Landscapes of Cultivation in Mesoamerica on the Eve of the Conquest

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Abstract. Pre-Columbian Amerindian agriculturalists developed technologies and management practices with which to crop a wide range of ecological conditions, giving rise to a multiplicity of cultivated landscapes. This variety was particularly evident in Mesoamerica, where agricultural practices ranged from swiddening to multicropped, hydraulically transformed wetlands. Here we explore these indigenous cultivated landscapes as they existed about the time of the Columbian Encounter. We illustrate them through the examination of three transects approximating the courses of the initial Spanish *entradas* through this diverse region: the first extends from the Gulf coast to central Mexico; the second traverses the Yucatán peninsula from north to south; and the third climbs into highland Guatemala from the Pacific coastal plain.

Second, we broadly sketch the major changes that took place in these landscapes during the first phase of Spanish domination and some of the forces that shaped these changes. Three processes were especially significant: the Amerindian depopulation, the introduction of exotic biota and technologies, and the reordering of land and the rural economy. Ultimately, however, reconfigured "hybrid" landscapes resulted that reflected the union of cultures.

Last, we argue that the scale of environmental transformation of Amerindian agriculture has not always been fully appreciated, the scale of environmental degradation associated with Spanish introductions has been overstated at times, and the contrasting ideologies of nature between the two cultures has been oversimplified.

Key Words: Amerindian agriculture, Mesoamerica, sixteenth century, Columbian Encounter.

THE Columbian Encounter opened the world to the treasures of Amerindian plant domestication, the impacts of which would be global in reach and range far beyond agriculture per se. The potato, for example, increased the caloric base of northern Europe, facilitating its exponential population growth after 1750, while maize, manioc, sweet potato, and peanut became dietary mainstays for much of the rest of the world (Hamilton 1976, 856–57, 860). Amerindian cotton was literally the fabric of the industrialization of textiles (Sauer 1976, 818), and tobacco claims the dubious distinction of "vice of choice" for much of the world.

Less well known is that these and other Amerindian domesticates of global significance (e.g., avocado, bean, cacao, chile, papaya, squash, and tomato) coevolved with equally impressive systems of cultivation. Long before the Columbian Encounter, Amerindian agriculturalists had developed technologies and management practices with which to crop a wide range of environments and ecological conditions, giving rise to a variety of landscapes of cultivation. This variety was particularly evident

Annals of the Association of American Geographers. 82(3), 1992, pp. 402–425

in Mesoamerica, where advanced material culture and state organization extended from the southern border of the Bajío in Central Mexico southeastward to Guatemala, including parts of Belize, Honduras, Nicaragua, and Costa Rica (Fig. 1). Some of these cultivated landscapes consisted of intermingled or patchwork-like microsystems, fine-tuned to small-scale environmental variations, while others were dominated by zonal patterns keyed to the broad environmental zones created by elevation, aspect, and slope.

The *conquistadores* marveled at these landscapes, even as they sowed the seeds of change. A new rendering of the land emerged at a pace only slightly slower than that of the conquest itself. Within fifty years of Columbus's initial landfall, Spanish hegemony over Middle America (the Caribbean, Mexico, and Central America) was complete and, in the course of the sixteenth century, most of the cultivated landscapes of Mesoamerica had been forever altered from their former condition. This alteration followed not only from changes in control of the land, but from the introduction of exotic biota, technologies, and management practices as well.

The cultivated landscapes of the preconquest Amerindians and the implications of their transformation, especially in Mesoamerica, have been the subject of rather polarized views, many of which have been empirically uninformed (see Denevan, this volume and Doolittle, this volume). Amerindian agriculture has not always been fully appreciated, the scale of environmental degradation associated with Spanish transformation of this agriculture has been overstated at times, and the contrasting ideologies of nature between the two cultures has been oversimplified.

Here we explore the indigenous cultivated landscapes that were witnessed by the Spanish adventurers as they existed about the time of the Columbian Encounter. Our primary objective is to illustrate the variety of these landscapes through the examination of three transects traversing different environmental and sociopolitical terrain. Each transect approximates the course of one of the initial Spanish *entradas* through this diverse region: the "Cortés transect" extends to central Mexico from the Gulf coast, the "Montejo transect" traverses the Yucatán peninsula from north to south, and the "Alvarado transect" climbs into highland Guatemala from the Pacific coastal plain (Fig. 1). Second, we broadly sketch the major changes that took place in these landscapes during the first phase of Spanish domination and some of the forces that shaped these changes. Our intent is neither to mythologize the accomplishments of the Amerindians nor to vilify the conquerors, but to illustrate the magnitude and breadth of the changes that took place in the cultivated landscapes of Mesoamerica as a result of the Columbian Encounter.

The Cortés Transect

Cortés and his small band probably first saw the snowcapped summit of Orizaba (5,639 m) from ship's deck in the vicinity of modern Veracruz, Mexico. From that vantage point, they were observing the eastern flanks of the Aztec empire, a domain that stretched east-west from the Gulf of Mexico to the Pacific Ocean and north-south from the Bajío to the Isthmus of Tehuantepec (Figs. 1, 2). More properly identified with the "Triple Alliance" of the city states of Tenochtitlán, Texcoco, and Tacuba in the Basin of Mexico (Gibson 1964, 17), the empire has taken its popular name from the dominant Mexica (Tenochtitlán) and their mythical homeland, Aztlan. The Alliance commanded a political and economic realm unparalleled in Mesoamerican history, complete with a supreme ruler, professional armies and merchants, and a system of taxation and marketing that siphoned the wealth of the empire into its lacustrine heart. Population estimates for Central Mexico, roughly corresponding with the empire, range from <10 million–>50 million (Denevan 1976, 77–84; 1992).

