forces of erosion become unequal when a farmer clears the land for agriculture. Gravity, tillage, and water work in conjunction to loosen and transport soil downslope (Carson and Kirkby 1972, 188). By obstructing water flow, contouring banks reduce its velocity and allow suspended soil to deposit behind them, reducing overall hillslope erosion and locally deepening soil (Foster and Highfill 1983, 48-49). Thus while the overall slope of the hillside remains constant, the banks increase slope within their own structures and decrease the slope of their associated fields. As water velocities slow further with continued deposition and reduced slope, erosion is further controlled (Foster and Highfill 1983, 336).

However, completely halting erosion is neither possible nor beneficial. Turner notes that while contouring walls prevent the downslope colluvial loss of soils and nutrients such as phosphorus, walls also limit the field supply area to the inter-wall distance (1983a, 66 and 93). In fact, Wright argues that due to rapid "weathering" (eluviation?) of tropical soils, without manuring and fertilization, erosion is necessary to renew soil nutrients and maintain fertility (1962, 98).

Moreover, neither the rendzinas nor the vertisols which dominate the upland field area are overly susceptible to erosion. Given the shallow slopes and relatively stable soils involved, then, terracing to prevent erosion is not the most convincing motive for the upland fields. However, accumulated soil behind contouring walls or banks not only provides a deeper matrix for root development but stores moisture which allows plant growth into the dry season (Bunyard 1980, 312). Vertisols, in particular, can retain large amounts of water because of their high montmorillonite clay content; although much of this moisture is held so tightly that plants cannot utilize it (Strahler and Strahler 1987, 399). Moreover, reduced slopes and contouring banks slow sheet wash and rills sufficiently to increase infiltration, reducing water lost to runoff. In addition to providing for photosynthetic needs, water also replenishes nutrients such as nitrogen (Wilken 1987, 69).

In summary, sloping-field terracing displays some general morphological and functional similarities among differing cultural and environmental contexts, although details vary. Hand cultivation does not demand level fields for ease of tillage. Generally, only irrigation requires level terraces and the resulting necessary investment in high walls. The bunded Asian rice paddy and the stone faced Andean terrace are examples (Wernstad and Spencer 1967, 83; Bray 1984, 106-10; Mejía Zamalloa 1987, 7). As evident at La Gloria, the Veracruzan upland fields are too high above adjacent perennial streams for irrigation without pumps or large dams (figure 9). But Precolumbian farmers, recognizing the desirability of stone clearance, deeper soils, and increased water infiltration and storage, seem to have constructed contouring banks or low walls of earth and field stones. Today, the vestiges of those sloping-field terraces are evident as linear concentrations of stones.

The associated stone circles might also represent stone clearance, but more likely they are vestigial house foundations. Their 5-10 m diameter is typical of the size of Precolumbian houses from other regions (Flannery 1976; Blanton, Kowalewski, Feinman, and Appel 1981, 192). And stone foundations are also present in other areas of Mesoamerica (Flannery 1976, 21 and 23). However, their round rather than rectangular plan might signify structures for storage rather than dwelling. The much larger feature near Tamarindo might be the remnant of a fortress or walled settlement. Today, and probably in Precolumbian times, this strategic site overlooks one of the major transportation corridors between the Gulf Coast and the Central Highlands (figures 11 and 15).

Possible Cultivars

Plant ecology, Aztec tribute lists, and other ethnohistorical materials indicate that maize, cotton (*Gossypium* spp.), cacao (*Theobroma cacao*), and agave (*Agave* spp.) are all possible cultivars for Central Veracruz. Maize was already *the* Mesoamerican staple by the Preclassic, and agave might have been an important resource even earlier (Coe 1962, 45-49). However, since maize and agave both grow well in the highlands, they were not desirable as tribute to the peoples of the Valley of Mexico, and therefore are not apparent in the Aztec tribute lists. Except in a case of extreme need, such as famine, only luxury products warranted long-distance transport in Mesoamerica (Drennan 1984, 106-7). But the tribute lists do indicate that these lowlands were a source of cotton, an important fiber crop by the Preclassic, and cacao, the beans of which were a medium of exchange and yielded a fermented beverage (Barlow 1949, 1-7, 89-92, and map insert). Moreover, in 1571, Arias Hernandez noted that the

Totonac of Zempoala not only cultivated "_árboles de algodón_" and wove cotton textiles but made ropes out of "_maguei_ [_sic_]" (1947 [1571], 200; regarding Totonac "tree-cotton," also see Sahagún 1961 [ca. 1578], Book 10, 75). However, sisal (_A. sisalana_) and henequen (_A. fourcroydes_) are the two agave species more usually associated with cordage manufacture. _Maguey_ yields finer and suppler but weaker fibers (Purseglove 1972, 10-15). Because the agave species all appear quite similar Hernandez might have confused them. The Texcocan _Mexican Picture-Chronicle of Cempoallan_ also hints at an association between Zempoala and agave cultivation (1890 [1530]).

Modern maize varieties grow under widely varying conditions. Generally, however, maize does not produce well in humid areas or when subjected to frost. In the tropics it requires 600-900 mm of precipitation during its 90-200 day growing season (Purseglove 1972, 300-44). Even considering the wilder maize varieties involved, the frost-free and well-watered conditions of the Veracruzan wetland fields would have produced an annual _tonamíl_ crop and, perhaps, an additional _temporál_ crop during the summer along the drier wetland margins.

In the upland fields, assuming approximately 800 mm of precipitation during the 135 days from mid May to late September as an indication of water availability, one _temporál_ crop per year would have been possible (figure 3).

But, unlike the wetland fields where mucking would have maintained fertility, the upland fields must have required regular fallowing. Farmers, then, would not have contemporaneously cultivated all of the hypothesized 300 ha of fields at Tamarindo.

Moreover, the canicula, an annual drought typically one to two weeks long, occurs in August; lack of cloud cover results in a higher mean temperature and evapotranspiration rate, further reducing available moisture (Garcia 1970, 17). Significantly, the canícula coincides with the critical period of maize's maximum growth which immediately follows tasseling (Melgarejo 1980, 22). Without adequate moisture the male inflorescence dies before the female inflorescence becomes receptive. A successful maize crop in the upland fields, therefore, would have depended on sufficient soil moisture storage to weather the annual canícula. The hypothesized increases in soil depth, infiltration, and water storage in the upland fields might have been able to meet this demand.

The close juxtaposition of wetland and upland fields at La Gloria and a modern agricultural practice suggest another strategy Precolumbian farmers might have employed in concert with soil and water management (figure 9). Some modern farmers in Central Veracruz who cultivate the margins of the wetland near La Gloria use starter-beds, locally known as planteles, to germinate the seeds of their tonamíl crops (Siemens 1990a, 240). Similarly, Precolumbian farmers could have planted maize in high-density wetland starter-beds near the end of the dry season, utilizing what water remained in the canals for scoop irrigation. With the first rain in mid-May, the farmers would have transplanted the seedlings to the upland fields at much lower densities. Such a strategy would have advanced the crop's growth cycle far enough that the canícula would have occurred after pollination. Such a strategy only seems possible, however, where upland fields directly border on wetland fields.

Perhaps most importantly, the wetland fields were a regional means of reducing the risk inherent in the upland cropping. While the average annual precipitation for much of the area is 1,000 mm, a drought year would have caused famine if upland fields were the only means of production. Even with increased soil depth, infiltration, and water storage, a year in which less than 600 mm of rain fell would have meant a near total failure of the upland maize crop. Records kept over the last 40 years indicate such dry years can be very dry indeed, only 286 mm of precipitation at Rinconada in 1945 for example (Sanders 1953, 41; García 1970, Appendix I). The wetland fields might have ensured at least some regional maize supply, even during the driest years.

That cotton is represented in Maya Precolumbian wetland agriculture indicates that the Veracruzan wetland fields might also have supported intensive cotton cultivation (Wiseman 1983, 110-17; Pohl and Miksicek 1985, 16). Certainly, although lint cotton derives from a xerophytic ancestor and requires high insolation and frost-free conditions, it also thrives in mesophytic and irrigated contexts (Purseglove 1968, 333-64). Yearly precipitation requirements for rain-fed annuals range from 1,000-1,500 mm (Purseglove 1968, 348; Berger 1969, 29; Munro 1987, 74). However, any Precolumbian cotton would have been a perennial rather than the now almost universal annual favoured to reduce pest carry-over (Hearn and Constable 1984, 496; Munro 1987, 316). Such perennial varieties probably required even less precipitation than modern annuals. Moreover, cotton favours a unimodal precipitation regime because the growth and boll swelling periods require adequate moisture, while boll ripening and lint harvesting require dry weather to minimize boll shedding and lint spoilage (Purseglove 1968, 348; Berger 1969, 38). These requirements accord well with the upland field moisture regime: the bolls could develop during the wet summer, then ripen and yield their lint during the dry winter. In addition, cotton grows well in rendzinas and vertisols, the dominant soil types in the upland field area (Purseglove 1968, 348; Berger 1969, 30). In Texas, in fact, the colloquial "black cotton soil" refers to vertisols (Strahler and Strahler 1987, 398).

One impediment to cotton production would have been the <u>nortes</u> which sporadically blow from October to March.

Strong winds can blow lint away and reduce yields (Berger 1969, 30). Nonetheless, colonial cotton production further south along the Gulf Coast near Cosamaloapan and Tuxtla also relied on the dry winter months for harvesting. Perhaps the practice of breaking the tops of the stems down to produce a ground creeping shrub ameliorated wind damage (Sartorius 1961 [1858], 174-75).

Cacao is a tropical forest tree-crop which cannot withstand frost, large annual or diurnal temperature ranges, nor an extended dry season. To yield well, cacao requires 1,250-2,500 mm of precipitation well-distributed throughout the year and moist but non-saturated soils (Purseglove 1968, 575-91). Good cacao yields from the Veracruzan wetland fields, then, might have been possible, but only given careful soil management and water control during the wet season to prevent waterlogging. Despite excavation, however, no direct evidence for wetland cacao cultivation yet exists from the Maya region (Turner and Harrison 1983, 257-58; Turner and Miksicek 1984, 189-90). The upland fields certainly could not have supported cacao because of its high moisture requirements. Perhaps cacao plantations were restricted to the limited alluvial plains, as Muhs, Kautz, and MacKinnon suggest for a site in Belize (1985, 124).

Although little evident in Central Veracruz today, xerophytic agave thrives in arid to sub-humid environments (Purseglove 1972, 7-29). The Maya cultivated henequen in

Yucatán on shallow calcareous gravels with an approximate annual precipitation of 760 mm. And although _maguey_ can tolerate up to 2,500 mm of precipitation annually, these succulents will not withstand saturated soil conditions. Therefore, the wetland fields would not have been a suitable environment for agave, but the upland fields could have supported _maguey_, sisal, or henequen. The better drained embankments or stone alignments would have been the best niches, again recalling the _metepantli_ field systems of the Central Highlands.

Based on plant ecology and some suggestive ethnohistorical sources, therefore, the most likely cultivars for the upland fields would have been maize, cotton, and agave. Past practice among the Teenek of Northern Veracruz and other agriculturalists included intercropping and rotating cotton with maize to improve yields (Sartorius 1961 [1858], 175; Alcorn 1984, 390). A similar practice might have obtained in the upland fields. In the fields proper, famers might have intercropped maize and cotton. Farmers would have harvested the maize at the beginning of the dry season, thus exposing the cotton to additional sun for boll ripening. The perennial shrub would have protected the soil from erosion. Along the _bordos_, farmers might have taken advantage of the better drainage and grown agave. Sartorius, in fact, notes that "bromelias and agaves start up from _heaps of stones_" throughout the savanna country (my emphasis) (1961 [1858], 9). The agave would have acted as a living terrace wall, slowing and directing runoff and retarding colluviation. Rows of agave would also have acted as wind breaks, providing some protection against maize lodging and cotton lint loss.

Ethnohistorical Evidence for a Chronology

The ethnohistorical data not only suggest some possible cultivars for the upland fields but suggest a Precolumbian origin. After 1519, European diseases such as smallpox, yellow fever, and malaria quickly devastated indigenous populations everywhere in Mesoamerica, but particularly in the lowlands (Kelly and Palerm 1952, 9; Cook and Borah 1960, 1-4; Borah and Cook 1963, 89; Denevan 1976, 4-7). Veracruz, the principal port of New Spain, only became crowded when the annual treasure fleet arrived. The remainder of the year, merchants and officials retreated to more temperate climates in Jalapa and Mexico City (Arreola 1982). The lowlands inland from the port were also almost completely depopulated, certainly up until the late nineteenth century. And by then Sartorius and Finck had already noted the vestigial upland fields.

The ethnohistorical materials are fragmentary for Central Veracruz but do indicate that depopulation and agrarian abandonment were extremely rapid after European contact. In 1528, Cortés claimed two ingenios at Rinconada, indicating the prospect of sugar cultivation there and an indigenous labour force (Cortés 1963, 396 and 490). But by 1567, an English merchant described the Central Veracruzan lowlands as pestiferous and uncultivated, relief coming only with altitude.

> [From La Antigua Veracuz] this hote or sicke countrey continueth five and forty miles toward the city of Mexico; and the five and forty miles being passed, then there is a temperate countrey, and full of tillage (my emphasis) (Henry Hawks in Hakluyt 1926 [1589], 280).

Unlike Cortés' lands in Morelos and Oaxaca, apparently, the holdings at Rinconada never prospered. In confirmation, Arias Hernández reported in 1571 that

> there is no other profit nor work in the city and land [of La Antigua Veracruz] but buying and selling, and thus the negroes' services are all in cartage...and livestock... [and] there is no work in the countryside, only carpenters getting wood (1947 [1571], 192-93).

The first detailed account is from 1580. Alvaro Patiño de Avila noted that because of the lack of Indian labourers the land remained largely uncultivated under the Spaniards, except for some vegetable gardens in and immediately around the port. Instead, vast livestock herds provided hides and meat for the fleets that anchored at Veracruz. And, consequently, the port's inhabitants imported the bulk of their provisions from the highlands (Millares and Mantecón 1955; Pasquel 1958, 178-208).

> The cultivated trees of this land, like the banana and *árboles de calor*, are few in this district even though the land is very suitable

for them. This is due to the lack of Indians, that as mentioned above, have been lost (Patiño 1580, 10v-11r).

Although in this city's district there are many rich and excellent lands in which come together all those things required for fertility and the sowing of wheat and growing of vines, as yet this has not been done because the people of this city are occupied with other speculations and do not care for cultivation. They must also fear that the goodness of the earth holds false promise and will not ensure prosperity and ease because of the diversity of the seasons (Patiño 1580, 11v-12r).

In the territory of this city, of all the grains and seeds of the earth are gathered only beans, although few, and maize, which is the main bread and sustenance of the natives and of the negro slaves of this land, moreover being the fodder of the horses and mules and other beasts of burden, of which there are many in this district. Although, because the lands sown in maize are restricted to marginal areas, the crop is little compared to what one would gather if one wanted to sow it for profit, for the land is so extremely accommodating to it that ordinarily more than one hundred fanegas for every one sown are harvested, and that is the least, and at times they are wont to raise one hundred and fifty fanegas for each one sown (Patiño 1580, 11v).

Rivers, born in the snowy mountains [104 km] westward, water all the flat land between the said mountains and the sea.... Along their very fertile banks are fields and very beautiful pastures and savannas in which ordinarily are herded an infinite number of small and large livestock.... Thus it is that...in little more than [29 km] all around are ordinarily herded more than one hundred and fifty thousand head of large livestock, between the cows and the mares, not including the innumerable small livestock that descend each year from Tascala [Tlaxcala], Cholula, and other areas to winter in this district.... [Therefore, this] city has meat of its own in great abundance...[and] supplies itself with bread from Los Angeles [Puebla] and the valleys of Atrisco [Atlixco, Puebla] and San Pablo, fertile and abundant places. [The] many carts and mule trains that come here to load goods and dispatches from the fleet are obliged

> to bring provisions to the city, in order to come loaded, leaving the said provisions to take out cargo. And by this means this city is always well supplied with flour and maize, as if it had it in abundance from its own harvest (Patiño 1580, 4v-5v).

A 1609 account by Fray Alonso de la Mota y Escobar confirms the continuation of herding and the lack of agriculture in the region during the early colonial period. He noted a dozen estancias on a journey through the coastal lowlands and that only eight married Totonac men remained living in Zempoala (Mota y Escobar 1987 [1609], 56). His description evokes an image of ecological destruction.

> [Zempoala's] lands have been converted to cattle ranches..., though they are already devastated and ruined by the thorn woods and grasses which are due to the cattle (1987 [1609], 56).

As late as the nineteenth century the livestock economy still dominated this thinly populated lowland region. In 1850, Zempoala had only two houses (Galindo y Villa 1912, CX). Tylor, on his descent from Jalapa to Veracruz, noted the scarcity of "any habitation but a few Indian cane-huts by the wayside" and the "tens of thousands" of cattle roaming the savannas (1861, 323). Sartorius also noted the cattle and the low population density. Moreover, he elaborates on the environment and the cattle herding ecology involved.

> In general the savannahs are met with at the elevation of [250 m] to [300 m] above the sea, and extend as high as [800 m]. These districts form almost invariably a sloping plain, rent by

> fearful chasms, stretching from east to west, where mountain-streams foam in their deep beds. The reader must not picture to himself fair lovely meadows, but rather dreary wilderness, overgrown with low thorny mimosas, frequently varied with larger groups of trees and small forests.... In the summer months, from June to October, the tropical rains call forth a lively green, thousands of cows pasture in the rich juicy grass, and afford variety to the uniformity of the landscape. With the cessation of the rains, the prairies fade, the soil dries up, the trees lose their foliage, the herds seek the forests and chasms, and in the cloudless skies, the sun scorches up the unsheltered plains. In this season the prairies are often set on fire, partly to destroy the clouds of tormenting ticks and tarantulas, partly to call forth a new crop from beneath the ashes.... Neither towns nor villages are found in these extensive districts, but merely here and there the solitary farms of the cattle-proprietors, or of the herdsmen (1961 [1858], 9-10).

Despite the limited presence of cattle herders throughout the colonial and early republican periods, these lowlands were a zone of transit and remained sparsely populated and scarcely cultivated. Generally travellers remarked at the tropical luxuriance of the wetlands but did not linger long, rejoicing when they reached the oak and pine forests of the temperate slopes around Jalapa (Siemens 1990b).

Only with the eradication of yellow fever and the amelioration of malaria early in the twentieth century did agriculture again become a significant part of this lowland landscape. Particularly after the 1910 revolution, agrarian settlers from the highlands began to occupy the Central Veracruzan lowlands (Gonzales-Jacome n.d.). Initially, famers kept to the wetland margins and limited alluvial plains. But later, with the advent of pump-fed irrigation, the interfluvial uplands also came under cultivation.

However, the linear stone concentrations seem unconnected with the ruler-perfect field divisions of modern agricultural. In figures 8, top, 15, 17 and 18, modern roads cut across the linear concentrations of stones. In figures 8, bottom, and 14, modern irrigation canals cut across the upland field pattern. Some alignment is evident because both ancient and modern fields are oriented to slope direction in order to control water flow.

In any case, the countryside was already "intersected with parallel lines of stones" (Finck 1870, 373) and "formed into terraces with the assistance of masonry" (Sartorius 1961 [1858], 10) by the mid-nineteenth century. Even at that time their origin was uncertain. Furthermore, nothing in the ecology of cattle herding suggests features of this kind, nor was the labour force necessary for such construction available during the colonial and early republican periods. Therefore, the upland fields are Precolumbian.