This transect parallels the Cortés route and crosses virtually every major climatic and agroecological zone in Mesoamerica: the hot and humid *tierra caliente* of the Gulf Coast Plains, the *tierra templada* (temperate land) of the coastal piedmont and the basins on the *altiplano* or Mesa Central, and the upper reaches of the sierras that separate the basins from one another (Figs. 2, 3). Each of these broad realms, with the exception of the cold lands and steep slopes of the sierras, was or-

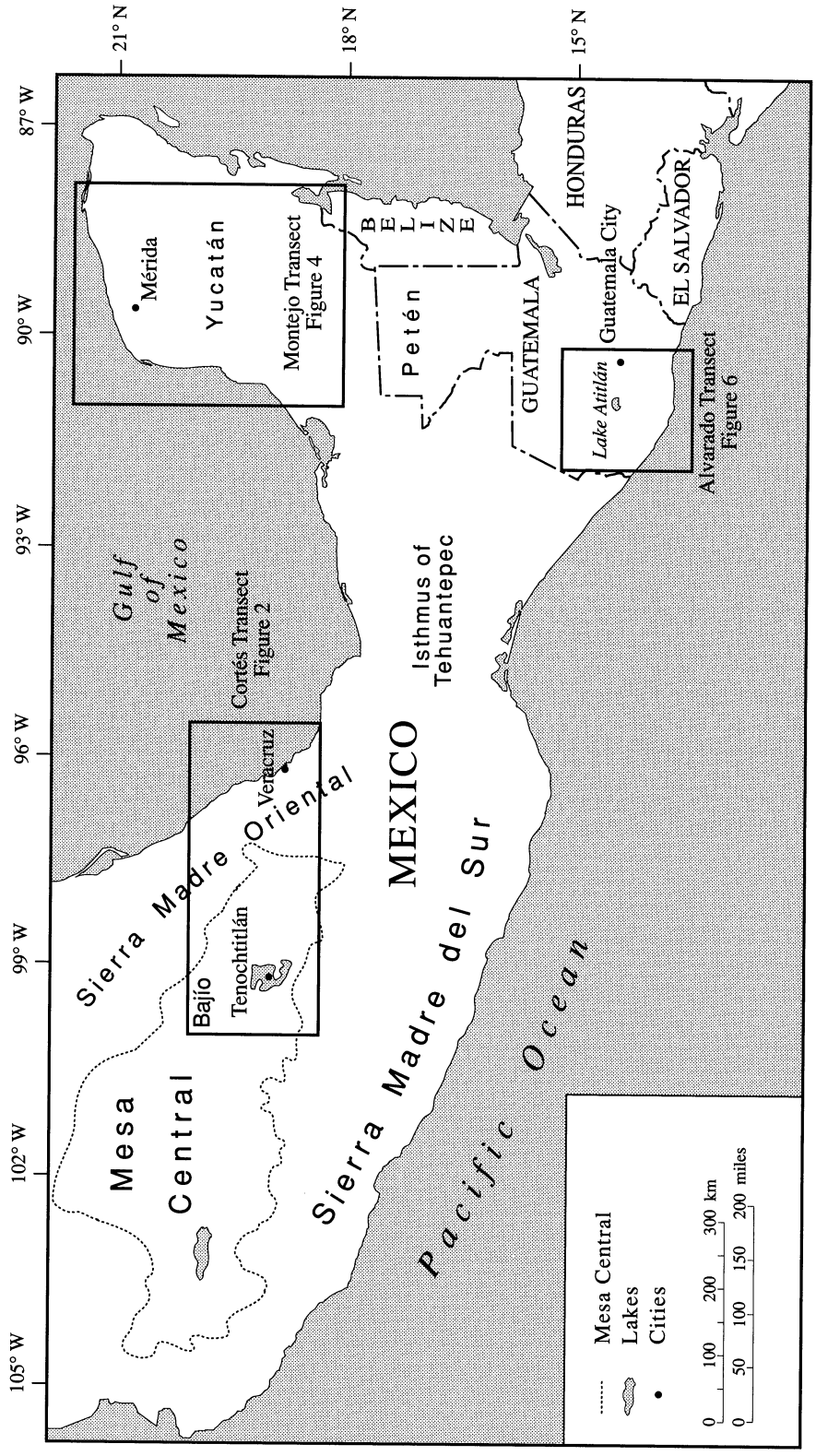

Figure 1. Mesoamerica, locating Cortés, Montejo, and Alvarado transects. Sources: adapted from National Geographic Society (1980) as base map only and West (1964a) for other locational information.