Direct Evidence for a Chronology and Cultivars

The ethnohistorical data certainly indicate that the upland fields have a Precolumbian origin. In addition, several 7 m high earth mounds occur near the La Gloria fields, suggesting a substantial Precolumbian presence there (figure 9). However, whether the fields and mounds were contemporaneous is a subject for investigation. Similarly, whether the fields are Postclassic, Classic, or Preclassic remains an open question.

Preliminary excavations in the upland fields similar to those in the wetlands have yielded neither maize pollen, maize phytoliths, nor cultural artifacts. Soil samples from two preliminary upland sites exhibit only grass phytoliths (Siemens, Navarrete, and Sluyter 1989; Piperno-Siemens, pers. comm. 25/9/1989). Grasses of the Chloridoid tribe heavily dominate, with Festucoid grasses also present in significant amounts. The lack of Panicoid grasses, which usually dominate over Chloridoid in undisturbed tropical contexts, indicates to Piperno that these two phytolith assemblages represent Postcolumbian pastures. She believes that colonial and modern burning in aid of pasture and the introduction of non-native grasses might have obscured any phytolithic remains of Precolumbian land use.

Other difficulties in dating and identifying cultivars in the upland fields also exist. Ceramic and lithic artifacts which can date paleophytes through association are uncommon in agricultural fields. Moreover, preservation of both phytoliths and pollens seems generally to be poor in terraced soils (Pohl and Miksicek 1985, 11). Pollens, in particular, will not withstand the repeated wetting and drying of the upland soils (Pearsall 1989, 253-54). Phytoliths, being non-organic, are often more durable than pollens, but the former are diagnostic of only some cultivars. Maize forms diagnostic phytoliths, but cotton, maguey, sisal, and henequen do not (Piperno 1988, 45-7 and tables 2.1-2.4; Pearsall 1989, 340-41). In addition, even if the upland fields were to yield phytoliths and ceramics, the vertisolic churning prevalent over much of the area would complicate dating. The stratigraphy would be disturbed, and associations between phytoliths and datable artifacts would be insecure. However, the direct dating of phytoliths through thermoluminescence is an emerging possibility (Piperno-Siemens, pers. comm. 25/9/1989).

Presumably, relevant pollens might occur in the sediments of the wetland immediately downslope from the La Gloria complex, where the anaerobic environment would have promoted preservation (Pearsall 1988, 255-56). However, while wind and water could have carried anemophilous maize pollen into the wetlands, entomophilous cotton pollen and largely entomophilous agave pollen typically deposit *in situ* and indicate local cultivation (Purseglove 1972, 20; Wiseman 1983, 107-8 and 114-17). Moreover, any connection between upland maize cultivation and maize pollen from the La Gloria wetland fields would be tenuous because excavation has already confirmed *in situ* maize cultivation in Veracruzan wetlands (Siemens et al. 1988). Only datable paleophytes from the upland fields themselves can unequivocally indicate their Precolumbian cultivation. Of course, wetland sediment cores will still be immensely valuable for a diachronic understanding of the paleoclimatic and environmental context and changes in upland and wetland cultivation (Butzer 1982, 171-90; Oldfield, Worsley, and Baron 1985; Hughes 1985).

Given the upland context and list of probable cultivars, success in future excavations demands consideration of biotic, edaphic, and cultural factors. Several points are already clear. First, maize's diagnostic phytoliths remain the best chance for recovering in situ evidence of a cultivar. Secondly, maize's hypothetical distribution within the fields rather than along the linear stone concentrations suggests an emphasis for new excavations in midfield locations. Nonetheless, colluviation might have concentrated phytoliths along the hypothesized bordos; therefore, new excavations cannot totally neglect those areas. Thirdly, the rendzina soils which dominate the western upland field area around Rinconada are the most promising for excavation because of the churning characteristics of the vertisols which dominate elsewhere (figure 4). Fourthly, the slab-type Gasoducto features, which are easier to locate at ground level than the linear concentrations of field stones, probably only occur west of Tamarindo. Only that part of the upland field area has limestone slabs, igneous field stones occurring elsewhere. And fifthly, Postcolumbian land use necessitates excavation in areas of least disturbance. Deep ploughing and stone clearance, in particular, must have disturbed Precolumbian remains. Cadastral maps, land tenure records, and ethnographic enquiry might identify the most promising areas.

ETHNOHISTORICAL EVIDENCE

Recent fieldwork has prompted a reevaluation of this region. Vestiges of upland and wetland fields indicate that Precolumbian farmers did successfully cope with their seemingly uncongenial environment and that intensive agriculture was widespread. In hindsight, ethnohistorical data also confirm such a view and require systematic reconsideration.

Unquestionably, indigenous historiography portrays these lowlands as agriculturally productive during the Late Postclassic. Before destroying the native books, two of the early colonial priest-ethnographers recorded accounts of a famine in the Valley of Mexico from 1454 to 1457 which forced the Aztecs to sell their children to the Totonacs in return for maize (Durán 1867-80 [ca. 1580], Capitulo XXX; Torquemada 1975 [1615], Libro II, Capitulo XLVII). Within the next decade, the armies of Motecozuma I had subjugated Totonacapan and brought it within the Aztec tribute domain (Kelly and Palerm 1952, 22).

For the temperate Valley of Mexico, these tropical lowlands were an important source of cotton, cacao, amber, rubber, and quetzal plumage. In figures 26 and 27, two pages from the Codex Mendoza, an Aztec tribute list, illustrate the produce of two coastal provinces. Quauhtochco stretched from the coast to the Sierra Madre Oriental, its northern boundary the Sierra de Chiconquiaco,

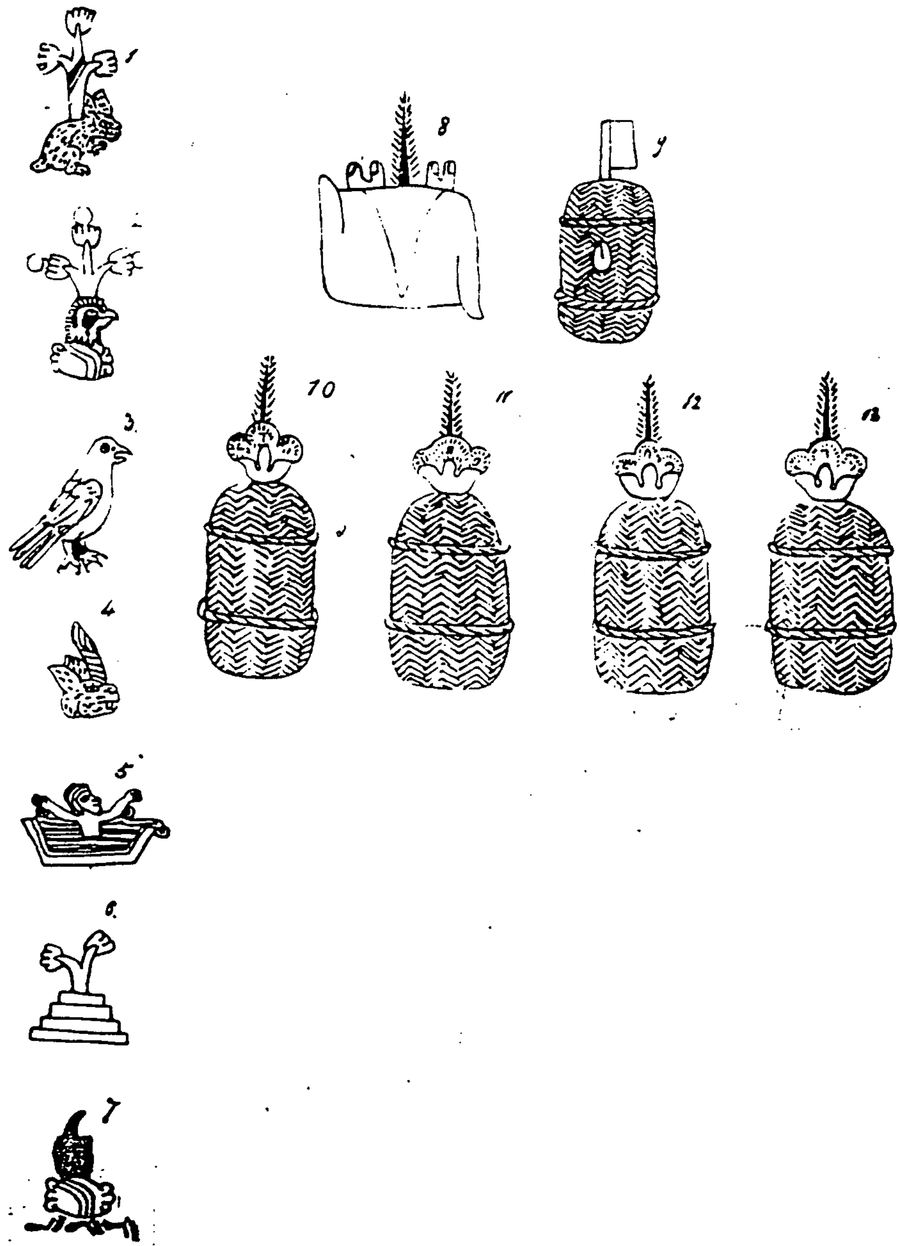


Figure 26. The Codex Mendoza: tribute list for Quauhtochco province. Feathers indicate 400 and flags 20. Mantles are at 8, cacao at 9, and cotton at 10-13. The Spanish glosses are not reproduced (Kingsborough 1831, Vol. I, plate 50).

Figure 27. The Codex Mendoza: tribute list for Cuetlaxtlan province. Feathers indicate 400 and flags 20. Mantles are at 7-16, cacao at 22, and various other items such as amber and feathers at 17-21 and 23-26. The Spanish glosses are not reproduced. (Kingsborough 1831, Vol. I, plate 51).

its southern boundary extending southwestward from the mouth of the Río La Antigua. The other province, Cuetlaxtlan, lay immediately to the south, its southern boundary just beyond the Cotaxtla River. Unfortunately, only some of the specific places the glyphs represent are identifiable, and these were probably all Aztec garrison towns in the western parts of the provinces, the two principal ones being Quauhtochco [Huatusco] and Cuetlaxtlan [Cotaxtla] (Barlow 1949, 1-7, 89-92, and map insert).

Knowing the area of cultivated land the tribute cotton and cacao represent would give some indication of the Late Postclassic population and its agricultural ecology. However, interpretation of the Codex Mendoza is too uncertain for accurate calculations of tribute quantities. Also, the need for analogy to convert tribute to area also introduces error. Yet a rough idea of the area in tribute crops is possible and useful.

Even the amounts and frequency of payment for each commodity are unclear. In the Codex Mendoza, flags signify 20 and feathers 400. Therefore, the glyphs indicate 1,600 bales of cotton, 220 loads of cacao, and 3,760 loads of cotton mantles. However, although tributaries paid cotton and cacao once yearly, they paid mantles twice yearly, yielding a total of 7,520 loads of mantles annually (Kingsborough 1831-48, vol. V: 120-21; Long 1942, 41-3; Barlow 1943, 152-55). A sixteenth century Spanish writer confirms these figures by glossing the glyphs, writing, for example, "400 cargas de mantas" beside the feather-over-mantle glyphs.

Since the Codex Mendoza is an early colonial copy or compilation of an Aztec tribute list or set of lists, its provenance indicates the probable veracity of its glyphs and glosses. Despite this logic, however, Borah and Cook (1963, 41) argue for an interpretation which assumes the sixteenth century Spanish glosses are mistaken and count loads of mantles where single mantles are intended. However, Borah and Cook do not acknowledge that the Aztecs regularly counted certain commodities in lots, mantles always being in lots of 20 (Oroxco y Berra 1960, 450-51). Therefore, a mantle glyph surmounted by a feather signified 400 loads of 20 mantles each, or 8,000 mantles. The scribe who added the glosses to the Codex Mendoza would have been atuned to this convention and simply glossed "400 cargas de mantas" for the elucidation of his Spanish masters, the 20 mantles per carga being standard and assumed.

Nevertheless, Borah and Cook count 33,120 mantles of standard length (1963, 41 and table 1). These 33,120 mantles divided by 20 mantles per load equals 1,656 loads, only 22% of the 7,520 loads the glosses indicate. By ignoring the vigesimal base of Aztec mathematics, Borah and Cook might have made a seriously low estimate of Aztec tribute.[4]

The terms fardos and cargas, bales and loads, are also somewhat equivocal but do generally indicate the absolute quantity of each commodity. In New Spain the carga was both a measure of number and of weight which varied with commodity, region, and terrain. A carga equaled 20 cotton mantles or 24,000 cacao beans (Borah and Cook 1958, 10-12). It also designated the weight that cargadores carried on their backs for days over the rough colonial roads. It varied from 182 kg to 23 kg, the latter being the legal maximum porters carried after 1531 (Simpson 1940, 67-68; Carrera Stampa 1949, 11-16; Borah and Cook 1958, 10-11; Zavala 1984, 121-71). Despite legislation, however, the carga remained as high as 90 kg, but more typically it ranged, and still ranges, from 40-50 kg (Simpson 1940, 16n and 69; Roys 1943, 104; Díaz 1956 [1632], 61n; Sartorius 1961 [1858], 80; West and Augelli 1966, 250; Hammond 1978, 23). Considering both that the early colonial cargadores were previously Aztec porters and that many facets of the Precolumbian tribute economy became integrated into colonial life (Miranda 1952, 35-6), the Aztec tamemes likely carried similar weights, and a single load was probably the standard measure of trade and tribute represented in the Codex Mendoza.

Therefore, assuming 40-50 kg per bale--which also accords well with the 100 lb paca, the standard colonial measure for cotton (Carrera Stampa 1949, 16)--the unwoven cotton alone would have amounted to 64,000-80,000 kg annually. The woven cotton would have amounted to 300,800-376,000 kg annually, assuming 20 mantles at 2-2.5

kg each made up a 40-50 kg carga. And the cacao would have amounted to 8,800-11,000 kg annually, assuming 24,000 beans at 1.7-2.1 g each made up a 40-50 kg carga (cf. Purseglove 1968, 380: large beans weigh 1.82 g).

The cultivated area this tribute represents is also uncertain. Yields for cotton and cacao vary enormously with local environmental conditions and technological inputs. As modern farmers in Central Veracruz cultivate neither crop commercially, analogues are tenuous. Regarding cotton, nearly all cultivation today is of annuals under highly mechanized, irrigated production; those of Precolumbian America were perennials, and presumably less productive due to greater annual pest carry-over (Purseglove 1968, 344; Hearn and Constable 1984, 496). Modern rain-fed cotton annually produces 112-225 kg/ha of lint in India and Africa, 472 kg/ha near Tampico, Mexico; and, under irrigation, yields increase to 2,700 kg/ha (Harness and Barber 1964; Purseglove 1968, 357; Berger 1969, 97). Yields in the early twentieth century, however, were generally lower: 100 kg/ha in India, 270 kg/ha in the United States of America, 550 kg/ha under irrigation in Egypt, and 300 kg/ha under irrigation in Peru (Purseglove 1968, 357; Munro 1987, 147). Using a probable yield of 100-200 kg/ha, then, the tribute cotton would have required some 1,800-4,600 ha of non-irrigated land. Regarding cacao, surviving traditional cultivation in Africa and Trinidad yields approximately 225 kg/ha of beans

(Purseglove 1968, 591). Therefore, the tribute cacao would have required some 40-50 ha of cultivated land. The total land in tribute crops, therefore, would have been some 1,900-4,600 ha.[5]

The earliest Spanish chroniclers somewhat confirm this indigenous indication of Late Postclassic productivity, at least around Zempoala. Soon after the beginning of the year 1-reed, five hundred Spaniards coasted northward from Yucatlán and landed at Tlayacac, now the port of Veracruz (Díaz 1956 and 1984 [1632]; Cortés 1962 and 1963 [1519]; León-Portilla 1962). The Spaniards arrived in April, at the height of the dry season, and did not leave until August, well into the rainy season. In July, Cortés described the land as "being of very beautiful plains and river banks,...as pleasant to look at as it is fruitful in the crops they sow here,...and good to graze all kinds of livestock" (Cortés 1963 [1519], 22). Since no livestock other than Spanish horses could have been present at that time, Cortés was at least partially inferring, and possibly exaggerating, the country's fertility to gain Charles V's support for his adventure. Bernal Díaz, a soldier with lesser ambitions, is generally more reliable and informative. Yet he largely confirms Cortés' description of prosperity, at least around Zempoala.

> As we entered among the houses [of Zempoala] we saw so great a town, and we had seen no larger, that we admired it greatly. And it was so luxuriant and like a garden, and so populated with men and women, and the streets so full with

> those who had come to see us, that we thanked God for having discovered such a country...[,and] we named it City of Abundance (Díaz 1984 [1632], 181).

Half a century later, Alvaro Patiño de Avila confirmed in more detail Central Veracruz's prosperity and dense population during the Late Postclassic.

> According to the oldest residents of this land, when the Spaniards came there were many places and large Indian populations within [25 km] all around this city [of Veracruz La Antigua]. These have become much diminished, many becoming completely depopulated, leaving no trace except the memory of their name.... Cenpoala,...a city of twenty thousand <u>vecinos</u>, now barely has thirty houses. And the town that we call Rinconada, which the Indians call Illapa [or Hizcalpan]..., was a principal place of more than ten thousand <u>indios</u>, and now it has not fifty houses. And similarly...there are many other towns which now have but twelve or fifteen houses: like Xamloluco [?], less than [4 km] west; and Espiche [Plan de Espiche], [21 km] southeast; and Cotastla [Cotaxtla].... In this notable way the Indians of this district have become bankrupt and scarce since the Spaniards mastered the land, and each day the towns continue to disappear...(Patiño 1580, 5v-6r).

Arias Hernández, corroborates this demographic collapse. His informants attributed 30,000 <u>indios</u> to Precolumbian Zempoala, declining to 20 by his day (Hernández 1947 [1571], 193 and 201). If these authors are referring to adult males only, as the terms <u>indio</u> and <u>vecino</u> suggest, a correction factor of 3.3 indicates a possible decline from 99-66,000 people to only 99-66 for Zempoala, and from 33,000 to only 165 for Rinconada (Kelly and Palerm 1952, table 14; Cook and Borah 1960, 38).

Taken together, then, these indigenous and Spanish accounts portray a densely populated, fertile region centred on Zempoala by the Late Postclassic. Besides the 1,900-4,600 ha in tribute crops, much additional land must have provided subsistence crops, notably maize, as well as cotton and cacao for trade and local consumption. But the sources are silent regarding the basis of agricultural production and the detailed nature of the settlement pattern during the Postclassic. They are completely absent for the Classic and Preclassic.

However, the productivity to sustain a dense Postclassic population likely was not solely based on a limited area under permanent irrigation at Zempoala--as Sanders, Palerm, and Wolf suggest. For the Postclassic Valley of Mexico, Sanders calculates that based on an 80% maize diet, average annual per capita consumption would have been 160 kg of maize (1976, 109). Therefore, a population of 66,000 at Zempoala, as Patiño reports, would annually have consumed 10,560,000 kg of maize. Sanders also calculates that permanent irrigation on alluvial plains yields 1,400 kg/ha of maize (1976a, 108-9; Sanders, Parsons, and Santley 1979, 372-76 and table 9.1). Therefore, assuming two annual harvests and no need to fallow, and assuming that pest and blight losses in the lowlands would have equaled frost, pest, and blight losses in the highlands, Zempoala's irrigated lands must have amounted to some 3,800 ha. According to Hernández, however, Zempoala's population might have been as high as 99,000. Moreover, fallowing would have been necessary, and 160 kg of maize per annum (440 g per diem) seems positively miserly. In fact, if irrigation was the basis of Zempoalan agriculture, as much as 5,000 ha might have been necessary for subsistence crops in addition to the at least 1,900 ha in tribute crops.

Absolutely no evidence exists for such large areas under canal irrigation there or elsewhere in Central Veracruz. Paso y Troncoso did some initial archaeological work at Zempoala in 1891 (Galindo y Villa 1912), and subsequently others have also worked there, but study and reconstrucion of the pyramids has taken priority over study of the agricultural infrastructure. Certainly, modern irrigation works and sugar cane fields have obscured any remains of Precolumbian canals and make investigation difficult. But nonetheless, García Payón determined that

> [Zempoala] had an elaborate canal irrigation system and extensive aqueducts, branching out through subterranean masonry passages and distributing water for daily use in the temple compound and principal houses of the town.... [These] aqueducts emptied into house- or enclosure-cisterns and from them, through another passageway, to other cisterns, until they finally discharged into an irrigation canal (1971, 537-38).

In fact, given the small size of the desague del muro which Paso y Troncoso uncovered (Galindo y Villa 1912, plate 19), the system primarily may have supplied limited quantities of water for domestic use. Doolittle, in considering

Zempoala, concludes that "it can be surmised that ancient irrigation canals, if they existed, might not have been all that 'elaborate' and would have watered only a few hectares" (my emphasis) (1990, 114). To date, then, the function, extent, and relation to agriculture of the hydraulic system at Zempoala still remains uncertain and in need of systematic investigation.

For that matter, the importance and prosperity of the site near the north bank of the Río Actopan could have had as much to do with fish as with suitability for permanent irrigation. Patiño reports vast spawning runs on the Actopan and other nearby rivers as well as a source of salt to preserve them (1580, 4v-5r, 9r-10r, and 13r-13v). The Totonac probably exploited such an obvious resource, and evidence of that activity might remain. Without a systematic and comprehensive research effort, however, such theories about fish and irrigation remain speculative.

In any case, farmers during the Postclassic probably coped with the severe dry season by employing technologies other than canal irrigation. Upland and wetland fields might both have provided subsistence and other crops. Both have a wider potential distribution than the hypothetical Zempoalan irrigation. Both, in fact, already have a wider apparent distribution. The wetland fields certainly date from the Late Preclassic, much earlier than canal irrigation at Zempoala. The upland fields might well also date from the Preclassic. Unquestionably, then, the assumption that dense Precolumbian population in Central Veracruz was limited to an area of permanent irrigation agriculture at Zempoala is mistaken.

Ultimately, the utility of the ethnohistorical data regarding Precolumbian society in Central Veracruz is limited. The Spanish clergy destroyed most of the indigenous books. The surviving codices extend back only to 1200, and the bulk of them deal with the immediate precolonial period (Davies 182, 178). Cortés, Díaz, and colonial officials were more concerned with conquest and economic exploitation than with ethnography. And the sudden, virtually complete lowland depopulation during the first decades of the colonial period caused a sharp cleavage in oral history. Any further understanding of Precolumbian society in Central Veracruz largely depends on continuing work in the field.

CENTRAL VERACRUZ AND THE GENESIS OF MESOAMERICAN URBAN SOCIETY AT TEOTIHUACAN

Given the new evidence from the field and the reconsideration of ethnohistorical data, a new conception of the relationship between people and land in Central Veracruz is warranted. Low agricultural productivity did not constrain this region; it supported a dense population which produced an agricultural surplus not entirely based on the rather late development of an irrigation system at Zempoala. Conceiving of Central Veracruzan "autochthonous self-generated political development" (Palerm and Wolf 1957, 15-16) is now possible, just as it was for the Maya upon the demise of the swidden thesis. Moreover, such a region might even have stimulated social and cultural changes in other parts of Mesoamerica. A reconsideration of various data suggests that during the Late Preclassic, Central Veracruz's inhabitants might have played a role in the dramatic transition to hierarchical urban society at Teotihuacán.

The Pristine Mesoamerican State

Teotihuacán was the first highly stratified urban society in Mesoamerica, a so-called "pristine state" (Fried 1967, 111; Harris 1977, 67-95). This monumental Classic centre in the Valley of Mexico dominated Mesoamerica for half a millennium, spreading its social, artistic, and religious influence as far as the Maya realm. A city of

150,000-200,000 at its peak, it covered 20 km centred on a pyramid as large as that of Cheops in Egypt. The reasons for Teotihuacān's emergence and sudden collapse remain enigmatic (Davies 1982, 63-113).

Some Mesoamericanists use a materialistic, evolutionistic, and functionalistic paradigm, "explaining" the genesis of Teotihuacān in terms of technological adaptation to environment driven by population pressure. Epitomizing this paradigm, Sanders and Price hypothesize that given the valley's semi-arid climate, a number of springs initially determined Teotihuacān's location (1968, 145-50 and 175-87). Then, as irrigation technology developed and population increased, a managerial elite emerged to regulate water distribution and canal maintenance. The result was Mesoamerica's first urban, highly stratified, "hydraulic" society and state. Its despotic ruler-priests glorified themselves and maintained control through monumental architecture and ceremonies to worship fertility and water gods. This theory continues to find an audience (Sanders, Parsons, and Santley 1979, 359-403; Sanders and Santley 1983, 257-68).

The hydraulic society thesis is not only deterministic, it argues _a priori_ from a theory from another context (Wittfogel 1957). Unlike Mesopotamia and the Ganges Valley, however, no direct evidence for large-scale, permanent irrigation exists at Teotihuacān (Turner 1983b, 18; Nichols 1988; Doolittle 1990, 48-52, 63-7, and 143-54). Millon, therefore, proposes an alternative hypothesis that respects the data and considers that metaphysical factors can be equally as important as physical factors (1976 and 1981). Directly beneath the centre of the major pyramid is a natural cave which contains pre-Teotihuacān ceramics and evidence of ritual activity (Heyden 1975 and 1981). The site, therefore, might have been a religious mecca before the growth of the city and construction of the pyramids. Its siting, expansion, and subsequent influence could have had an ideological rather than a material basis, the result of human belief and agency rather than structural and environmental determination.

Such an approach admits historical process and human beings' active structuration of society. And such an approach allows the possibility of an historical explanation which tautological prime movers such as "population pressure" and "cultural adaptation" never will (Giddens 1984; Hodder 1986; Shanks and Tilley 1987). Population pressure, for example, is not an independent variable; at least partially, birth rates reflect cultural attitudes toward family size and abortion. Cultural attitudes are not an independent variable either, but they do have an historical inertia. Population pressure and cultural attitudes toward family size are reciprocally related in a historical process. Therefore, an understanding of the metaphysical as well as the physical factors involved during the initial stirrings of a radically different society at Teotihuacán is central to interpreting the process of urbanization and social stratification.

Teotihuacán And Lowland Central Veracruz

Some iconographic, ceramic, and ethnohistorical data suggest a connection between the Preclassic people of the Central Veracruzan lowlands and the genesis of highland Teotihuacán. Lowland cultural attitudes might have influenced the nature of the society that emerged at that highland metropolis.

Thus far, the upland fields lack direct evidence for a chronology, and whether they date from early enough to have supported people who played a part in Teotihuacán's genesis is unknown. However, the results from wetland excavations indicate intensive maize cultivation in Central Veracruz at the time of Teotihuacán's emergence (figure 2) (Siemens et al 1988). The excavation data are from only two sites and therefore are tentative. However, air photo interpretation corroborates this chronology and widens its scope to include the majority of the Veracruzan wetland fields. Moreover, these data suggest a close relationship between Central Veracruz and Teotihuacán. Individual, contiguous wetland field complexes exhibit a strong trend in their rectilinear orientations (Siemens 1983b). When graphed, a pronounced clustering is evident around 15 degrees 28 minutes east of north, the same orientation as the avenue that forms Teotihuacán's major axis (figures 28 and 29).

Two broad explanations exist for Teotihuacan's orientation. One explanation emphasizes that a sighting along the main avenue points at the summit of Cerro Gordo, the area's major peak and the source of several streams (Winning 1976, 150). A cross-spiral petroglyph near the summit gives Cerro Gordo added significance and corroborates this topographical hypothesis (Aveni 1980, 226). The other explanation emphasizes that the avenue's orientation marked the horizon position of the Pleiades star group during its first annual predawn appearance on May 18, also the date of the first of the two annual solar zenithal passages at Teotihuacán's latitude (Aveni 1980, 225). This is also Central Veracruz's latitude, and in both areas this date marks the beginning of the summer rainy season, undoubtedly holding great significance. The topographical hypothesis, tied to Cerro Gordo, suggests that the origin of "Teotihuacan north" lies within the Teotihuacan Valley. The astronomical hypothesis allows that this Mesoamerican "sacred direction" might have originated elsewhere, albeit somewhere with a similar latitude. Perhaps the two hypotheses compliment each other.

Regardless, together with the data from the excavations, this concordant orientation begins to define an interrelationship between the two areas. They shared a

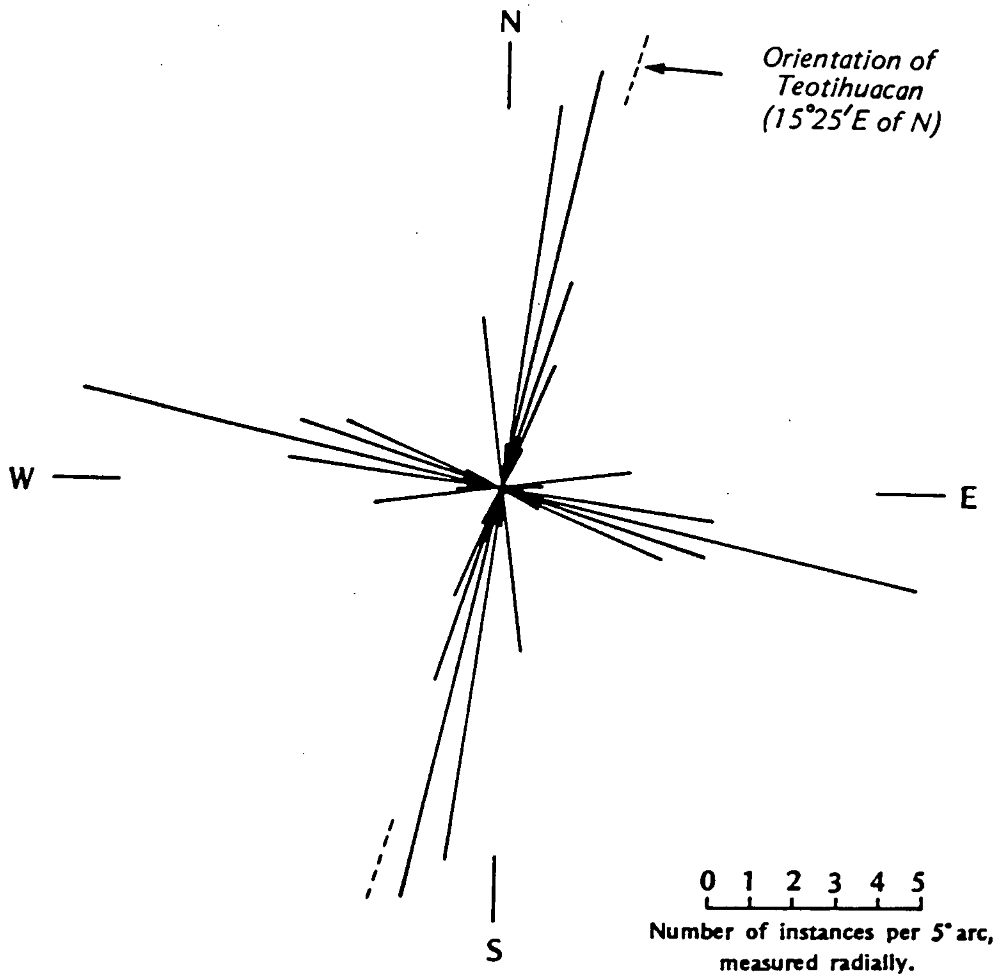


Figure 28. Graph of Central Veracruzan wetland field orientations (reproduced by the permission of the Society for American Archaeology from Siemens 1983b, fig. 8).

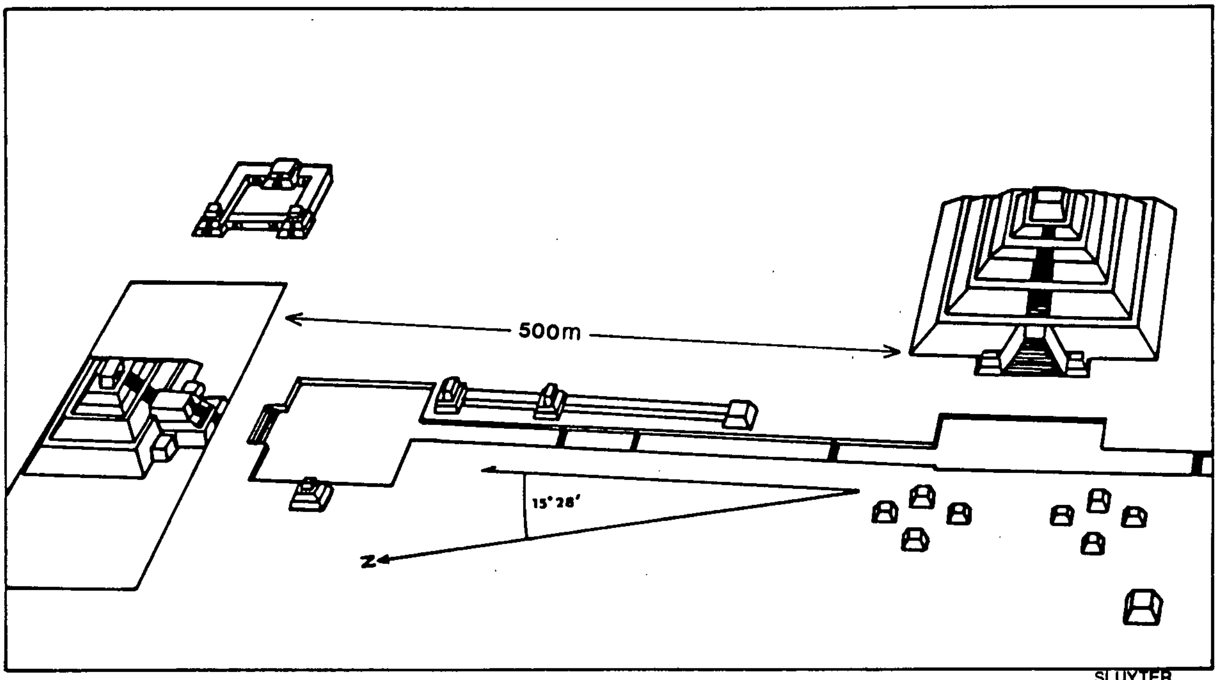


Figure 29. The orientation of Teotihuacán's major avenue to 15 degrees 28 minutes azimuth (after Gamio 1912, Vol. 1, plate 12).

time and a way of materializing time in space which entailed sacred considerations, for simpler, more functional ways exist of tracking the solar transit. Interestingly, the La Gloria upland field system exhibits a similar orientation (figure 9); however, the other mapped instances of upland patterning do not. The organizing impetus for the upland fields was topography, and it could not accommodate cosmological considerations as easily as could architecture and wetlands.

The "Teotihuacān north" orientation became closely mirrored in many other Classic monumental sites as the centre's influence spread as far as the Maya realm (Aveni 1980, Appendix A). But the direction of influence _vis a vis_ Central Veracruz might be reversed, at least initially. According to Fray Juan de Torquemada, a sixteenth century cleric with an ethnographical bent, the Totonac claimed the honour of building Teotihuacān. In 1600 he recorded a Totonac origin myth.

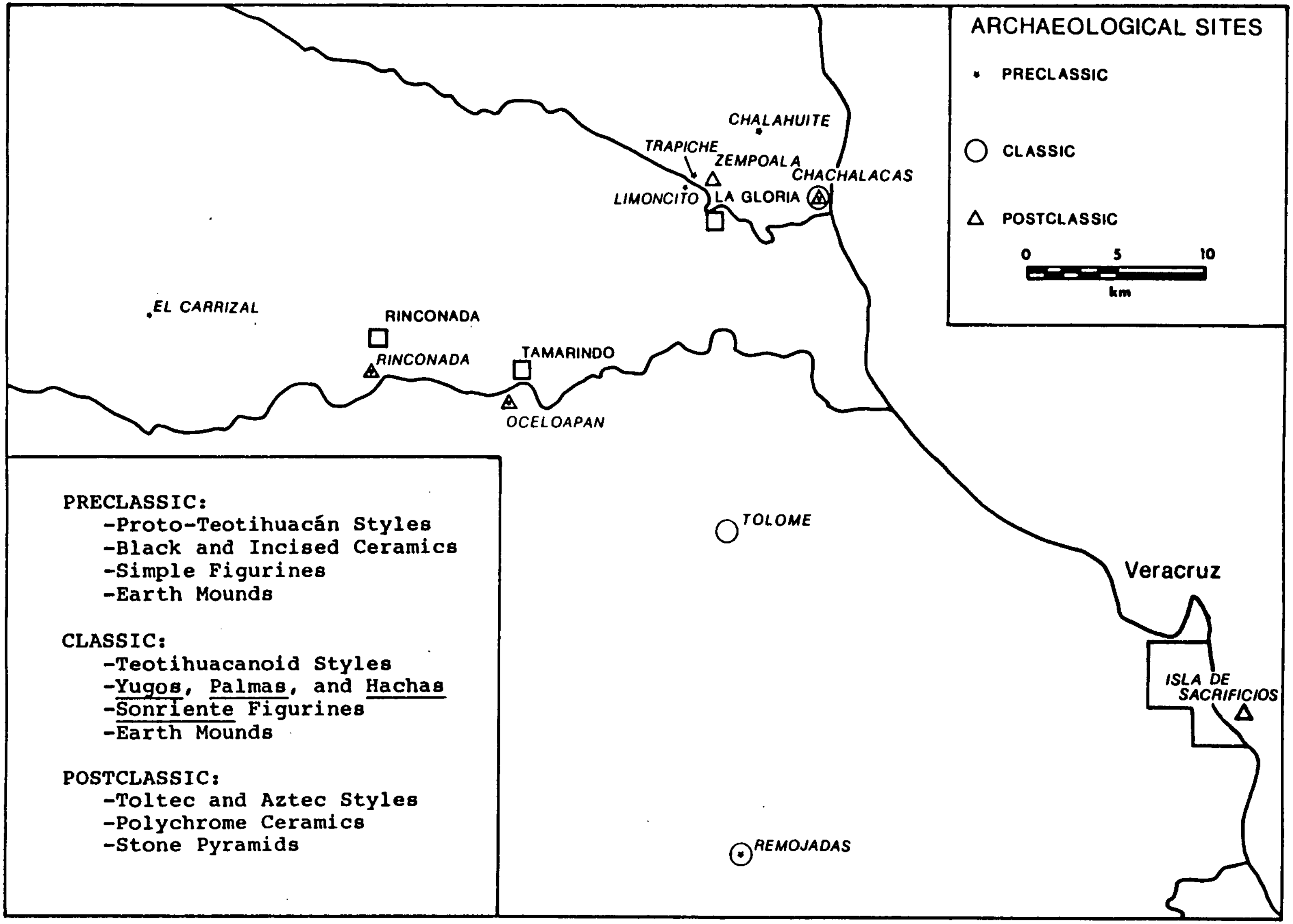
> Of the origin is said that they came out of the place called Chicomoztoc or Seven Caves.... It is said that they left that place, leaving the Chichimecs intered, and came to Mexico. Arriving at the plains by the lake they stopped at the spot where now stands Teotihuacān, and there they claim to have built those Pyramids of the Sun and Moon that are of so great a height. They stayed there a while, and after...they went to Zacatlān, and from there they went four leagues lower, among very rugged mountains. And there they first began to proliferate, and they expanded throughout all that mountainous region...and to

> the plains of Zempoala, populating all that country with many people (1975 [1615], Libro III, Capítulo XVIII).