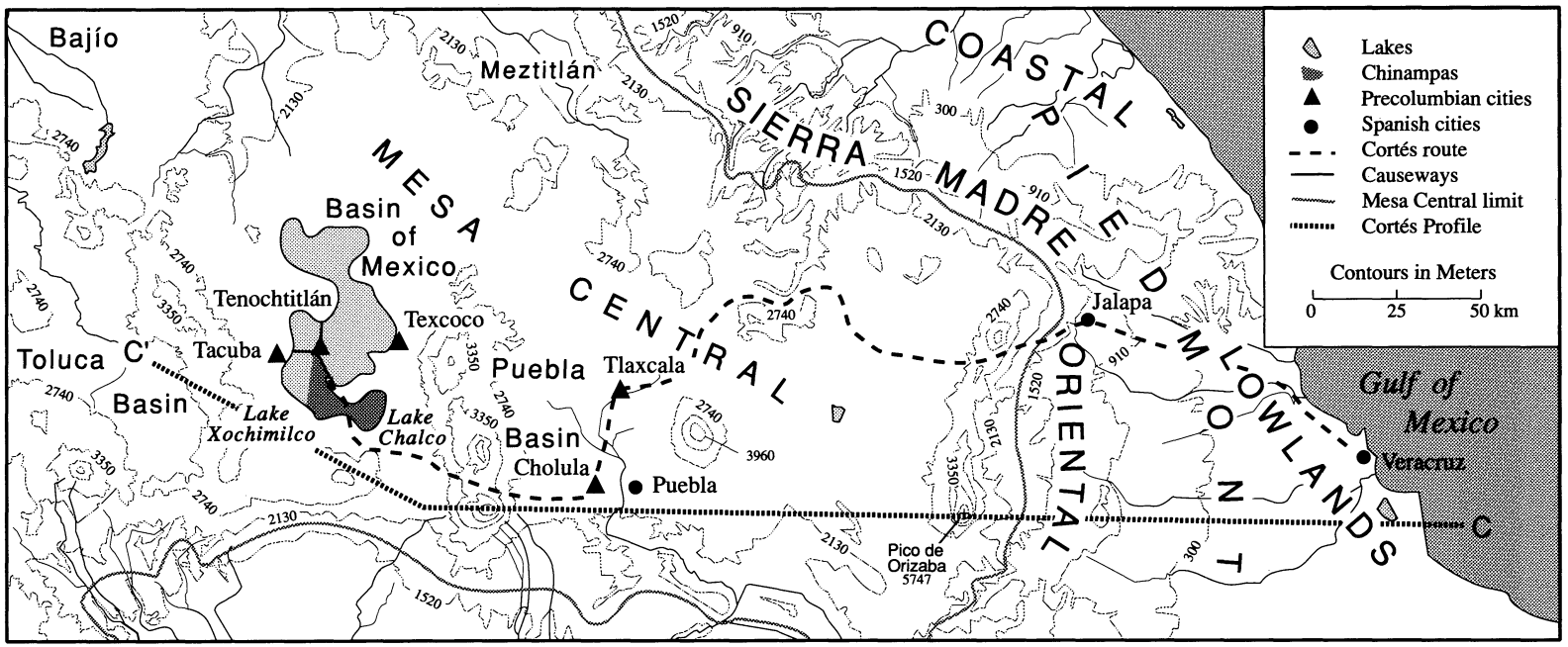

Figure 2. Cortés Transect, showing Central Mexico, Cortés's route, and the path of the Cortés Profile C-C' (see Fig. 3). Sources: adapted from U.S. Defense Mapping Agency (1965) as a base map and West (1964a) for other locational information.

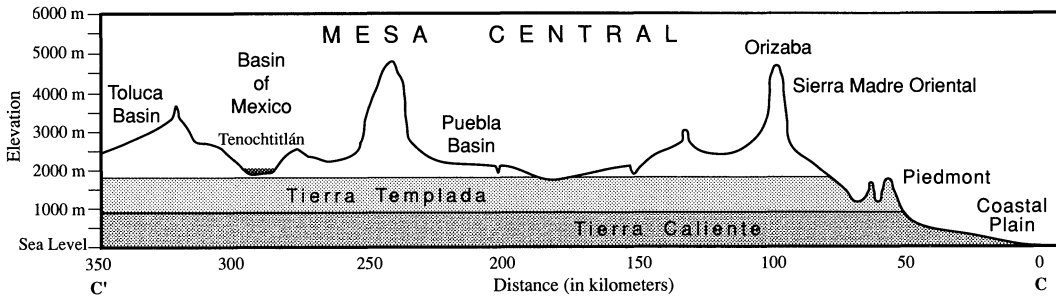

Figure 3. Cortés Profile, showing vertical relief along C-C' transect, as noted in Fig. 2. Sources: based on Fig. 2.

chestrated and transformed into landscapes of cultivation.

Gulf Coastal Plain and Piedmont

The area of the Spaniards landfall was inhabited by the Totonac who mastered the seasonal rhythm and environmental variation of the coastal plain and piedmont to produce crops for local subsistence as well as tribute, and possible commerce, with the Aztec empire (Barlow 1949; Hassig 1985, 114, 115; Stark 1990, 269). The coastal plains and hills offered a complex mosaic of microenvironmental opportunities and constraints for agriculture. The cultivated landscapes encountered in this complex natural terrain consisted of a patchwork of different cultivation types interspersed with forests and scrub land. It is even likely that the forests were managed and may have sheltered orchards. The Totonac orchestrated their year-round cultivation with the spatial and temporal variations in soil-water conditions, working the well-drained lands during the rainy season, and the inundated lands in the dry season (Siemens 1988, 1992; Wilkerson 1983, 58). The landscape configured by these practices led Spaniards to describe the lowlands around Zempoala as "a garden with luxuriant vegetation" (Diaz del Castillo 1956, 87).

The mainstay of Totonac (and Mesoamerican agriculture generally) was rainfed cultivation or *temporal*. In the Gulf Coast area, such cultivation dominated the well-drained, usually sloping, terrain and incorporated terraces with rock-walled, earthen, and probably also earth and *maguey* (*metepantli*) embankments (Rojas Rabiela 1988, 118; Sluyter 1990, 20–37, 51–53; Wilkerson 1983, 64, 76).

Perhaps as important, however, were a variety of wetland adaptations that allowed cultivation during the marked dry season (Siemens 1983, 87; 1990, 117; Vivió Escoto 1964, 212; West 1964b, 58). In some instances, the margins of wetlands and levees were cultivated as water receded in the dry season, facilitated by the use of small drainage ditches. In others, more elaborate networks of canals were used to create field systems in wetlands proper. Siemens (1982, 1983) believes that these more elaborate networks may also have functioned in a flood-recessional manner. Contemporary flood-recessional cultivation in the Gulf Coast (and elsewhere) does not employ the elaborate and major canal networks found in the relics of the ancient systems. Thus we suspect that the cultivation associated with wetlands proper may have functioned through most of the year rather than only during recession of the floods.