Although suggestive, this oral history would have been 1600 years old by Torquemada's time and is certainly much distorted in its particulars. Yet the myth does raise the possibility of Central Veracruzan involvement in Teotihuacán's founding.

In corroboration, proto-Teotihuacán ceramic styles commonly occur in Veracruzan Preclassic sites (Covarrubias 1957, 168; García Payón 1971, 525-26). Medellín Zenil cites examples from Remojadas: articulated figurines with coffee bean eyes, Teotihuacanoid bowl profiles, "negative" decoration, and basal flanges (1953, 104). As well, sea shells and their representations are abundant at Teotihaucán (Kolb 1987, 19). Perhaps most dramatically, two thin basalt disks found in that primordial cave beneath the Pyramid of the Sun at Teotihuacán display a "Gulf Coast stylistic influence" (Heyden 1975, 131).

The Central Veracruzan archaeological sequence is largely based on relative seriations of stylistic elements without adequate absolute dating and is "among the more imperfect ones of Western Mesoamerica" (Tolstoy 1978, 269). Figure 30 shows dated sites but not the more than one hundred others which occur throughout the area and, apparently, remain unexcavated (García Payón 1971, 506-11; Coe 1986, 112). Some of these sites are large earth mounds associated with upland and wetland field complexes. The



SLUYTER

Figure 30. Central Veracruz: dated archaeological sites and characteristic traits (sources: García Payón 1971; Medellín Zenil 1953).

only new insights a recent regional overview (Ochoa 1989) presents stem from Wilkerson's excavations and radiocarbon dates in the Tecolutla River basin, immediately north of Central Veracruz (Wilkerson 1989).

Nonetheless, a sharp occupational discontinuity seems to exist between the Veracruzan Preclassic and Classic (García Payón 1971, 526-30). Diffusion of ceramic styles indicates migration to the Valley of Mexico and other regions beginning in the Middle Preclassic, before the emergence of Teotihuacán. Depopulation left most sites abandoned by the end of the Preclassic. During the Classic a repopulation occurred, bringing with it Teotihuacanoid ceramic styles such as the diagnostic cylindrical tripod vase (Medellín Zenil 1953, 104).

Other data which suggest a lowland involvement in the genesis of Teotihuacán come from the Maya. The importance of wetland agriculture in their society is apparent from the prevalence of the water lily (Nymphaea spp.) motif and the associated worship of a crocodilian earth god (Wolf 1959, 78; Puleston 1977). Similar iconography evident from Central Veracruz and Teotihuacán might indicate a relationship between these regions and a diffusion of wetland agricultural technology from lowland to highland.

The water lily glyph, Imix, represents day-one of the twenty-day cycle in the Maya version of the pan-Mesoamerican calendar. However, in non-calendrical Maya writing, Imix often appears with Kan, the day-four glyph which signifies maize. The resulting Kan-Imix compound stands for abundance and fertility (Thompson 1960, 72). Maya writers often added crocodilian features to the conventionalized Imix glyph; in fact, the Northern Mesoamerican day-one glyph is a stylized crocodile (*Crocodylus* spp.) (Thompson 1960, 70-3).

Altar T at Copán, a Classic Lowland Maya site, is the most naturalistic illustration of this association between crocodiles, fertility, maize, and water lilies (figure 31) (Puleston 1977, 458-63). There the Maya artists carved the image of the earth god Itzam Cab Ain, the "wizard-of-water-earth-crocodile [that]...will give birth to enduring life on earth" (*The Books of Chilam Balam* 1948 [ca. 1600], 146, quoted in León-Portilla 1988, 61). The figure has water lilies around its legs, maize leaves sprouting from its temples, and fish feeding on the lilies. In addition, the artist emphasized the regular configuration of the crocodile's epidermal shields (figure 32). This motif, together with the maize and the aquatic symbolism of crocodile, fish, and water lily, are suggestive of the rectilinear patterning of wetland agriculture (cf. figures 6 and 32) (Puleston 1977).

Another Maya artist also emphasized the epidermal shields of a crocodilian figure, this one in the *Dresden Codex* (1972 [ca. 1200], plates 4-5). Seler maintains this painting also represents Itzam Cab Ain, but Thompson calls it the celestial form of the crocodilian deity (Seler

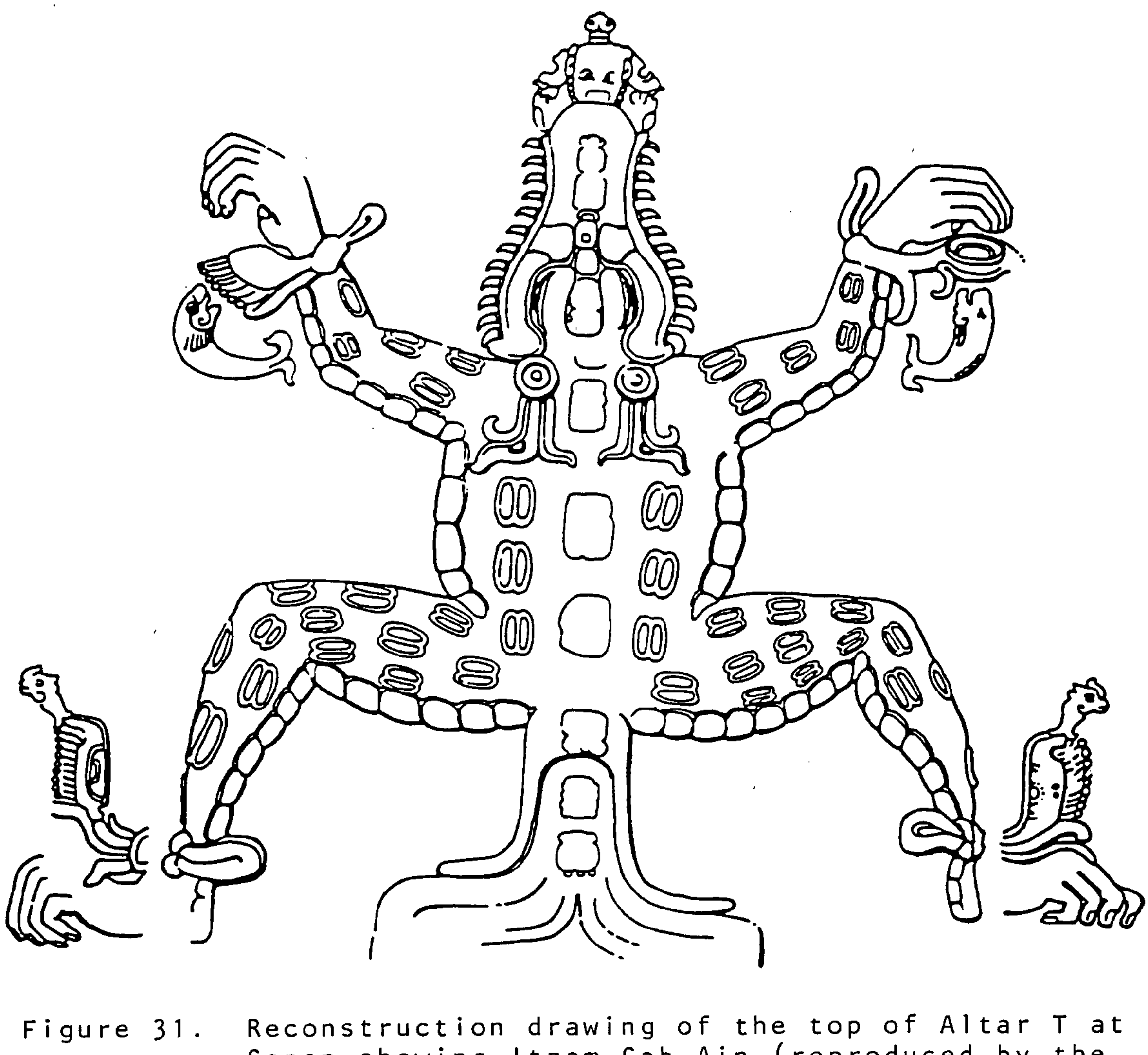


Figure 31. Reconstruction drawing of the top of Altar T at Copan showing Itzam Cab Ain (reproduced by the permission of Academic Press, Inc. from Puleston 1977, fig. 4).

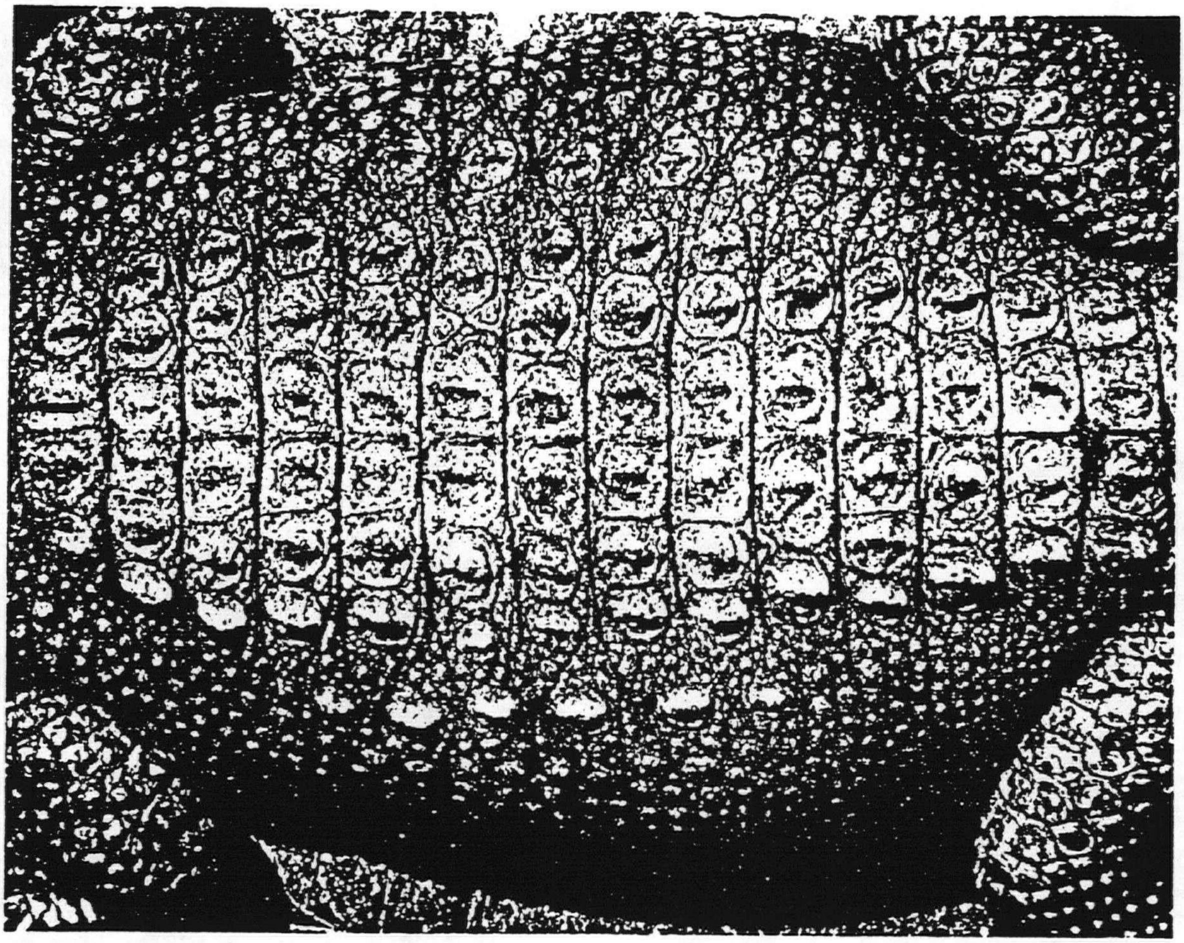


Figure 32. A crocodile back showing the pronounced epidermal shields (reproduced by the permission of Academic Press, Inc. from Puleston 1977, fig. 5).

1960-61, vol.IV: 650; Thompson 1972, 37). Not surprisingly, the Maya's multifaceted crocodilian earth-sky deity is as ambiguous as some aspects of the Christian trinity (cf. Thompson 1970, 209-33: León-Portilla 1988, 56-90). Ultimately, like so much in Mesoamerica, this aspect of Maya cosmology probably has Olmec antecedents (Joralemon 1976, 58-65; Stocker, Meltzoff, and Armsey 1980, 742).

Central Veracruzan art displays similar motifs suggestive of a crocodilian earth-fertility deity (Proskouriakoff 1971, 562). _Yugos_ sometimes have "earth monsters" carved into them (García Payón 1971, 524-26). These highly stylized figures are clearly reptilian and mix crocodilian and frog (_Rana_ spp.) features (Covarrubias 1957, 180; Parsons 1980, 172-73). One _yugo_ illustrates a reptilian head with a human figure in its mouth, legs ending in human hands, and supplementary long-snouted heads on the yoke-ends (Parsons 1980, fig. 268). All of these features prompt comparison with the Itzam Cab Ain figure at Copán (figure 31). A stone _palma_ from Texolo, a site 45 km west of Rinconada, depicts a more naturalistic crocodile (figure 33) (Fewkes 1907, 262).

Although the crocodile's natural habitat is the tropical lowlands (Stuart 1964, 330), the highlands also had a crocodilian earth deity: Cipactli floated in a great pond, his furrowed back forming the cultivated earth. The _Codex Borgia_ depicts an earth -sky-water deity, probably

Figure 33. Central Veracruzan crocodile palma. (May 1989.)

Tlaloc, wearing a crocodilian headdress and watering maize growing from Cipactli's back under a cloudy sky (figure 34) (Seler 1960-61, vol. IV, 648; Puleston 1977). Although this codex's provenance is uncertain, most scholars agree on a Mixtecan origin in Western Oaxaca or Southern Puebla. The Tehuacán Valley, intermediate in elevation and distance between Veracruz and Teotihuacán, is a strong possibility (Chadwick and MacNeish 1967, 114-26; Sisson 1983, 655). But a coastal, Central Veracruzan provenance remains another possibility, and given the current thesis an interesting one (Glass 1975, 65). Unfortunately, although Bernal Díaz noted that "there were many books made of their paper" in the Totonac towns, not one has positively survived the inquisitorial Spanish clergy (1956 [1632], 72).

Significantly, some murals at Teotihuacán display a similar iconography. In the "Temple of Agriculture" water lilies emerge from scalloped lines representing water (figure 35) (Gamio 1912, plate 27; Pasztory 1976, 131). In the "Sowing Priests Room" at the Tepantitla complex, a figure similar to the Codex Borgia Tlaloc also waters the earth and wears a crocodilian headdress (figure 36). And in figures 37 and 38, the lower halves of two Tlalocan Patio murals at the Tepantitla complex depict agricultural activity (Pasztory 1976, 78, 141, and 183-86; Siemens 1983b, 97). The alternating blue and green stripes of the bottom borders are suggestive of a plan view of the

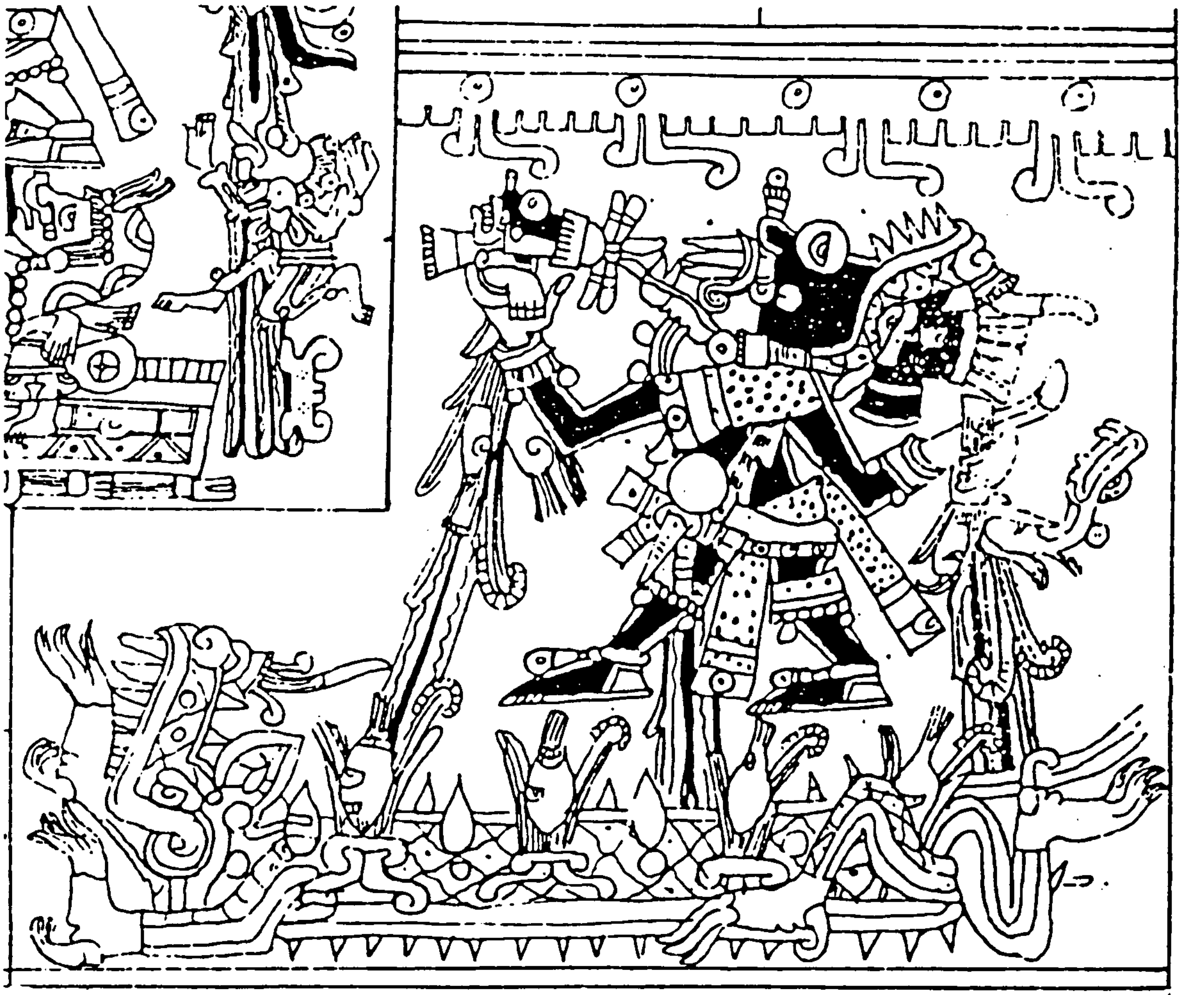


Figure 34. Tlaloc and Cipactli as depicted in the _Codex Borgia_ (Kingsborough 1831, Vol. III, plate 12).