Relics of walls and embankments on drylands and fields and canals in wetlands are abundant in the Gulf Coast area, although dating their continued use up to the eve of conquest is difficult to establish (Sluyter 1990; Siemens 1982, 1983). Indeed, Siemens et al. (1988, 107) found evidence that at least one wetland system in Veracruz was probably abandoned 500–700 years before the Columbian Encounter. Further southeast, however, Spanish accounts describe conditions that imply wetland cultivation in the sixteenth century (Pohl 1985). This evidence, the relatively large populations along portions of the Gulf Coast (López de Gómara 1964, 91; Stark 1978, 214–19; Wilkerson 1983, 55), and the amount of tribute extracted by the

Aztec from the area (Barlow 1949), lead us to suspect that many of the relic agricultural features found throughout the Gulf Coast zone may have been operating at the time of Spanish contact. These issues require further investigation. In addition, Wilkerson (1983, 81) speculates that runoff and other types of irrigation were used in the area.

It can also be presumed that two types of orchard-gardens were found in the area: the ubiquitous *solar* or *calmil,* carefully tended household gardens providing vegetables, fruits, condiments, medicinals, and fiber products (Siemens 1983, 97); and orchards, especially of cacao and various fruits grown for commercial purposes and tribute (Bergmann 1969, 86, 88; Millon 1955, 705; Schmidt 1977, 57; Stark 1974, 204, 210; 1978, 215). Orchard species may have been cultivated as special plots (see Montejo Transect), and/or they may have been integrated within managed forests as described by Alcorn (1984) for the modern Huastec.

Field management practices were probably similar to those used in the *altiplano,* including *montones* (mounded soil) or *camellones* (ridged or furrowed soil) and possibly transplanting from seedbeds (*almácigos* or *tlalacalli*) (Rojas Rabiela 1988, 33, 74–75, 82; Schmidt 1977, 57). While maize dominated, ethnohistorical and ethnographic analogs suggest that fields were intercropped with beans, squash, cotton, maguey (*Agave spp.*), *tuna* (*Opuntia spp.*) or root crops (Rojas Rabiela 1988, 93; Sluyter 1990, 56, 62; Stark 1974, 205; 1978, 216).

Sierra Madre Oriental

The eastern versant of the Sierra Madre Oriental presented a formidable escarpment separating the Gulf Coastal Plains and Piedmont from the mineral wealth and cooler climates on the *altiplano.* Its ascent took the Spaniards from the *tierra caliente* to the *tierra templada* and, ultimately the *tierra fría* beyond the 2000–3000 m saddle of the range (Fig. 2). The slope is steep and rugged throughout, dissected by the deep, narrow canyons of the Gulf-bound streams (West 1964b, 52–53). Much of the mountain slope receives large amounts of orographically-induced rainfall (2000 mm–3000 mm annually), giving rise to cloud forests near the crest (Vivió Escoto 1964, 201).

This escarpment was an agricultural transition zone perhaps shaped less by agroecological conditions than by declining population pressures between the piedmont and the upper slopes. The piedmont apparently was a landscape of terraces, and Siemens (1990, 145) quotes a nineteenth-century German resident who described "terraces . . . on every slope." As slopes grew steeper, however, the intensity of cultivation diminished to a shifting type, although fog moisture in the dry season supported two maize crops annually in a single field in some locations (Rojas Rabiela 1988, 78). Gutiérrez Ruvalcaba (forthcoming) notes sixteenth-century cultivation frequencies in the Sierra Madre Oriental of 1:8–1:10 (i.e, one year of cultivation and eight–ten years of fallow for each *milpa* plot). Another source notes shorter cycle periods (1:4–1:5) for the same region (the Colonial-era province of Meztitlán on the present-day Hildago-Veracruz border [Rojas Rabiela 1988, 62]).[1] Local inhabitants also may have employed a vertical zonation strategy, cultivating plots at different elevations to reduce risk and augment production (Gutiérrez Ruvalcaba forthcoming; Siemens 1990, 144).

Mesa Central

Crossing the Sierra, the Spaniards entered the great semiarid volcanic basins and ranges of the Mesa Central, encountering landscapes that they found more familiar and appealing than those of the *tierra caliente* (Figs. 2, 3). Here, a large Amerindian population was arranged in settlement hierarchies dominated by city-states whose hinterlands spread across basin floors and up the surrounding slopes. Agriculture formed the basis of subsistence and commerce among city-states and was central to the tribute extracted by the Aztec.

The Mesa Central is composed of broad, flat-floored basins ringed by imposing volcanoes and broad slopes (West 1964b, 42, 47), many of which offered fertile soils for agriculture (Stevens 1964, 195–296; West 1964b, 47). Most of this area is above 1800 m (Figs. 2, 3). Here, Mesoamerican crop production was limited by recurrent frosts and low levels of precipitation (Sanders et al. 1979, 230) (mean annual precipitation ranges from 250 mm–1000 m) combined with high annual variability (Vivió Escoto 1964, 199). Paradoxically, poor interior drainage gave rise to various wetlands on the basin floors.

While each basin differed according to its

features and occupation, commonality of use gave rise to a characteristic pattern of cultivated landscapes.[2] The upper *sierras* remained in forest, a source of wood and regulator of water. Below the forest line, rainfed terraced and semiterraced cultivation dominated. Various forms of floodwater irrigation were pursued within ephemeral water courses and along lands adjacent to them, including the edges of the basins' floors into which the drainages emptied. On the basin floor proper, where poor drainage was common, various kinds of wetland cultivation were adapted to the perihumid conditions.

Small clusters of villages and hamlets were scattered across the landscape. Their intensively cultivated gardens produced food crops, condiments, ornaments, and medicinal plants (Evans 1990, 117, 126; Palerm 1955; Rojas Rabiela 1988, 92–93; forthcoming). Specialized orchards of avocado, *nopal de grana* (the cacti hosting the cochineal insect used for red dye, *Opuntina spp.*), *maguey* (agave or century plant, *Agave spp.*), *tejocote* (Mexican hawthorn, *Crataegus mexicana*), *capulín* (capulin cherry, *Prunus capuli*) and other fruits occupied favored niches (Rojas Rabiela 1988, 93: forthcoming).