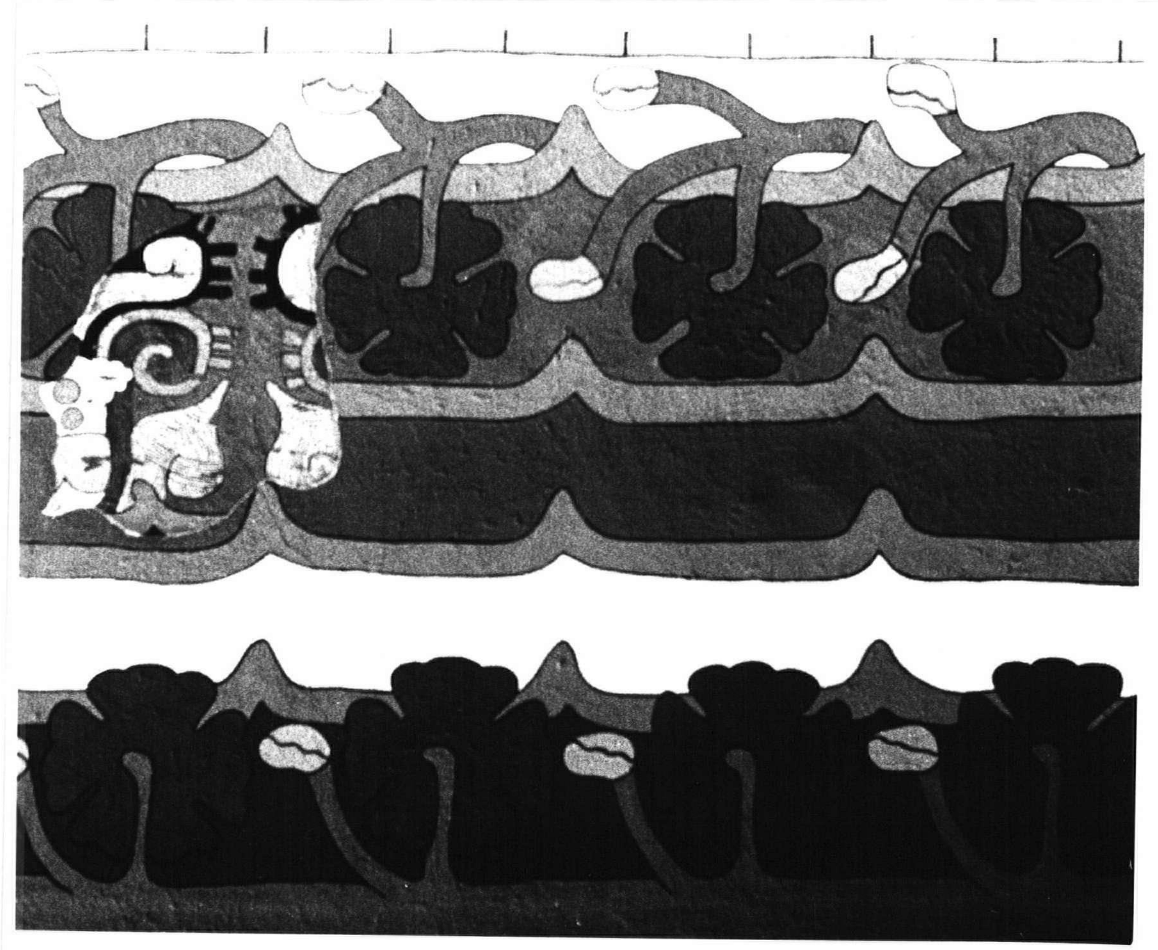


Figure 35. A section of the water lily mural in the Temple of Agriculture, Teotihuacán. (May 1989.)

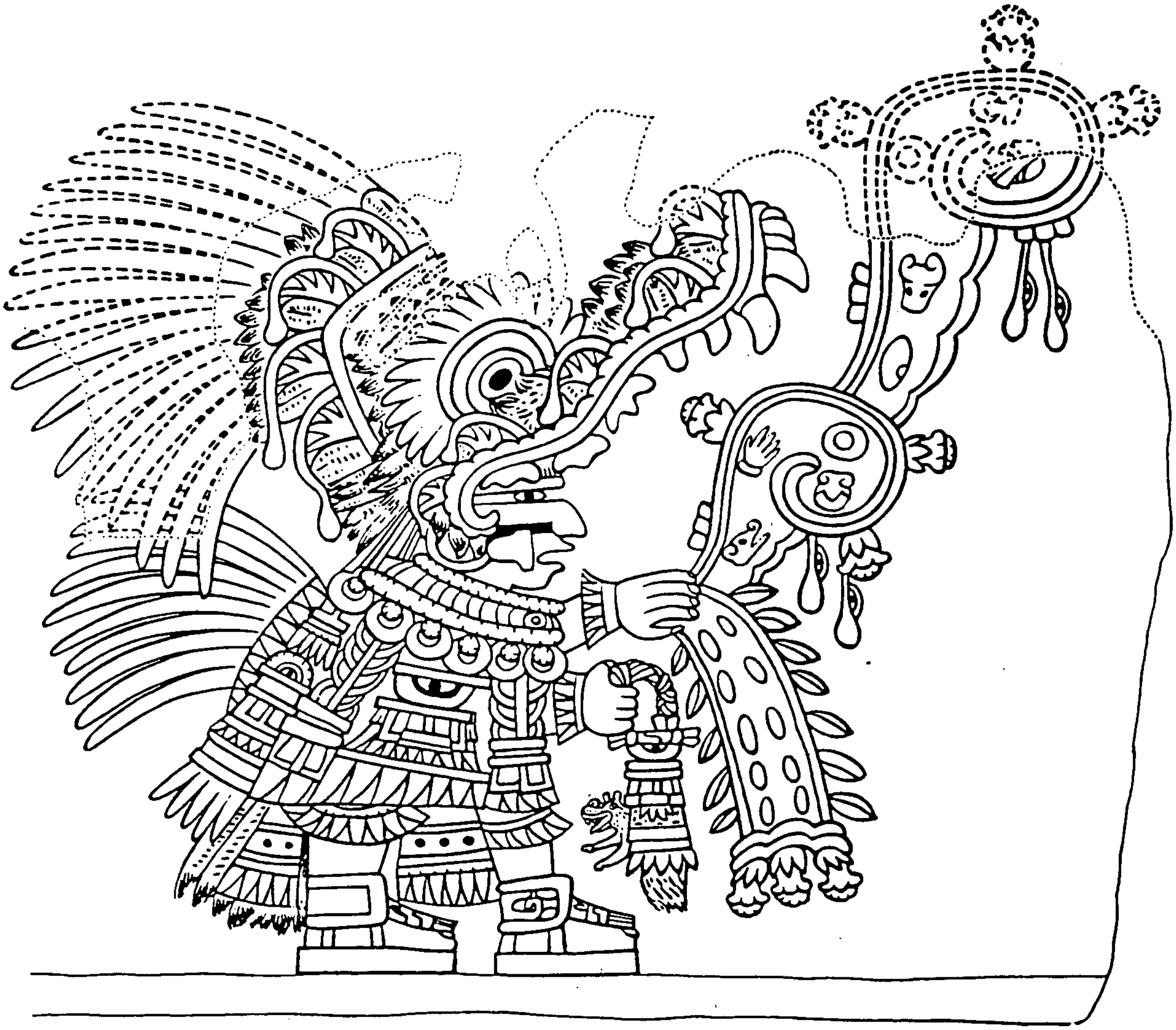


Figure 36. Reconstruction drawing of a Tlaloc figure from the Sowing Priests Room, Teotihuacān (reproduced by the permission of Dumbarton Oaks from Miller 1973, fig. 183).

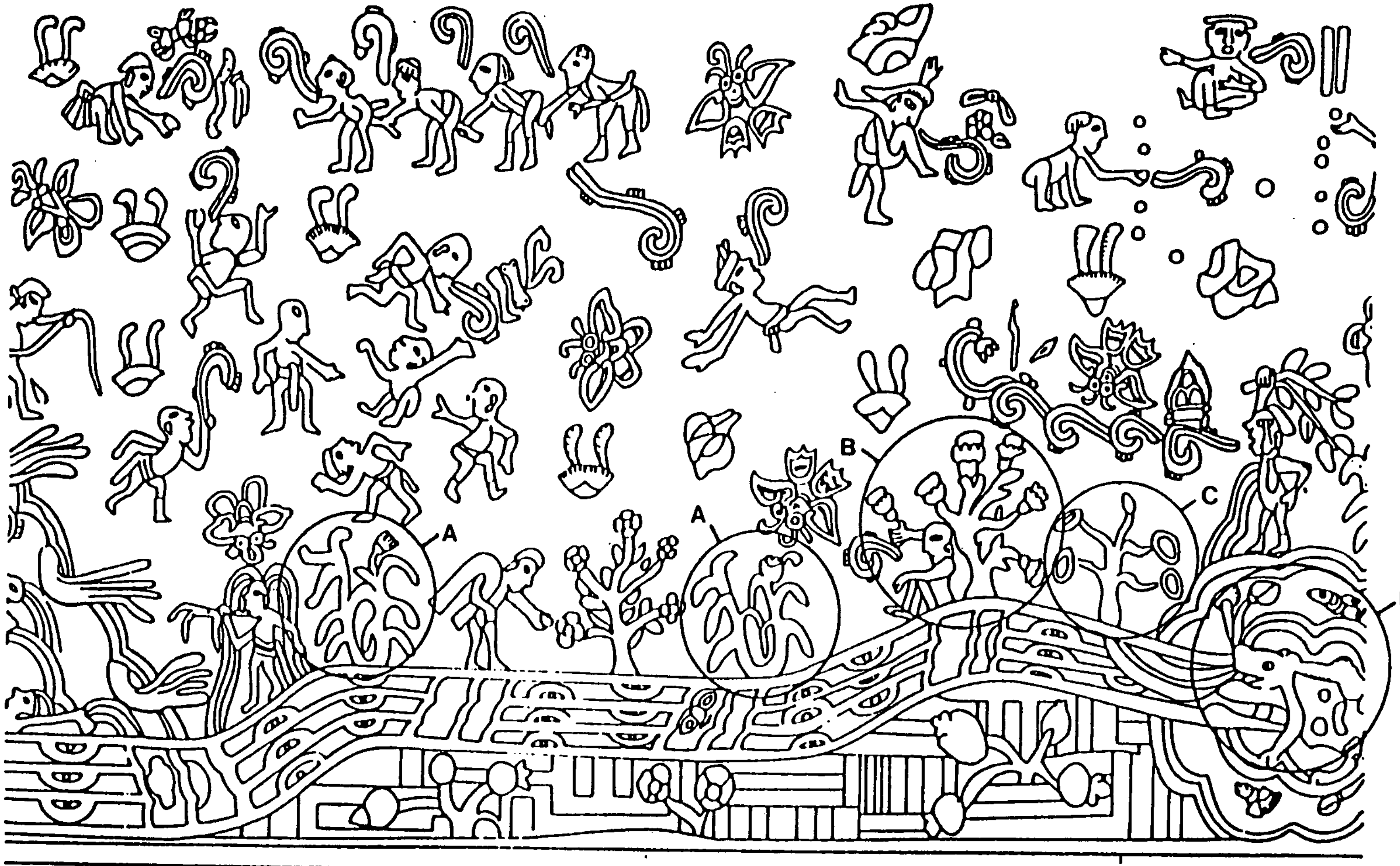


Figure 37. Reconstruction drawing of the Water Talud of the Tlalocan Patio, Teotihuacán. Maize is at A, cotton at B, cacao at C, and Cipactli at D (reproduced by the permission of Garland Pub., Inc. from Pasztory 1976, fig. 36).

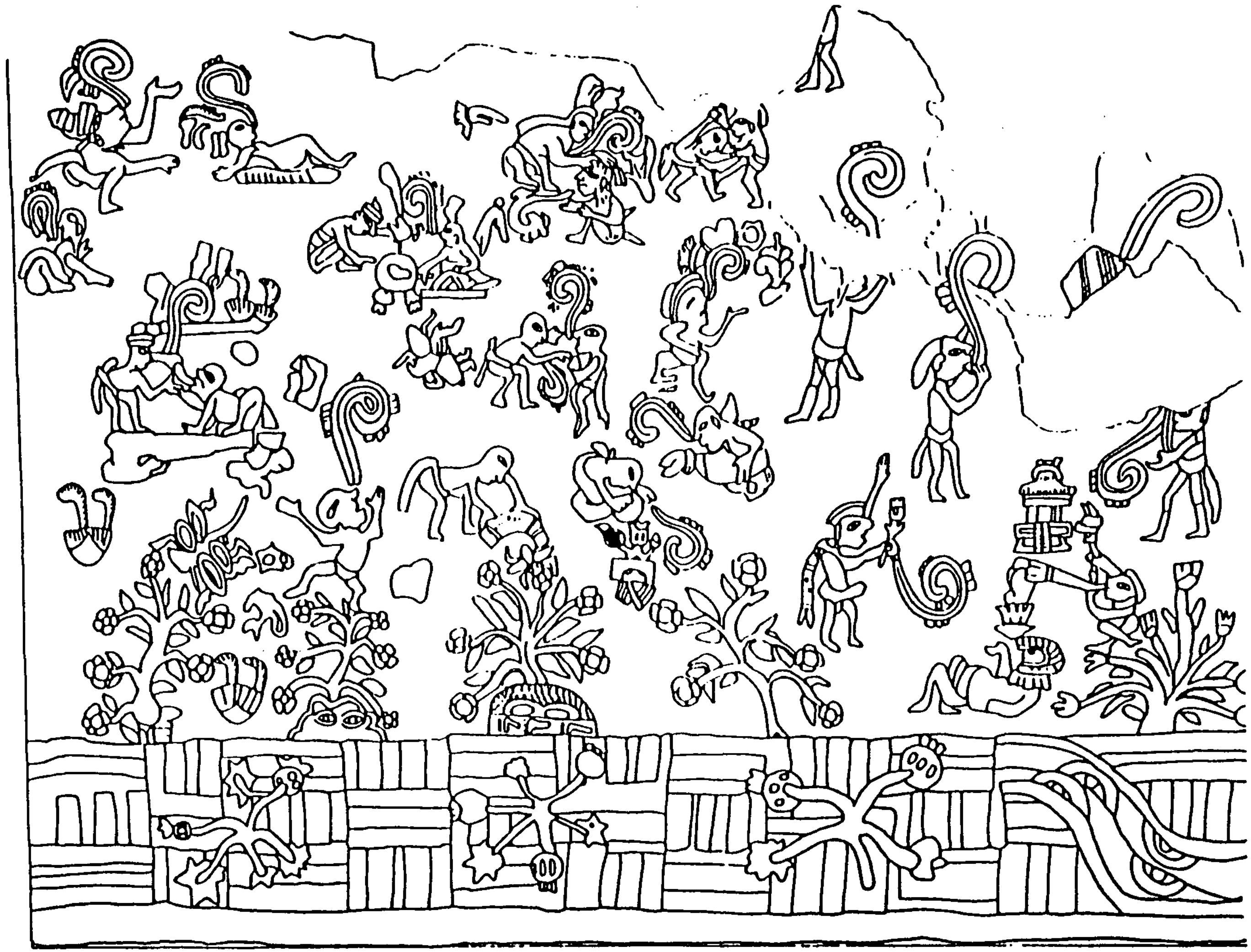


Figure 38. Reconstruction drawing of the Medicine Talud of the Tlalocan Patio, Teotihuacán (reproduced by the permission of Garland Pub., Inc. from Pasztory 1976, fig. 42).

channels and planting platforms of the Veracruzan wetland fields or the similar Valley of Mexico <u>chinampas</u>, the rectilinear designs consistently oriented along two perpendicular axes. The <u>Codex Borgia</u> contains a similar motif, maize growing from what appear to be alternating strips of land and water or furrowed, irrigated fields (figure 39). At Teotihuacán, the undulating rectilinear design above the bottom border might well represent an oblique view of wetland fields or a stream. Maize at A, cotton at B, and cacao at C grow from the fields; the last two are lowland crops (figure 37) (Lozoya 1983, 170 and fig. 1). And at D, Cipactli the "earth monster" floats in a pond surrounded by fish and water lilies, although Pasztory believes the latter figure "resembles a frog" more than a crocodile (1976, 141).

The Valley of Mexico also contains wetland agricultural features which might suggest the regular configuration of the crocodile's epidermal shields. Forty-five kilometers south of Teotihuacán lies the major <u>chinampa</u> area of the Valley of Mexico (figure 40). The <u>chinampas</u> are rectangular fields built up out of earth and vegetative matter in the wetlands ringing the former freshwater Lakes Chalco and Xochimilco. Farmers achieve a highly intensive and productive horticulture through continuous subsurface irrigation, mucking, and nursery germination. Now largely abandoned to a sprawling Mexico City, these "super wetland fields" separated by canals

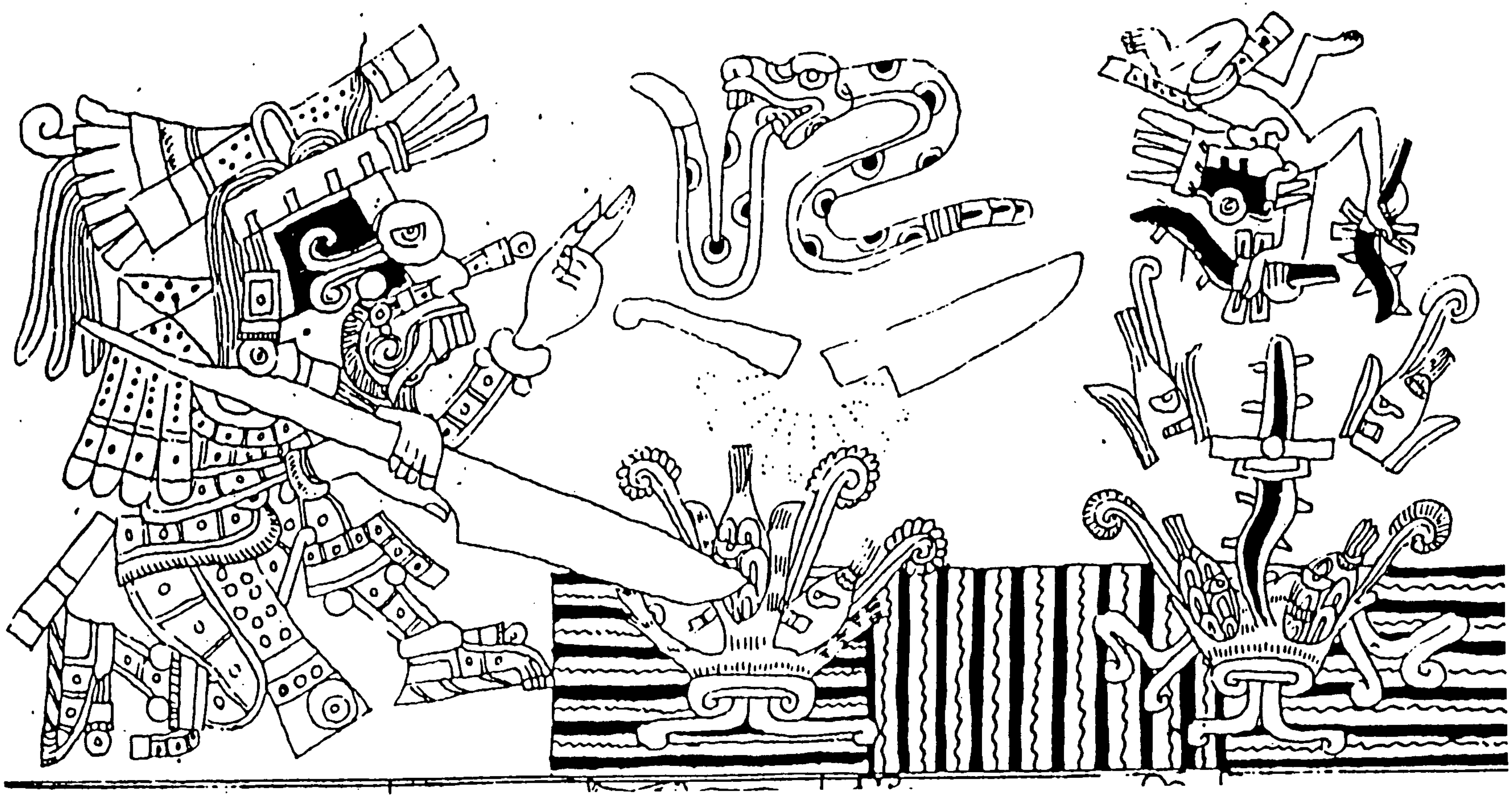


Figure 39. The divine cultivation of maize fields with a coa as depicted in the Codex Borgia (Kingsborough 1831, Vol. III, plate 19).

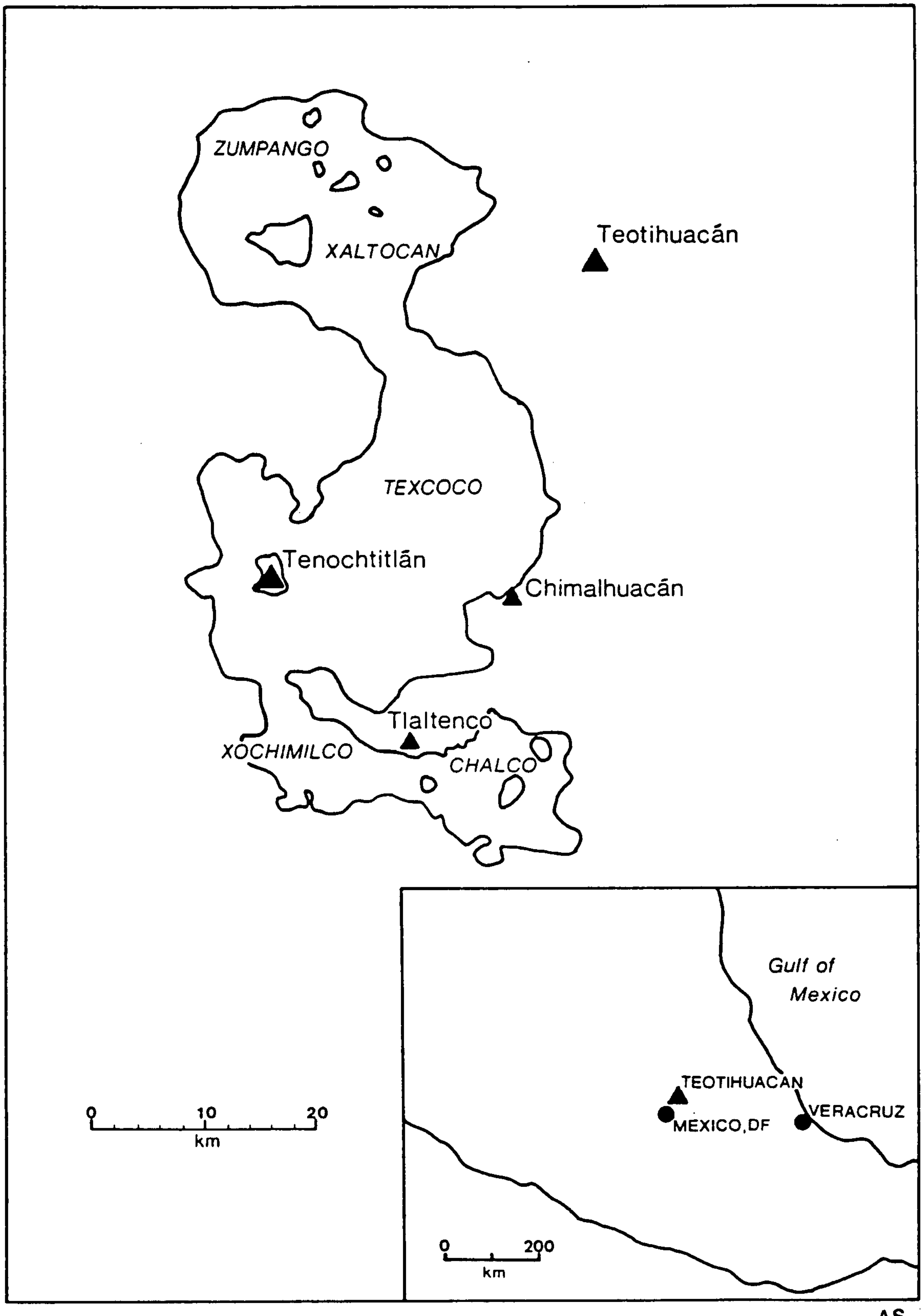


Figure 40. The lakes of the Basin of Mexico during the wet season, Postclassic period (after Coe 1964, 91).

formed a Venice-like landscape when the system reached its greatest extent under the Aztecs (Coe 1964; Armillas 1971; Palerm 1973).

Despite this late florescence, however, like the Veracruzan raised fields and Teotihuacán's main axis, the rectilinear chinampa grid is also consistently oriented between 15 and 17 degrees azimuth (Coe 1964, 96); although in a latter study Armillas claims a mean deviation of 22 degrees azimuth (1971, note 20). Since the Aztec capital of Tenochtitlán does not display this over-riding orientation, the chinampa's genesis seems linked to Teotihuacán. In fact, ceramics from the chinampas indicate that their origins are at least as early as Teotihuacán's (Coe 1964, 96; Parsons, Parsons, Popper, and Taft 1985, 59). Investigations at Tlaltenco, a settlement site near Xochimilco, demonstrate women and men were farming and living in these wetlands as early as the last several centuries BC (Armillas 1971, 658). More recent work suggests limited occupancy in the area during the Preclassic and Classic, then a steady expansion during the Postclassic. However, unstable soils and high water tables often prevented excavation down to a culturally sterile stratum, leaving the question of earliest occupancy and cultivation unresolved (Parsons, Parsons, Popper, and Taft 1985, 59; also see Tolstoy, Fish, Boksenbaum, Vaughn, and Smith 1977, 93; Turner 1983b, table 1).

Other relict chinampa areas, although less extensive and preserved than those at Xochimilco-Chalco, exist closer to Teotihuacán. The former saline Lakes Texcoco, Zumpango, and Xaltocán all supported chinampa agriculture where freshwater springs and streams sufficiently reduced salinity (Alvarado Tezozómoc 1949 [1609] 37-8; Gibson 1964, 268 and 320; Palerm 1973, 173-83; Sanders, Parsons, and Santley 1979, 280-81). Associations with dated settlements indicate that much of this northern chinampa development might be Postclassic, and that around Tenochtitlán certainly is (Sanders 1981, 184-86). However, direct dating of one possible chinampa-habitational site on the former eastern shore of Lake Texcoco near Chimalhuacán has yielded an abundance of early Teotihuacán ceramics (Noguera 1943; Apenes 1943).

In addition, the small area of former wetland around the springs on the western edge of Teotihuacán's ruins also contains some one hundred hectares of "chinampa" cultivation, perhaps dating from as early as 500 BC (Charlton 1970, 271; Millon 1973, 47 and fig. 44b; Sanders 1976a, 119; also see Gamio 1912, Tomo II: 112 and lamina 32a). Although the long, narrow fields separated by channels lined with ahuejote trees (Salix bonplandiana) are certainly reminiscent of the Xochimilco chinampas, the former are, presently at least, much smaller in scale. Nonetheless, Millon believes that the "potential of labor-intensive chinampa cultivation may have been first exploited in the small chinampa area of Teotihuacán" (1976, 244). The 15 degree azimuth orientation of some of the Teotihuacán "*chinampas*" certainly supports this contention. Sanders, Parsons, and Santley go so far as to conjecture that small proto-*chinampa* sites might have occurred at numerous places around the lakeshore and springs as early as 1500 BC (1979, 281). However, since no direct evidence from excavations is as yet forthcoming, such speculation remains unsupported.

In summary, while iconographic interpretation is always tentative, the pattern of motifs from carvings, codices, and murals suggests that Mesoamerican wetland field technology originated in lowland wetlands occupied by crocodiles and water lilies. This association stimulated beliefs in a crocodilian earth deity, those "beliefs...[being] modeled on features of the natural environment as interpreted through the specific social structure and value systems of the people concerned" (Stocker, Meltzoff, and Armsey 1980, 742). Diffusing from the tropical lowlands into analogous highland lacustrine environments, this technology retained its crocodilian associations and attained a high degree of sophistication in the *chinampas* of the Valley of Mexico. The Totonac origin myth, field and architectural orientations, and patterns of ceramic diffusion all support the iconographic data.

Moreover, these data imply more than technological diffusion; apparently lowland ideology partially shaped highland society. Perception, belief, technology, and environment reciprocally informed each other in a process of human ecological structuration. In a Mesoamerican archaeology dominated by the materialist-functionalist paradigm, the importance of human beliefs as active rather than epiphenomenal social elements requires constant emphasis (Coe 1981). Precolumbian women and men invented Central Veracruz and Teotihuacán in radically different ways than the subsequent conquistadors, Mexicans, and archaeologists. And the invention of the meaning of a place by the people that live there is as significant as any of that location's "objective" aspects. As Carl Sauer noted, "it is clear that the habitat is revalued or reinterpreted with every change in habit" (1963 [1941], 359). Teotihuacán's precisely orientated grid, its monumental scale, and the primordial cave beneath the Sun pyramid all suggest that the city's location and foundation had as much to do, if not more, with ideology as with ecology (cf. Sanders and Price 1968; Sanders, Parsons, and Santley 1979; Sanders 1981: Heyden 1975; Millon 1976; Millon 1981; Coe 1981). Moreover, the motifs of some Teotihuacán murals indicate that the highland ideology might well have had its origins in the lowlands.

SUMMARY AND CONCLUSIONS

Field and ethnohistorical data reveal that the upland fields are vestiges of Precolumbian intensive agriculture, although their precise chronology remains unclear. The upland fields have a wide distribution throughout the Central Veracruzan lowlands. The linear concentrations of stones closely follow slope contours, forming contiguous networks; some might well cover hundreds of hectares. The contouring nature and several analogues suggest a sloping-field terrace technology. The Central Mexican <u>metepantli</u>, in particular, and the environmental context suggest a technique to deepen soil and increase water infiltration and storage. Sartorius' and Finck's nineteenth century observations of the the features corroborate this hypothesis. Moreover, those accounts, together with the rapid and near total Postcolumbian depopulation of the lowlands and the delay in subsequent settlement till the twentieth century, suggest that the upland fields are Precolumbian. Ethnohistorical data and plant ecology indicate that the crops might well have been maize, cotton, and agave.

Central Veracruzan farmers were also growing maize in wetland fields during the Late Preclassic and Early Classic. These features have a much narrower distribution than the upland fields, being limited to seasonally inundated lands.

Such evidence of widespread intensive agriculture forces a reconsideration of the region's Precolumbian agricultural potential and role in Mesoamerican social history. Ethnohistorical data also suggest that the region was agriculturally productive and densely populated, at least by the Late Postclassic. Canal irrigation could only have formed a part of the production system. Other types of intensive agriculture must have been more widespread and, possibly, earlier than the canal irrigation at Zempoala. Furthermore, the data suggest a link between these lowlands and the emergence of Teotihuacán. The Totonac origin myth, the diffusion of ceramic styles, the similar landscape orientations, and the crocodilian-wetland iconography all suggest a lowland influence in Teotihuacán's genesis. Possibly such an influence was related to the diffusion of agricultural technology from the Gulf lowlands to the Central Highlands.

This relationship remains hypothetical, but it urges a comprehensive investigation of Central Veracruz. The timing of its subsistence, settlement, and social changes is of more than regional interest. Such research will further understanding of Mesoamerica's wider social history and inform more general theory on the emergence of urban societies.

Above all, however, the intention is not to encourage theories of unidirectional diffusion or to further entrench the highland-versus-lowland debate over the "origins of

Mesoamerican civilization" (West 1965; Tolstoy and Paradis 1970; Harris 1977, 83-95). A select few "suitable environments" did not determine the nature of Mesoamerican society. Rather the intention is to view social process historically and as a dialectic among people from throughout Mesoamerica. Increasingly the data demonstrate strong interconnections between all regions of Mesoamerica. Tlaxcala, for example, also seems to be implicated in the emergence of Teotihuacán (Garcia Cook 1981, 261-62). And the propinquity of the Central Veracruz and Olmec regions, as well as the instance of field orientation to "Olmec north" at Tamarindo-1, suggests that further study might cast new light on the debate over the Olmec role in Central Mexico (cf. Coe 1965, 122-23: Grennes-Ravitz and Coleman 1976). Typically, such integration of data from other regions and disciplines has been lacking among the area and subdisciplinary specialists who dominate Mesoamerican scholarship (Miller 1983, 3).

The hypothetical relationship between Central Veracruz and Teotihuacán remains tenuous without firm dates for changes in the nature of subsistence and settlement in both regions. Therefore, the immediate emphasis should be on the collection of new data pertaining to the upland fields, wetland agriculture, canal irrigation, flood plain agriculture, paleoenvironment, and settlement pattern and population. Yet data cannot speak for themselves; hypotheses unavoidably direct every inquiry. Most importantly, therefore, hypotheses must engage in a dialectic with the data, remaining open and self-critical.

The wide distribution of the upland fields implies their importance in the Precolumbian production system and prompts further study. A priority should be to locate less-disturbed vestiges. They would enable a more thorough morphological and functional analysis. Further study of the Guerrero terraplenos would also be useful in this endevour. Systematic inquiry of that analogue would yield data on function, labour input, and yield. Less-disturbed vestiges might also enable recovery of paleophytes, ceramics, and lithics for indications of cultivars and chronology. At a smaller scale, continued aerial photographic interpretation and reconnaissance would elaborate the regional distribution of upland fields.

The wetland fields also require further work. Their areal extent, distribution, morphology, and function are already quite clear. Further excavations, however, are essential in order to elaborate the chronology already apparent at El Yagual.

The issue of canal irrigation in Central Veracruz, remains as unresolved as it is prominent. The Totonac at Zempoala no doubt did practice some irrigation. Systematic study of the site's hydrology, topography, and the hydraulic system's remains should clarify how much land was under irrigation.

Quite likely, flood plain agriculture was an early and continuing strategy. The vestiges of cross-channel dams and terraces that Sartorius noted (1961 [1858], 10) might well remain in the depths of the barrancas. But such features are not yet apparent, although Wilkerson does report that "terraces may [?] also exist along the now barren canyon of the Antigua River upstream of Ocolapan [sic] [Oceloapán?] not far from Rinconada" (1983, 81). Continued air and ground reconnaissance guided by cartographic interpretation of hydrology and topography should locate any remains. At a minimum, an estimate of the total cultivable flood plain area would inform questions of carrying capacity and population distribution.

The sequence of Quaternary environmental change in Central Veracruz is unclear. Palynological and sedimentological analysis of cores from lakes would reveal the nature and timing of changes in climate, vegetation, and land use. Laguna Mandinga and Laguna Catarina are possible sites for such a study.

The Precolumbian settlement patterns also remain unclear. Necessarily, García Payón's synthesis in the Handbook of Middle American Indians is quite general (1971). His map shows some one hundred archaeological sites in Central Veracruz, but the scale is small and the locations imprecise (1971, fig. 2). Moreover, he does not make chronological distinctions between sites. Yet he does indicate the availability of data. This material requires cartographic synthesis at a large scale for several periods, as is now available for the Basin of Mexico and the Valley of Oaxaca (Sanders, Parsons, and Santley 1979; Blanton, Kowalewski, Feinman, and Appel 1981).

Data on the upland fields, wetland agriculture, canal irrigation, flood plain agriculture, paleoenvironment, and settlement pattern and population can all inform an understanding of Central Veracruz's dynamic human ecology. Basic questions revolve around the changing spatial relationships between settlement pattern and the various agricultural strategies. The immediate goal is the regional synthesis of diverse data, but not without a sensitivity to possible inter-regional relationships. Ultimately, such a study will have more than regional interest, as the possible relationship with Teotihuacán illustrates.

ENDNOTES

1.) While agricultural intensification is multifactorial, it generally indicates an increase in food production per unit area per unit time (Turner and Doolittle 1978; Farrington 1985; Turner and Denevan 1985). However, these terms are neither conceptually nor operationally unproblematic, and several complications arise when theorizing paleointensification.

Because the output of food production leaves few direct remains, a surrogate measure is necessary. Usually, the only assessable one is the vestigial production infrastructure, a measure of inputs such as labour, technology, and energy. Input, however, can only be a surrogate for output through ethnographically known analogues, with all the attendant problems of cross-contextual comparison. Moreover, such features as relic irrigation canals which might seem to be indicative of an attempt to intensify production, perhaps due to increasing population, might actually represent an attempt to reduce the risk of occasional crop failure in areas susceptible to periodic drought (Nichols 1987). Alternatively, such features might represent an attempt to produce non-staple crops, such as cacao, in areas not suited to such production without infrastructural investments (Turner 1985, 202). The production infrastructure, then, is difficult to generalize from because differing ecological and cultural contexts modulate the outputs of similar inputs.

Similarly area is problematic because the relevant area often fluctuates during intensification. For example, a new technology might permit cultivation of previously barren land surrounding an oasis containing a small settlement and its fields. This case represents intensification by expansion of area through technological innovation. The settlement's annual yield per hectare of oasis lands does not increase, but the total annual yield of the settlement's land base does increase. In addition, a wider range of crops might become available throughout the year because of the utilization of complimentary environments--wetland and terra firma, for example (Siemens 1990a).

Time is also problematic when addressing relic fields. Even though contiguous, fields might not all be contemporaneous. Moreover, climatic fluctuations affect the number of annual harvests and the number of years between fallows. And the field use might have been intermittent with sporadic but cumulative infrastructural improvements, either initially or chronically (Doolittle 1988). Wet years and dry years, fluctuating tribute demands, or immigration and emigration can all influence agricultural intensification and disintensification. Deducing a dense population engaged in sedentary cultivation on the basis of fixed field boundaries is unwarranted without an indication of use frequency and contemporaneity. Similarly, given the possibility of incremental improvement, reasoning from an elaborate agricultural infrastructure to continuous, intensive production is fallacious--unless the particular technology and context suggest a system which could only have functioned as a whole.

Despite these conceptual and operational difficulties, in considering the dialectic between agricultural intensification and social change the critical conceptualization of intensification is of an increasing availability of food within the area accessible to a potential urban nucleation. The, Veracruzan wetland fields at least potentially represent such an intensification over, but not of, the previously postulated swidden cultivation. Farmers could annually grow more food within easy access of a nucleated population centre through the elaboration of a new technology and an investment of labour. However, as clear from even a brief consideration of the conceptual and operational dfficulties of "intensification," a precise and detailed understanding of the wetland field chronology and frequency of use is crucial before forming definite conclusions about the amount of agricultural production involved and its significance in human ecological processes. More excavations are necessary.

2.) Since the features exhibit no appreciable relief and are indiscernible at ground level, mapping from aerial imagery was essential. Until the advent of accessible and sophisticated computer rectification, attaining accurate planimetric maps from oblique aerial photographs will always be problematic. Currently, several approaches are available: draughting techniques, such as the polygonal network, paper strip, and plate parallel methods; optical techniques; and simple computer based techniques which do not correct for topographic variation (Palmer 1977; Scollar 1978; Dickinson 1979; Burnside et al. 1983; Riley 1987, 68-73). Since even simple computer hardware and software were unavailable during the data analysis, and to save time while maintaining accuracy, the optical method proved most expeditious.

This technique consists of constructing a transparent overlay of the modern field boundaries and relic ground patterning from the oblique photograph. After this separate interpretive stage, a Caesar-Saltzman vertical projector rectifies the distorted pattern by projecting it onto a tilting table, reachieving the true trapezoidal ground shape represented as rectangular on the photograph. A planimetric diagram of modern field boundaries obtained from ground survey and attached to the tilting table serves as ground control. To avoid unintentional bias, no topographic lines are indicated on this control map. Tilt is adjusted until the projected boundaries match the planimetric boundaries, at which point the angle of tilt is correct and all lines are rectified. The lines are sketched in, and the scale of the resulting diagram is adjusted before transferring it to a topographic base map.