Rainfed cultivation dominated spatially, although its forms were adapted to the varying terrain.[3] Upper and lower slopes were embraced by flights of sloping *metepantli* (semiterraces) which preserved soil and soil moisture (Donkin 1979, 131; Patrick 1985; Rojas Rabiela 1988: 118–19; Sanders 1981, 192). More than a simple slope adjustment, *metepantli* incorporated food and fiber production into the terrace by using *maguey* or *nopal* cacti as berm anchors (Evans 1990, 125; Patrick 1985, 542; Wilken 1979). Maize, beans, and squash were the mainstays of slope cultivation, but Mesoamerican cultivators grew a large variety of other cultigens, including amaranth (*Amaranthus annuus*), *chía* (*Salvia hispanica*), tomato, beans, squash, and chiles.

Perhaps the most common irrigation works were weirs or check dams that captured silt and water within intermittent drainages, or that spread water onto adjacent lands for floodwater irrigation (Donkin 1979, 42, 44; García Cook 1985; Parsons 1971, 220; Rojas Rabiela 1988, 120; 1985, 202; forthcoming; Sanders et al. 1979, 222–81; Wolf and Palerm 1955, 266). Perhaps it was these features in Cholula that Cortés described in 1520: "the farmlands are very fertile and they have much land and the greater part is irrigated" (1945, 146). In some cases, this technique was extended to valley floors, which were straddled by broad terraces that could be fed by channel runoff water (Donkin 1979, 44; Rojas Rabiela 1988, 120; Sanders et al. 1979, 253; Wolf and Palerm 1955).

Small dams and diversion weirs coupled with canals provided permanent irrigation water from springs or permanent streams in selected locations (Armillas et al. 1956; Doolittle 1990, 115; Millon 1957; Rojas Rabiela 1985, 198; 1988, 121; Sanders et al. 1979, 260–62). Thousands of small contour bench terraces in the Basin of Mexico are thought to have been irrigated in this way (Donkin 1979, 44; Sanders et al. 1979, 251–52). In some cases, lengthy canals, complete with aqueducts that spanned intervening *barrancas* (gullies), attest to the use of permanent irrigation (Doolittle 1990, 127; Donkin 1979, 42, 44; Parsons 1971, 220; Wolf and Palerm 1955, 266). At least one instance of the canalization and relocation of the flow of a large stream for irrigation is known in the Basin of Mexico (Doolittle 1990, 115–20). While terracing was located throughout the Mesa Central, its association with elaborate irrigation infrastructures has only been well documented for the Basin of Mexico.

Many of the seasonal and permanent wetlands and shallow lakes in the interior of the valleys of Tlaxcala, Mexico, and perhaps Puebla were transformed into a network of canals and planting surfaces (wetland fields) on which year-round cultivation could be practiced (Parsons 1971, 220; Rojas Rabiela 1985, 208; Sanders 1972, 131–32; Sanders et al. 1979, 275; Wilken 1969, 1987). In some cases, hierarchial systems of canals channeled excessive water to the interior, creating drained fields along the periphery of lakes or wetlands.

The latter form of wetland cultivation reached its zenith among the *chinampas,* or "floating gardens," of the Basin of Mexico, occupying thousands of hectares of the southern freshwater lakes of Chalco and Xochimilco (Armillas 1971, 653; Sanders et al. 1979, 275; West and Armillas 1952, 171) (Fig. 2). The actual *chinampa* was a narrow artificial island (a raised field), anchored by trees along its edges, and

constructed from lake muck and biotic materials dredged from the shallow lakes themselves (Wilken 1985, 42). The effect was to raise the planting surface relative to the water in the bordering canals, providing subsurface irrigation at all times, but also facilitating surface irrigation if needed. Canals were regularly cleaned, and the aquatic muck was used to fertilize the fields (Armillas 1971, 653; Palerm 1973; West and Armillas 1952, 171; Wilken 1985, 42).[4]

By the sixteenth century, *chinampas* were part of a state-designed and controlled hydraulic system that included dikes and sluice gates controlling water level and quality in the southern parts of the lacustrine network (Palerm 1973). Not only did dikes protect the two southern lakes from brackish Lake Texcoco, but an adjacent section of that lake was diked as well, making chinampa agriculture possible on the islands of the Aztec capital (Fig. 2) (Calneck 1972; Parsons 1976, 253; Sanders et al. 1979, 154).

Individually and as a system, *chinampas* required significant labor input to construct and maintain, but they combined very high productivity with risk-reduction (Armillas 1971, 660; Coe 1964, 98; Moriarty 1968, 473; Parsons 1976, 244–46; Sanders 1972, 133; Sanders et al. 1979, 390). Irrigation reduced problems of drought, and the presence of water mitigated frost hazard. *Chinampas* were probably double-cropped, using different cultigens and transplantation from seedbeds (Rojas Rabiela 1985, 165; 1988, 79–80). Few cultivation systems in the world could match their sustained level of productivity.

The Montejo Transect

The Yucatán Peninsula, home to the lowland Maya, provided a radically different experience for the Spaniards (Figs. 1, 4). As in the Mexican case, the northern Yucatán was well peopled, and the Maya were both skilled cultivators and active in long-distance trade (Andrews 1983; Chamberlain 1948; Farriss 1984). Nevertheless, by such measures as the number and spatial domain of city-states, and level of sociopolitical organization and affluence (as measured by the scale and quality of monumental architecture), the condition of the lowland Maya in Yucatán at the time of contact was not on par with that of their Classic Period ancestors of some 500–700 years earlier (Chase and Rice 1985; Jones 1989; Turner 1983a, b).

The Yucatán is composed of two environmental domains (Figs. 4, 5) over which a common set of cropping practices were differentially employed in association with differing intensities of occupation. The peninsula is a large limestone shelf with extreme karst conditions, dominated by a tropical wet-dry climate (*tierra caliente*) in which rainfall increases considerably from the northwest to the southeast (Finch 1965; Wilhelmy 1981; Wilson 1980). The northern periphery of the peninsula is a relatively flat, lowly elevated plain, but starting with the Puuc Hills (Figs. 3, 4), a rolling hill or upland area extends southward into the *Péten* (Guatemala). Everywhere in the north, extremely shallow and rocky soils, an absence of surface water, and a pronounced dry season impeded agriculture.

At the time of the Columbian Encounter, the northern low plains were moderately to heavily occupied. In contrast, the central and southern uplands, an area that was once the heart of the Classic Maya civilization (Culbert 1973; Turner 1990a), were very sparsely settled in 1492 (Jones 1989; Means 1917; Scholes and Roys 1968; Turner 1990a, b).

Northern and Coastal Plains

Spaniards officially discovered the Yucatán in 1517 (Chamberlain 1948, 61–64; Clendinnen 1987, 17–18; Means 1917) only to find that at least two Spaniards, survivors of a shipwreck, were present among the Maya. One of these men refused to return to his former comrades, but led the Maya in subsequent military encounters against them (Chamberlain 1948, 61–64; Means 1917). The Spaniards bypassed the Yucatán for Mexico, so that the initial conquest awaited 1527, while subjugation of the peninsula followed some twenty years later (Farriss 1984, 12). Led by Francisco de Montejo (the Elder), the first *entrada* began on the northeastern coast of the peninsula and marched inland. The transect that we follow here roughly corresponds to the north-south course of Montejo's route, with some liberties taken to include the interior uplands which Montejo's

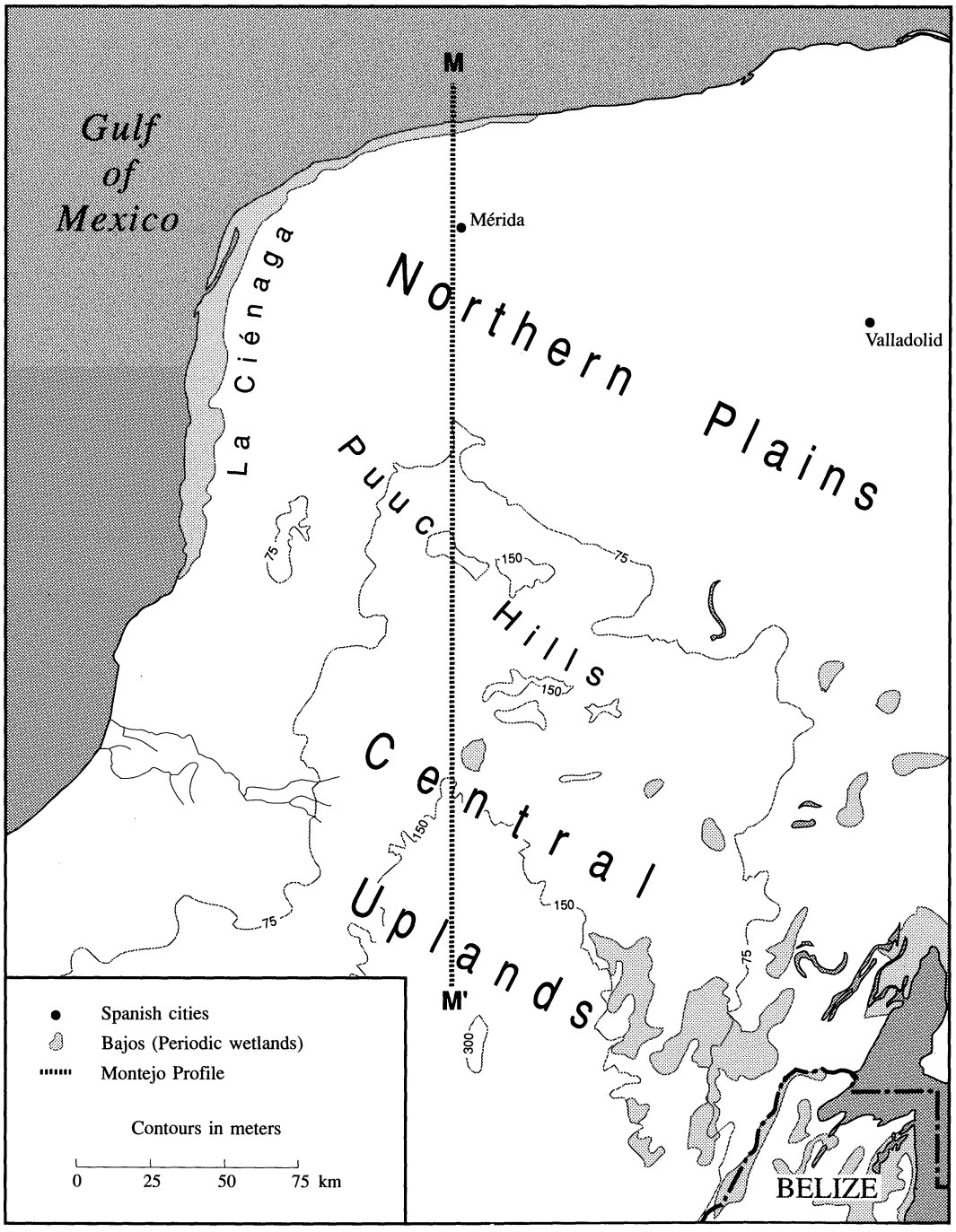

Figure 4. Montejo Transect, showing the Northern Yucatán, and the path of the Montejo Profile, M-M' (see Fig. 5). Sources: adapted from U.S. Defense Mapping Agency (1974) and National Geographic Society (1969) as base maps and West (1964a) for other locational information.