The assumption behind this method is the same as behind the draughting and simple computer methods: the area in question need not necessarily be horizontal, but it must be plane. Changes in slope angle cause non-linear scale changes which distort features. Therefore, in areas of complex relief, rectification is limited to small areas of constant slope which subsequently can be joined to form a mosaic. This practice introduces error as scales are adjusted and features are matched. Other distortions occur due to the optics involved at several stages. Moreover, if the angle of distortion is very large the depth of field of the Saltzman becomes a limitation, even though the lens stops down to f64. To achieve adequate focus for the area under consideration at large angles, scale must be reduced, again leading to error when scale is again increased to match the map base. The accuracy of this method is not, therefore, as good as sophisticated computer methods which compensate for complex topography. However, the comparable results obtained with the maps produced from rectified obliques and the topographic overlays of commercially obtained vertical imagery illustrates the basic soundness of the technique. And given the available resources, the choice was between optical rectification or no mapping at all.

3.) The Central Veracruzan upland fields clearly suggest anthropogenesis. However, in the Maya region, the possibility of natural ground patterning being mistaken for wetland fields has resulted in a heated debate (Turner and Harrison 1979; Sanders 1979). Therefore, a consideration of possible natural ground patterning processes seems prudent.

The poorly understood terracets which form on slopes in grasslands are linear and normal to slope but rarely more than 0.5 m wide (Carson and Kirkby 1972, 173).

Stone polygons and stripes might cause similar patterning but are confined to periglacial environments (Price 1981, 184-87).

In mid and tropical latitudes, buried lenses or horizons of stones sometimes become exposed in profile at road cuts and are known as "stone lines" (Ruhe 1959; Butzer 1971, 203). They vary widely in thickness, however, and would not appear as serried ranks of parallel lines on shallow slopes.

The area's vertisols with their high component of montmorillonite clay are subject to expansion when wet and to shrinkage and cracking when dry. The resulting soil churning can form the patterned ground known as gilgae which has been so central to the controversy over the Maya wetland fields. However, regarding the Veracruzan upland fields, the involvement of stones, the scale of the patterning, and the slopes preclude gilgae as a candidate.

In summary, no natural ground patterning process closely shares the upland field morphology. Stone stripes have some morphological similarity but only occur in periglacial environments.

4.) This controversy remains unresolved, some authors counting each glyph as a single mantle, others as a load of 20 (cf. Berdan 1987, 240; Drennan 1984, note 1). More generally, Sanders (1976b, 112-14) makes a telling critique of the methodology Borah and Cook utilize in their attempt to derive population figures from tribute lists.

5.) Borah and Cook's figure, 1,656 loads of mantles, would yield some 66,000-83,000 kg of woven cotton. The total cotton would be some 130,000-163,000 kg. The cotton hectarage would be 650-1,600 ha. And the total hectarage of tribute cotton and cacao would only be 700-1,700 ha.

BIBLIOGRAPHY

Alcorn, Janis B.
1984 Huastec Maya Ethnobotony. Austin: Univ. of Texas Press.

Alvarado Tezozómoc, Fernando.
1949 [1609] Crónica Mexicayotl. Adrian León, trans. México: Universidad Nacional Autonoma de México.

Apenes, Ola.
1943 "The Tlateles of Lake Texcoco." American Antiquity. 9: 29-32.

Armillas, Pedro.
1971 "Gardens on Swamps." Science. 174: 653-61.

Arreola, Daniel D.
1982 "Nineteenth Century Townscapes of Eastern Mexico." The Geographical Review. 72(1): 1-19.

Aveni, Anthony F.
1980 Skywatchers of Ancient Mexico. Austin: Unversity of Texas Press.

Barlow, R.H.
1943 "The Periods of Tribute Collection in Moctezuma's Empire." Notes on Middle American Archaeology and Ethnology. 1(23): 152-55.

______________.
1949 "The Extent of the Empire of the Culhua Mexica." Ibero-Americana. 28: 1-141.

Barrow, C.J.
1988 "The Present Position and Future Development of Rain-Fed Agriculture in the Tropics." Outlook on Agriculture. 17(3): 112-19.

Berdan, Frances F.
1987 "Cotton in Aztec Mexico: Production, Distribution and Uses." Mexican Studies/Estudios Mexicanos. 3(2): 235-62.

Berger, Josef.
1969 The World's Major Fiber Crops. Zurich: Centre D'Etude De L'Acote.

Blanton, Richard E., Stephen A Kowalewski, Gary Feinman, and Jill Appel.
1981 Ancient Mesoamerica: A Comparison of Change in Three Regions. Cambridge: Cambridge Univ. Press.

Books of Chilam Balam, The.
1948 [ca. 1600] El Libro de los Libros de Chilam Balam. Alfredo Barrera Vásque, trans. México: Fondo de Cultura Ecónomica.

Borah, Woodrow and Sherburne F. Cook.
1958 "Price Trends of Some Basic Commodities in Central Mexico, 1531-1570." Ibero-Americana. 40.

______________.
1963 "The Aboriginal Population of Central Mexico on the Eve of the Spanish Conquest." Ibero-Americana. 45.

Bray, Francesca.
1984 Science and Civilization in China, Vol. 6. Joseph Needham, series ed. Cambridge: Cambridge Univ. Press.

Buge, David E.
1984 "Prehistoric Subsistence Strategies in the Ojo Caliente Valley, New Mexico." In Prehistoric Agricultural Strategies in the Southwest, 27-34. Suanne K. Fish and Paul R. Fish, eds. Tempe: Arizona State Univ. Press.

Bunyard, Peter.
1980 "Terraced Agriculture in the Middle East." The Ecologist. Oct/Nov: 312-16.

Burnham, Philip.
1980 "Changing Agricultural and Pastoral Ecologies in the West African Savanna Region." In Human Ecology in Savanna Environments, 147-70. David Harris, ed. London: Acaemic Press.

Burnside, C.D. et al.
1983 "A Digital Single Photograph Technique for Archaeological Mapping and its Application to Map Revision." Photogrammetric Record. 11: 59-68.

Butzer, Karl.
1971 Environment and Archaeology: An Ecological Approach to Prehistory. Chicago: Aldine-Atherton.

______________.
1982 Archaeology as Human Ecology. Cambridge: Cambridge Univ. Press.

Carlson, John B.
1975 "Lodestone Compass: Chinese or Olmec Primacy?" Science. 189(4205): 753-60.

Carrera Stampa, Manuel.
1949 "The Evolution of Weights and Measures in New Spain." Hispanic American Historical Review. 29: 2-24.

Carson, M.A. and M.J. Kirkby.
1972 Hillslope Form and Process. Cambridge: Cambridge Univ. Press.

Chadwick, Robert and Richard S. MacNeish.
1967 "Codex Borgia and the Venta Salada Phase." In The Prehistory of the Tehuacan Valley, Vol. 1: Environment and Subsistence, 114-131. Douglas S. Byers, ed. Austin: Univ. of Texas Press.

Charlton, Thomas.
1970 "Contemporary Agriculture in the Teotihuacan Valley." In The Teotihuacan Valley Project, Final Report, Vol. 1, 253-384. Occasional Papers in Anthropology. Pennsylvania: Dept. of Anthropology, Pennsylvania State Univ.

Coe, Michel D.
1962 Mexico. New York: Frederick A. Praeger Publishers.

__________.
1964 "The Chinampas of Mexico." Scientific American. 211: 90-8.

__________.
1965 The Jaguar's Children: Preclassic Central Mexico. New York: Museum of Primitive Art.

__________.
1981 "Religion and the Rise of Mesoamerican States." In The Transistion to Statehood in the New World, 157-171. Grant D. Jones and Robert R. Kautz, eds. Cambridge: Cambridge Univ. Press.

__________.
1986 "Mesoamerica." In Atlas of Ancient America. Michael D. Coe, Dean Snow, and Elizabeth Benson, eds. New York: Facts on File Publications.

Cook, Sherburne F. and Woodrow Borah.
1960 "The Indian Population of Central Mexico, 1531-1610." Ibero-Americana. 44.

Cortés, Hernán.
1962 [1519-1526] Five Letters of Cortés to the Emperor, 1519-1526. J. Bayard Morris, trans. New York: W.W. Norton & Company.

________________.
1963 [1519-1532] Hernán Cortés: Cartas y Documentos. Mario Hernández Sánchez-Barba, ed. México: Editorial Porrúa.

Covarrubias, Miguel.
1957 Indian Art of Mexico and Central America. New York: Alfred A. Knopf.

Cowgill, U.M. and G.E. Hutchinson.
1963 "Ecological and Geochemical Archaeology in the Southern Maya Lowlands." Southwestern Journal of Anthropology. 19(3): 267-86.

Davies, Nigel.
1982 The Ancient Kingdoms of Mexico. Markham, Ontario: Penguin Books Ltd.

Denevan, William M.
1976 "Introduction." In The Native Population of the Americas in 1492, 1-12. William M. Denevan, ed. Madison: The Univ. of Wisconsin Press.

________________.
1980 "Tipología de Configuraciones Agrícolas Prehispánicas." America Indígena. 40(4): 619-52.

Díaz del Castillo, Bernal.
1956 [1632] The Bernal Diaz Chronicles: The True Story of the Conquest of New Spain. Albert Idell, trans. Garden City, New York: Doubleday & Company.

________________.
1984 [1632] Historia Verdadera de la Conquista de la Nueva España. Miguel León-Portilla, ed. Madrid: Historia 16.

Dickinson, G.C.
1979 Maps and Air Photographs. London: Edward Arnold.

Donkin, R.A.
1979 Agricultural Terracing in the Aboriginal New World. Tucson: Univ. of Arizona Press.

Doolittle, William E.
1988 "Intermittent Use and Agricultural Change on Marginal Lands: The Case of Smallholders in Eastern Sonora, Mexico." Geografiska Annaler. 70: 255-66.

________________.
1990 Canal Irrigation in Prehistoric Mexico: The Sequence of Technological Change. Austin: Univ. of Texas Press.

Drennan, Robert D.
1984 "Long-Distance Transport Costs in Pre-Hispanic Mesoamerica." American Anthropologist. 86(1): 105-12.

Dresden Codex, The.
1972 [ca. 1200] In A Commentary on the Dresden Codex, 123-47. J. Eric S. Thompson, trans. Philadelphia: American Philosophical Society.

Durán, Fray Diego.
1867-80 [ca. 1580] Historia de las Indias de Neuva España y Islas de Tierra Firme, Vols. 1-2 and atlas. México: J.M. Andrade y F. Escalante.

Epstein, E., W.J. Grant, and R.A. Struchtemeyer.
1966 "Effects of Stones on Runoff, Erosion, and Soil Moisture." Soil Science Society of America, Proceedings. 30: 638-40.

Evenari, Michael, Leslie Shanan, and Naphtlai Tadmor.
1971 The Negev: the Challange of a Desert. Cambridge, Mass: Harvard Univ. Press

Farrington, I.S.
1985 "The Wet, the Dry, and the Steep: Archaeological Imperatives and the Study of Agricultural Intensification." In Prehistoric Intensive Agriculture in the Tropics, 1-9. I.S. Farrington, ed. British Archaeological Reports, International Series. 232.

Fewkes, Jesse Walter.
1907 "Certain Antiquities of Eastern Mexico." Twenty Fifth Annual Report of the Bureau of American Ethnology to the Secretary of the Smithsonian Institution, 1903-1904. Washington: The Smithsonian Institution.

Finck, Hugo.
1870 "Account of Antiquities in the State of Vera Cruz, Mexico." Smithsonian Annual Report for 1870, 373-76.

Fish, Paul R. and Suzanne K. Fish.
1984 "Agricultural Maximization in the Sacred Mountain Basin, Central Arizona." In Prehistoric Agricultural Strategies in the Southwest, 147-59. Suzanne K. Fish and Paul R. Fish, eds. Tempe: Arizona State Univ.

Flannery, Kent V.
1976 "The Early Mesoamerican House." In The Early Mesoamerican Village, 16-24. Kent V. Flannery, ed.

New York: Academic Press.

Foster, G.R. and R.F. Highfill.
1983 "Effects of Terraces on Soil Loss." Journal of Soil and Water Conservation. 38: 48-51.

Fowler, Peter.
1981 "Wildscape to Landscape: 'Enclosure' in Prehistoric Britain." In Farming Practice in British Prehistory, 9-54. R. Mercer, ed. Edinburgh Univ. Press.

________________.
1983 The Farming of Prehistoric Britain. Cambridge: Cambridge Univ. Press.

Fried, Morton H.
1967 The Evolution of Political Society. New York: Random House.

Galindo y Villa, Jesús.
1912 Las Ruinas de Cempoala y del Templo del Tajín, Exploradas por el Director del Museo Nacional de Arqueología, Historia, y Etnología en Mision en Europa, Don Francisco del Paso y Troncoso. México

Gamio, Manuel.
1912 La Población del Valle de Teotihuacán, Vols. 1-2. México: Direccion de Talleres Graficos.

García, Enriqueta.
1970 "Las Climas del Estado de Veracruz." Anales del Instituto de Biología. 41(1): 3-22.

García Cook, Angel.
1981 "The Historical Importance of Tlaxcala in the Cultural Development of the Central Highlands." In Supplement to the Handbook of Middle American Indians, Vol. 1, 244-76. Jeremy A. Sabloff, ed. Austin: Univ. of Texas Press.

García Payón, José.
1971 "Archaeology of Central Veracruz." In Handbook of Middle American Indians, Vol 11, 505-42. Gordon F. Ekholm and Ignacio Bernal, eds. Austin: Univ. of Texas Press.

Gibson, Charles.
1964 The Aztecs Under Spanish Rule. Stanford: Stanford Univ. Press.

Giddens, Anthony.
1984 The Constitution of Society. Berkeley: Univ. of California Press.

Glass, John B.
1975 "A Survey of Native Middle American Pictorial Manuscripts." In _Handbook of Middle American Indians, Vol. 14_, 3-80. H.F. Cline, ed. Austin: Univ. of Texas Press.

Gómez-Pompa, Arturo.
1973 "Ecology of the Vegetation of Veracruz." In _Vegetation and Vegetational History of Northern Latin America_, 73-148. Alan Graham, ed. Amsterdam: Elsevier Scientific Publishing Company.

González-Jácome, Alba.
n.d. Historical Environmental Management and the Development of Modern Agroecosystems in Central Veracruz: The Case of El Palmar. Manuscript. Department of Anthropology, Univ. Iberoamericana, México.

Grennes-Ravitz, Ronald and G. Coleman.
1976 "The Quintessential Role of the Olmec in the Central Highlands of Mexico: a Refutation." _American Antiquity_. 41(2): 196-205.

Hakluyt, Richard.
1926 [1589] _The Principal Navigations, Voyages, Traffiques, and Discoveries of the English Nation, Vol. 6_. London: J.M. Dent and Sons, Ltd.

Hammond, Norman.
1978 "Cacao and Cobaneros: An Overland Trade Route Between the Maya Highlands and Lowlands." In _Mesoamerican Communication Routes and Cultural Contacts_, 19-25. Thomas A. Lee Jr. and Carlos Navarrete, eds. _Papers of the New World Archaeological Foundation_. 40.

Harness, Vernon L. and Charles H. Barber.
1964 _Cotton in Mexico_. Washington: United States Department of Agriculture.

Harris, Marvin.
1977 _Cannibals and Kings: the Origins of Cultures_. New York: Random House.

Hearn, A.B. and G.A. Constable.
1984 "Cotton." In _The Physiology of Tropical Field Crops_, 495-527. Peter R. Goldsworthy and N.M. Fisher, eds. New York: John Wiley and Sons.

Hernández, Arias.
1947 [1571] "Declaración Sobre Veracruz." In _Papeles de Nueva España, Vol. 5_, 189-201. Francisco de Paso y

Troncoso, ed. Mexico: Biblioteca Aportación Historica.

Heyden, Doris.
1975 "An Interpretation of the Cave Underneath the Pyramid of the Sun in Teotihuacan, Mexico." American Antiquity. 40(2): 131-47.

______________.
1981 "Caves, Gods, and Myths: World-View and Planning in Teotihuacan." In Mesoamerican Sites and World-Views, 1-39. Elizabeth P. Benson, ed. Washington, D.C.: Dumbarton Oaks Research Library.

Hodder, Ian.
1986 Reading the Past. Cambridge: Cambridge Univ. Press.

Hughes, Philip J.
1985 "Prehistoric Man-Induced Soil Erosion: Examples From Melanesia." In Prehistoric Intensive Agriculture in the Tropics, 393-408. I.S. Farrington, ed. British Archaeological Reports, International Series. 232.

Joralemon, Peter David.
1976 "The Olmec Dragon: a Study in Pre-Columbian Art." In Origins of Religious Art and Iconography in Preclassic Mesoamerica, 27-71. H.B. Nicholson, ed. Los Angeles: UCLA Latin American Center.

Kelly, Isabel and Angel Palerm.
1952 The Tajín Totonac. Publications of the Smithsonian Institution, Institute of Social Anthropology. 13.

Kingsborough, Lord Edward.
1831-48 Antiquities of Mexico, Vols. 1-9. London: Robert Havell and Colnaghi, Son, and Co.

Kolb, Charles C.
1987 Marine Shell Trade and Classic Teotihuacán, Mexico. British Archaeological Reports, International Series. 364.

León-Portilla, Miguel.
1962 The Broken Spear: The Aztec Account of the Conquest of Mexico. Boston: Beacon Press.

______________.
1988 Time and Reality in the Thought of the Maya. Norman: Univ. of Oklahoma Press.

Long, R.C.E.
1942 "The Payment of Tribute in the Codex Mendoza." Notes on Middle American Archaeology and Ethnology. 1(10): 41-44.

Lozoya, Xavier.
1983 "Iconografía de Algunas Plantas Medicinales de los Antiguos Mexicanos." In Flora and Fauna Imagery in Precolumbian Cultures: Iconography and Function, 167-78. Jeanette F. Peterson, ed. British Archaeological Reports, International Series. 171.

Medellín Zenil, Alfonso.
1953 "Desarrollo de la Cultura Prehispánica Central Veracruzana." Anales del Instituto Nacional de Antropología e Historia. 7(36): 101-10.

Mejía Zamalloa, Juan.
1987 Caracterización, Rehabilitación, y Mantenimiento de Andenes. Lima: Ministerio de Agricultura.

Melgarejo Vivanco, José Luis.
1980 Antigua Ecología Indígena en Veracruz. Xalapa, México: Gobierno del Estado de Veracruz.

Mexican Picture-Chronicle of Cempoallan, The.
1890 [1530] London: Bernard Quritch.

Millares Carlo, Agustín and José Ignacio Mantecón.
1955 Album de Paleografía Hispanoamericana de los Siglos XVI y XVII. México: Instituto Panamericano de Geografía e Historia.

Miller, Arthur G.
1973 The Mural Painting of Teotihuacán. Washington, D.C.: Dumbarton Oaks Research Library.

____________.
1983 "Interdisciplinary Approaches to the Study of Mesoamerican Highland-Lowland Interaction: Some Introductory Remarks." In Highland-Lowland Interaction in Mesoamerica: Interdisciplinary Approaches, 1-12. Arthur G. Miller, ed. Washington, D.C.: Dumbarton Oaks Research Library.

Millon, Rene.
1973 The Teotihuacán Map, Vol. 1. Austin: Univ. of Texas Press.