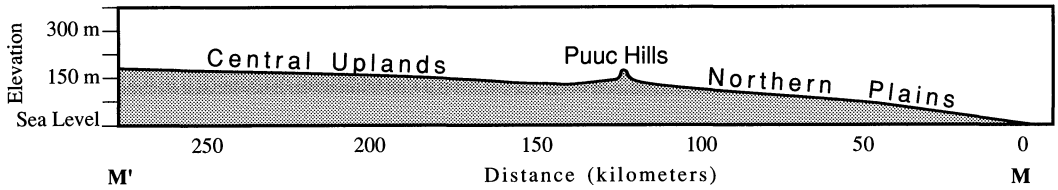

Figure 5. Montejo Profile, showing vertical relief along M-M' transect, as noted in Fig. 4. Sources: based on Fig. 4.

party apparently avoided because of its sparse occupation.

The littoral of northern Yucatán was extremely important economically to the Maya, who had converted coastal wetlands (the *ciénaga*) into the center of Mesoamerican salt production and trade. Salt was apparently transported by canoe along the coasts to Mexico and Central America (Andrews 1983). The settlements controlling salt production lay inland, spread throughout the northern plains, as was most of the Maya population. Here the Spaniards encountered large numbers of Maya, arranged in small-sized polities consisting of sizable villages and well-tended landscapes.

These villages and their lands had a common morphology. A small plaza and public monument, usually a small pyramid or some other shrine, marked the center of a village, from which homesteads, each demarcated by stone walls enclosing orchard-gardens, radiated outward (the elite lived closest to the center) (Clendinnen 1987; Gómez-Pompa et al. 1987). Homesteads gave way to open- or outfields in various stages of fallow, which in turn gave way to forest, much of which may have been managed. Here, culling and related activities may have supported forms of agroforestry (*pet kot*) (Gómez-Pompa et al. 1987). This spatial arrangement was repeated across the northern plains, with the apparent exception of savanna areas.

Spanish documents refer to both "plantations" and "orchard-gardens" in the area, using the former designation frequently for elite-owned "cacao" stands situated on the edges of Maya towns (Tozzer 1941, 194–95; Scholes and Roys 1968, 171–72).[5] The spatial arrangement and concentration of these plots may have given the impression of extensive orchards. Maya horticultural practices were not well documented by the Spaniards, other than reports that the elite used slaves and servants to care for their orchards, and evidence of monocropping or plantation-like labor organization is lacking (Scholes and Roys 1968, 171–72).

Orchard-gardens played an important role among the Maya and the Amerindians of *tierra caliente* in general (Killion forthcoming). Much of the Maya food supply was grown in orchard-gardens, as testified by their spatial extent and the quantity of remains of orchard-gardens species taken from excavations of Maya middens (Turner and Miksicek 1984). Indeed, Gómez-Pompa and colleagues (1987) argue that the unusual distribution of useful species currently found within ancient walled plots throughout Yucatán are remnants of ancient orchard-gardens (see also Folan et al. 1979). Individual trees and groves were apparently privately owned and inherited (Millon 1955, 700; Scholes and Roys 1968, 171–72).

Landa referred to the use of agaves, chiles, beans, and cotton in house gardens (Tozzer 1941, 194–95). Maya orchard-gardens included a large variety of native trees, shrubs, and other species adapted to the wet-dry tropical climate of the plains (Clendinnen 1987, 141; Chamberlain 1968, 52; Scholes and Roys 1968, 171–72, 328; Tozzer 1941, 179, 230). These included agave and cotton, avocado, *nance* (*Brysonima crassifolia*), allspice (*Pimenta dioica*), guava (*Psidium guajava*), *sapodilla* (*Manilkara zapote*), and *mamey zapote* (*Calocarpum mammosum*).

The prevalence of orchard-gardens notwithstanding, the staple crop of the northern Maya at the time of the Columbian Encounter was maize. Considerable documentation by earlier

chroniclers indicates that the bulk of it was produced in fields distant from the walled homesteads and orchard-gardens, although walls may have been present in these "outfields" (walls without occupation structures are common; see Freidel and Leventhal 1975). The cultivation practices in these "outfields" are uncertain, as is the intensity of cultivation. In the mid-1500s, Landa noted that the Maya prepared the land from January to April (in the dry season), planted with a digging stick, and cultivated by "collect[ing] together refuse and burn[ing] it in order to sow" (indicating shifting cultivation?); but they also had "improved" lands and "kept the land well cleared and free from weeds" (indicating nonshifting cultivation?) (Tozzer 1941, 62, 64, 97; Landa 1937, 38).

Because of the level of population and the well-defined boundaries of villages and provinces in the north, we suspect that a short-fallow rotational system was used in which plot preparation focused on burning collected and dried vegetation in order to provide essential phosphorus for the soil before the rains began in April. Plots were first sowed to maize and subsequently intercropped with squash and nitrogen fixing beans.[6] Interestingly, the region was known for its cotton and hemp production at the time of conquest, although virtually no descriptions of its cultivation exist. Weeding dominated the growing season labor until the fall harvest.

The outfields of each village were apparently separated from those of the next by forest which, in addition to possible agroforestry activities, formed a reserve for wood fuel, hunting, and tame animals. Deer were, perhaps, the most important of the semitame animals, apparently controlled from birth through biological imprinting, and later herded from the village to feed in the forest (Means 1917, 30; Tozzer 1941, 127).

The Uplands

Compared to the northern plains, the rolling karst hills of the central peninsular area must have been a disappointment and aggravation to the Spaniards, for here the population thinned dramatically (Means 1917; Scholes and Roys 1968, 333), and the tropical forest provided a frontier refuge for Maya fleeing Spanish control. The distinctive cultivated landscape of the northern plain was replaced in the uplands by extensive swidden systems, possibly similar to those described by ethnographers in the nineteenth and twentieth centuries.[7] This slash-and-burn or *milpa* (literally cornfield) method involved basically the same tools and crops as in the north, but utilized longer fallow cycles and lower labor inputs, especially for weeding. New plots were cut in January to allow the woody species to dry sufficiently for burning before the rains of April. After several seasons of cultivation, a plot was abandoned for a protracted period to escape the concentration of pests and weeds there and to allow regrowth of a secondary forest.