____________.
1976 "Social Relations in Ancient Teotihuacán." In The Valley of Mexico, 205-248. Eric R. Wolf, ed. Albuquerque: Univ. of New Mexico Press.

____________________.
1981 "Teotihuacán: City, State, and Civilization." In Supplement to the Handbook of Middle American Indians, Vol. 1, 198-243. Jeremy A. Sabloff, ed. Austin: Univ. of Texas Press.

Miranda, José.
1952 El Tributo Indígena en la Nueva España Durante el Siglo XVI. México: El Colegio de Mexico.

Mota y Escobar, Alonso de la.
1987 [1609] Memoriales del Obispo de Tlaxcala: Un Recorrido por el Centro de México a Principios del Siglo XVII. Alba González Jácome, ed. México: Secretaria de Educación Pública.

Muhs, Daniel R., Robert R. Kautz, and J. Jefferson MacKinnon.
1985 "Soils and the Location of Cacao Orchards at a Maya Site in Western Belize." Journal of Archaeological Science. 12(2): 121-37.

Munro, John M.
1987 Cotton. Harlow, Essex: Longman.

Nichols, Deborah L.
1987 "Risk and Agricultural Intensification During the Formative Period in the Northern Basin of Mexico." American Anthropologist. 89(3): 596-616.

____________________.
1988 "Infrared Aerial Photography and Prehispanic Irrigation at Teotihuacán: the Tlajinga Canals." Journal of Field Archaeology. 15(1): 17-27.

Nikiforoff, C.C.
1948 "Stoney Soils and Their Classification." Soil Science. 66: 347-63.

Noguera, Eduardo.
1943 "Excavaciones en El Tepalcate, Chimalhuacán, México." American Antiquity. 9: 33-43.

Ochoa, Lorenzo, ed.
1989 Huaxtecos y Totonacos. México: Consejo Nacional para la Cultura y las Artes.

Oldfield, F., A.T. Worsley, and A.F. Baron.
1985 "Lake Sediments and Evidence for Agricultural Intensification: A Case Study From the Highlands of Papua New Guinea." In Prehistoric Intensive Agriculture in the Tropics, 385-91. I.S. Farrington, ed. British Archaeological Reports, International

Series. 232.

Orozco y Berra, Manuel.
1960 Historia Antigua y de la Conquista de México, Vol. 1. México: Editorial Porrúa, S.A.

Pajares, Angel and Jeffrey Vonk.
1986 Construcción y Uso de Terrazas de Formación Lenta. Lima: Ministerio de Agricultura.

Palerm, Angel.
1953 "Etnografía Antigua Totonaca en el Oriente de México." In Huastecos, Totonacos, y sus Vecinos, 163-73. Ignacio Bernal and Eusebio Dávalos Hurtado, eds. Revista Mexicana de Estudios Antropológicos. 8(2-3).

____________.
1955 "The Agricultural Basis of Urban civilization in Mesoamerica." In Irrigation Civilizations: a Comparative Study, 28-42. Julian Steward, ed. Washington: Pan American Union.

____________.
1973 Obras Hidráulicas Prehispánicas en el Sistema Lacustre del Valle de México. México: Instituto Nacional de Antropología e Historia.

Palerm, Angel and Eric R. Wolf.
1957 "Ecological Potential and Cultural Development in Mesomaerica." In Studies in Human Ecology, 1-37. Lawrence Krader and Angel Palerm, eds. Washington: The Anthropological Society of Washington and The General Secretariat of the Organization of American states.

____________.
1972 Agricultura y Civilización en Mesoamérica. México: SEP.

Palmer, R.
1977 "A Computer Method for Transcribing Information Graphically from Oblique Aerial Photographs to Maps." Journal of Archaeological Science. 4:283-90.

Parsons, Jefery R., Mary H. Parsons, Virginia Popper, and Mary Taft.
1985 "Chinampa Agriculture and Aztec Urbanization in the Valley of Mexico." In Prehistoric Intensive Agriculture in the Tropics, 49-96. I.S. Farrington, ed. British Archaeological Reports, International Series. 232.

Parsons, Lee A.
1980 Pre-Columbian Art. New York: Harper & Row, Pubs.

Pasquel, Leonardo.
1958 La Ciudad de Veracruz, Tomo 2. México: Editorial Citaltépetl.

Pasztory, Esther.
1976 The Murals of Tepantitla, Teotihuacán. New York: Garland Pub., Inc.

Patiño de Avila, Alvaro.
1580 Descripción de la (Antigua) Vera Cruz, hecho por el alcalde mayor, Alvaro Patiño de Avila (redactada por el Lic. Alonso Hernández Diosdado, médico) 15 de Marzo de 1580. Original Relación Geográfica located in the Benson Latin American Collection, University of Texas at Austin.

Patrick, Larry L.
1985 "Agave and Zea in Highland Central Mexico: The Ecology and History of the Metepantli." In Prehistoric Intensive Agriculture in the Tropics, 539-46. I.S. Farrington, ed. British Archaeological Reports, International Series. 232.

Pearsall, Deborah M.
1989 Paleoethnobotany: A Handbook of Procedures. New York: Academic Press.

Piperno, Dolores.
1988 Phytolith Analysis. New York: Academic Press.

Pohl, Mary and Charles H. Miksicek.
1985 "Cultivation Techniques and Crops." In Prehistoric Lowland Maya Environment and Subsistence Economy, 9-20. Mary Pohl, ed. Papers of the Peabody Museum of Archaeology and Ethnology. 77.

Price, Larry W.
1981 Mountains and Man: A Study of Process and Environment. Berkeley: Univ. of California Press.

Proskouriakoff, Tatiana.
1971 "Classic Art of Central Veracruz." In Handbook of Middle American Indians, Vol. 11, 558-71. Gordon F. Ekholm and Ignacio Bernal, eds. Austin: Univ. of Texas Press.

Puleston, Dennis E.
1977 "The Art and Archaeology of Hydraulic Agriculture in the Maya Lowlands." In Social

Processes in Maya Prehistory, 449-67. Norman Hammond, ed. New York: Academic Press.

Purseglove, J.W.
1968 Tropical Crops: Dicotyledons, Vols. 1-2. New York: John Wiley and Sons.

______________.
1972 Tropical Crops: Monocotyledons. New York: John Wiley and Sons.

Riley, D.N.
1987 Air Photography and Archaeology. London: Duckworth.

Robertson, Alastair J.
1983 Chinampa Agriculture: the Operation of an Intensive Preindustrial Resource System in the Valley of Mexico. Masters thesis. Department of Geography, Univ. of British Columbia. National Library of Canada.

Roys, R.L.
1943 The Indian Background of Colonial Yucatan. Washington: The Carnegie Institution of Washington.

Ruhe, R.V.
1959 "Stone Lines in Soils." Soil Science. 87: 223-31.

Rzedowski, Jerzy.
1978 Vegetación de México. México: Editorial Limusa.

Sahagún, Fray Bernardino de.
1961 [ca. 1578] Florentine Codex: General History of the Things of New Spain, Book 10. Arthur Anderson and Charles Dibble, trans. Santa Fe: The School of American Research and the Univ. of Utah.

Sanders, William T.
1953 "The Anthropogeography of Central Veracruz." In Huastecos, Totonacos, y sus Vecinos, 27-78. Ignacio Bernal and Eusebio Dávalos Hurtado, eds. Revista Mexicana de Estudios Antropológicos. 8(2-3).

______________.
1971 "Cultural Ecology and Settlement Patterns of the Gulf Coast." In Handbook of Middle American Indians, Vol. 11, 543-557. Gordon F. Ekholm and Ignacio Bernal, eds. Austin: Univ. of Texas Press.

______________.
1976a "The Agricultural History of the Basin of Mexico." In The Valley of Mexico, 101-59. Eric R.

Wolf, ed. Albuquerque: Univ. of New Mexico Press.

________________.
1976b "The Population of the Central Mexican Symbiotic Region, the Basin of Mexico, and the Teotihuacan Valley in the Sixteenth Century." In The Native Population of the Americas in 1492, 85-150. William M. Denevan, ed. Madison: The Univ. of Wisconsin Press.

________________.
1979 "The Jolly Green Giant in the Tenth Century Yucatan, or Fact and Fancy in Classic Maya Agriculture." Reviews in Anthropology. 6: 493-506.

________________.
1981 "Ecological Adaptation in the Basin of Mexico: 23,000 B.C. to the Present." In Supplement to the Handbook of Middle American Indians, Vol. 1, 147-97. Jeremy A. Sabloff, ed. Austin: Univ. of Texas Press.

Sanders, William T. and Barbara Price.
1968 Mesoamerica: The Evolution of a Civilization. New York: Random House.

Sanders, William T., Jeffery R. Parsons, and Robert S. Santley.
1979 The Basin of Mexico: Ecological Processes in the Evolution of a Civilization. New York: Academic Press.

Sanders, William T. and Robert S. Santley.
1983 "A Tale of Three Cities." In Prehistoric Settlement Patterns, 243-91. Evon Z. Vogt and Richard M. Leventhal, eds. Cambrigde, Mass.: Harvard Univ. Press.

Sartorius, Carl Christian.
1869 "Fortificaciones Antiguas." Sociedad Mexicana Geográfica, Boletín. 2da Época(Tomo I): 818-27.

________________.
1961 [1858] Mexico About 1850. Stuttgart: F.A. Brockhause.

Sauer, Carl O
1963 [1941] "Foreword to Historical Geography." In Land and Life: a Selection From the Writings of Carl Ortwin Sauer, 351-79. John Leighly, ed. Berkeley: Univ. of California Press.

Schutt, Debra.
1988 "Success in Burkina Faso!" Plan Canada News. 14(3): 3.

Scollar, I.
1978 "Computer Image Processing for Archaeological Air Photographs." World Archaeology. 10: 71-87.

Seler, Eduard.
1960-61 Gesammelte Abhandlungen zur Amerikanischen Sprachund Altertumskunde, Vols. 1-5. Berlin: Akademische Druck-U. Verlagsanstalt.

Shanks, Michael and Christopher Tilley.
1987 Social Theory and Archaeology. Cambridge: Polity Press.

Siemens, Alfred H.
1980 "Indicios de Aprovechamiento Agrícola Pre-Hispânico de Tierras Inudables en el Centro de Veracruz." Biótica 5(3): 83-92.

______________.
1983a "Modeling Pre-Hispanic Hydroagriculture on Levee Backslopes in Northern Veracruz, Mexico." In Drained-Field Agriculture in Central and South America, 27-54. J.P. Darch, ed. British Archaeological Reports, International Series. 189.

______________.
1983b "Oriented Raised Fields in Central Veracruz." American Antiquity. 48(1): 85-102.

______________.
1983c "Wetland Agriculture in Pre-Hispanic Mesoamerica." Geographical Review. 73(2): 166-81.

______________.
1985 "Results of Recent Air Reconnaissance Over the Mexican State of Veracruz." In Prehistoric Intensive Agriculture in the Tropics, 127-47. I.S. Farrington, ed. British Archaeological Reports, International Series. 232.

______________.
1990a "Reducing the Risk: Some Indications Regarding Pre-Hispanic Wetland Agricultural Intensification From Contemporary Use of a Wetland/Terra Firma Boundary Zone in Central Veracruz." In Agroecology: Researching the Ecological Basis for Sustainable Agriculture, 233-50. Stephen R. Gliessman, ed. New York: Springer-Verlag.

______________.
1990b Between the Summit and the Sea. Vancouver: Univ. of British Columbia Press.

Siemens, Alfred H., Richard J. Hebda, Mario Navarrete Hernández, Dolores R. Piperno, Julie K. Stien, and Manuel G. Zola Baez.
1988 "Evidence for a Cultivar and a Chronology from Patterned Wetlands in Central Veracruz, Mexico." Science. 242: 105-7.

Siemens, Alfred H., Mario Navarrete Hernández, and Andrew Sluyter.
1989 "Prehispanic Field Systems on Hill Land in Central Veracruz: Sartorious Reappreciated." Paper presented at the Meetings of the Conference of Latin American Geographers, Queretaro, Mexico.

Simpson, Lesley Byrd.
1940 "Studies in the Administration of the Indians of New Spain." Ibero-Americana. 16.

Sisson, Edward B.
1983 "Recent Work on the Borgia Codices." Current Anthropology. 24(5): 653-56.

Sluyter, Andrew
1990 "New Evidence of Widespread, Intensive Precolumbian Agriculture in Central Veracruz, Mexico." Paper presented at the Meetings of the Western Division of the Canadian Association of Geographers, Vancouver, Canada.

SPP (Secretaria de Programación y Presupuesto, Mexico).
1980 Carta Geológica, México. Map Scale 1:1,000,000.

SPP (Secretaria de Programación y Presupuesto, Mexico).
1981 Carta Edafológica, México. Map Scale 1:1,000,000.

SPP (Secretaria de Programacion y Presupuesto, Mexico).
1983 Carta de Climas. Map Scale 1:4,000,000.

SRH (Secretaria de Recursos Hidráulicos, México).
1973 La Antigua/Actopan (#2409). Air Photo Scale 1:8,000 (CIA Mexicana Aerofoto, SA).

SRH (Secretaria de Recursos Hidráulicos, México).
1973 Rehabilitación de los Distritos de Riegos de Actopan y La Antigua, Veracruz. Map Scale 1:5,000.

Stocker, Terry, Sarah Meltzoff, and Steve Armsey.
1980 "Crocodilians and Olmecs: Further Interpretations in Formative Period Iconography." American Antiquity. 45: 740-58.

Strahler, Arthur N. and Alan H. Strahler.
1987 Modern Physical Geography. New York: John Wiley & Sons.

Stuart, L.C.
1964 "Fauna of Middle America." In Handbook of Middle American Indians, Vol. 1, 316-62. Robert C. West, ed. Austin: Univ. of Texas Press.

Szabo, Matyes.
1980 "Clearing of Stoney Ground and Cultivation in Sweden." Tools and Tillage. 4: 3-35.

Thompson, J. Eric S.
1960 Maya Hieroglyphic Writing: An Introduction. Norman: Univ. of Oklahoma Press.

______________.
1970 Maya History and Religion. Norman: Univ. of Oklahoma Press.

______________.
1972 A Commentary on the Dresden Codex. Philadelphia: American Philosophical Society.

Thornthwaite, C.W.
1964 Average Climatic Water Balance Data of the Continents, Part VI: North America (Excluding United States). Centerton, N.J.: National Science Foundation.

Tolstoy, Paul.
1978 "Western Mesoamerica Before A.D. 900." In Chronologies in New World Archaeology, 241-84. R.E. Taylor and Clement W. Meighan, eds. New York: Academic Press.

Tolstoy, Paul and Louise I. Paradis.
1970 "Early and Middle Preclassic Culture in the Basin of Mexico. Science. 167: 344-51.

Tolstoy, Paul, Suzanne K. Fish, Martin W. Boksenbaum, Kathryn Blair Vaughn, and C. Earle Smith.
1977 "Early Sedentary Communities of the Basin of Mexico." Journal of Field Archaeology. 4(1): 91-106.

Torquemada, Juan de.
1975 [1615] Monarquía Indiana, Vols. 1-3. México: Universidad Nacional Autónama de México.

Turner II, B.L.
1983a Once Beneath the Forest: Prehistoric Terracing in the Rio Bec Region of the Maya Lowlands. Boulder:

Westview Press.

______________.
1983b "Comparison of Agrotechnologies in the Basin of Mexico and Central Maya Lowlands: Formative to the Classic Maya Collapse." In Highland-Lowland Interaction in Mesoamerica: Interdisciplinary Approaches, 13-47. Arthur G. Miller, ed. Washington, D.C.: Dumbarton Oaks Research Library.

______________.
1985 "Issues Related to Subsistence and Environment Among the Ancient Maya." In Prehistoric Lowland Maya Environment and Subsistence Economy, 195-209. Mary Pohl, ed. Papers of the Peabody Museum of Archaeology and Ethnology. 77.

Turner II, B.L. and William E. Doolittle.
1978 "The Concept and Measure of Agricultural Intensity." The Professional Geographer. 30(3): 297-301.

Turner II, B.L. and Peter D. Harrison.
1979 "Comment on W.T. Sanders' review of Pre-Hispanic Maya Agriculture." Reviews in Anthropology. 6: 544-55.

______________, eds.
1983 Pulltrouser Swamp: Ancient Maya Habitat, Agriculture, and Settlement in Northern Belize. Austin: Univ. of Texas Press.

Turner II, B.L. and Charles H. Miksicek.
1984 "Economic Plant Species Associated With Prehistoric Agriculture in the Maya Lowlands." Economic Botony. 38(2): 179-93.

Turner II, B.L. and William M. Denevan.
1985 "Prehistoric Manipulation of Wetlands in the Americas: A Raised Field Perspective." In Prehistoric Intensive Agriculture in the Tropics, 11-30. I.S. Farrington, ed. British Archaeological Reports, International Series. 232.

Tylor, Sir Edward Burnett.
1861 Anahuac: Or Mexico and Mexicans, Ancient and Modern. London: Longman, Green, Longman, and Roberts.

Vivó Escoto, Jorge A.
1964 "Weather and Climate of Mexico and Central America." In Handbook of Middle American Indians, Vol. 1, 187-215. Robert C. West, ed. Austin: Univ. of Texas Press.

Wernstadt, Frederick and Joseph E. Spencer.
1967 The Phillippine Island World. Berkeley: Univ. of California Press.

West, Michael
1965 "Transition From Preclassic to Classic at Teotihuacán." American Antiquity. 31(2): 193-202.

West, Robert C.
1968 "Population Densities and Agricultural Practices in Pre-Columbian Mexico, With Emphasis on Semi-Terracing." Proceedings of the XXXVIII International Congress of Americanists, Stuttgard-Munchen, 1968. Vol. 2: 361-69.

West, Robert C. and John P. Augelli.
1966 Middle America: Its Lands and Peoples. Englewood Cliffs, N.J.: Prentice-Hall.

Wilken, Gene C.
1972 "Microclimate Management by Traditional Farmers." The Geographical Review. 62: 544-60.

________________.
1987 Good Farmers: Traditional Agricultural Resource Management in Mexico and Central America. Berkeley: Univ. of California Press.

Wilkerson, S. Jeffrey K.
1983 "So Green and Like a Garden: Intensive Agriculture in Ancient Veracruz." In Drained-Field Agriculture in Central and South America, 55-90. J.P. Darch, ed. British Archaeological Reports, International Series. 189.

________________.
1989 "Presencia Huasteca y Cronología Cultural en el Norte de Veracruz Central, México." In Huaxtecos y Totonacos, 257-79. Lorenzo Ochoa, ed. México: Consejo Nacional para la Cultura y las Artes.

Winning, Hasso von.
1976 "Late and Terminal Preclassic: The Emergence of Teotihuacán." In Origins of Religious Art and Iconography in Preclassic Mesoamerica, 141-56. H.B. Nicholson, ed. Los Angeles: UCLA Latin American Center.

Wiseman, Frederic M.
1983 "Analysis of Pollen From the Fields at Pulltrouser Swamp." In Pulltrouser Swamp: Ancient Maya Habitat, Agriculture, and Settlement in Northern Belize, 105-19. Austin: Univ. of Texas Press.

Wittfogel, Karl A.
1957 Oriental Despotism: a Comparative Study of Total Power. New Haven: Yale Univ. Press.

Wolf, Eric.
1959 Sons of the Shaking Earth. Chicago: Univ. of Chicago Press.

Wright, A.C.S.
1962 "Some Terrace Systems of the Western Hemisphere and Pacific Islands." Pacific Viewpoint. 3: 97-100.

Zavala, Silvo.
1984 El Servicio Personal de los Indios en la Nueva España, Vol. 1. México: El Colegio de México.