The role of orchard-gardens in the uplands during this period is not clear. They may have existed around larger settlements, but references to activity of this kind are sparse. House gardens were undoubtedly common. The forests were very much the product of past Maya activities and were well stocked with economic species from which extensive collecting took place.

Alvarado Transect

Pedro de Alvarado led the Spanish *entrada* into the highland Maya realm of Guatemala in 1524, charting a route southeastward from the Mesa Central, following the Pacific coastal plain, before turning northward into the well-defended highlands of present day Guatemala (Figs. 1, 6). Following the experience of Cortés, Alvarado brought thousands of Aztec and Tlaxcalan warriors to subdue the Maya, who fought the invasion in a series of bloody battles. The Spaniards found a populous highlands divided into provinces of different ethnolinguistic Maya stock. Each province had hereditary rulers, but no overarching state was present, nor were there many large cities of the material majesty found in the Aztec realm. The region, however, contained some of the finest agricultural soils in Mesoamerica and the lowlands of its Pacific versant gave the Spaniards a preview of yet another source of wealth—estate production of cacao.

The climb from the Pacific Coast to the homelands of the highland Maya transverses an array of broad agroecological zones associated with elevation (West 1964a, 373). The Coastal Plain (*La Costa*) and the Boca Costa or piedmont comprise a 40–50 km-wide strip between the ocean and highlands proper (Figs. 6, 7).

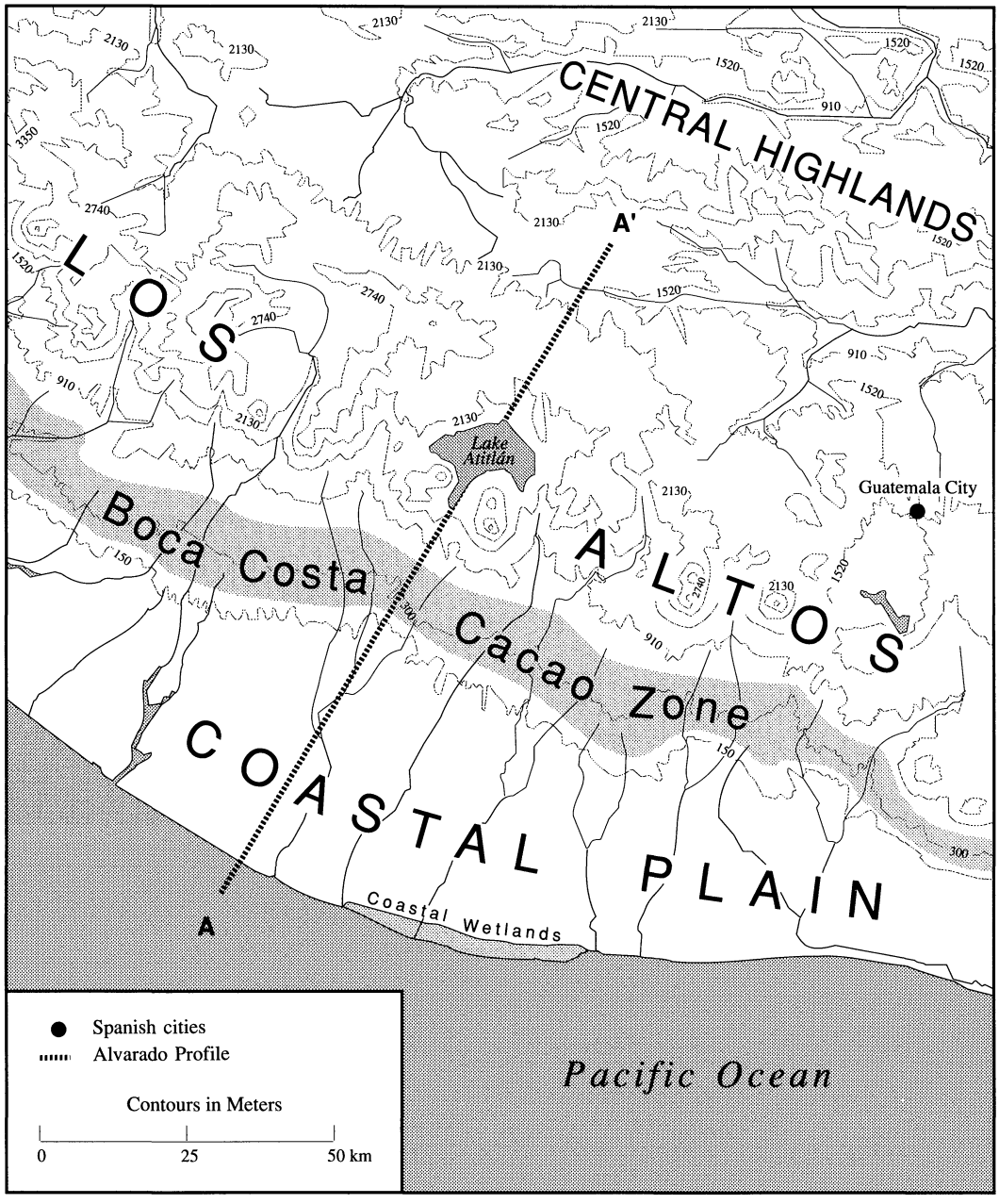

Figure 6. Alvarado Transect, showing southwestern Guatemala, and the path of the Alvarado Profile, A-A' (see Fig. 7). Sources: adapted from U.S. Defense Mapping Agency (1978) as a base map and Bergmann (1969) and Orelanna (1984) for other locational information.

The coastal plain (up to about 100 m elevation) and the lower Boca Costa (about 100 m–460 m elevation) are *tierra caliente* while the upper Boca Costa (about 460—1500 m elevation) is *tierra templada*. Precipitation increases inland and with elevation, such that portions of the Boca Costa receive in excess of 2000 mm annually (Vivó Escoto 1964, fig. 10). Around 1000 m elevation, the mountain front rises steeply to cinder cones and composite volcanos, some of

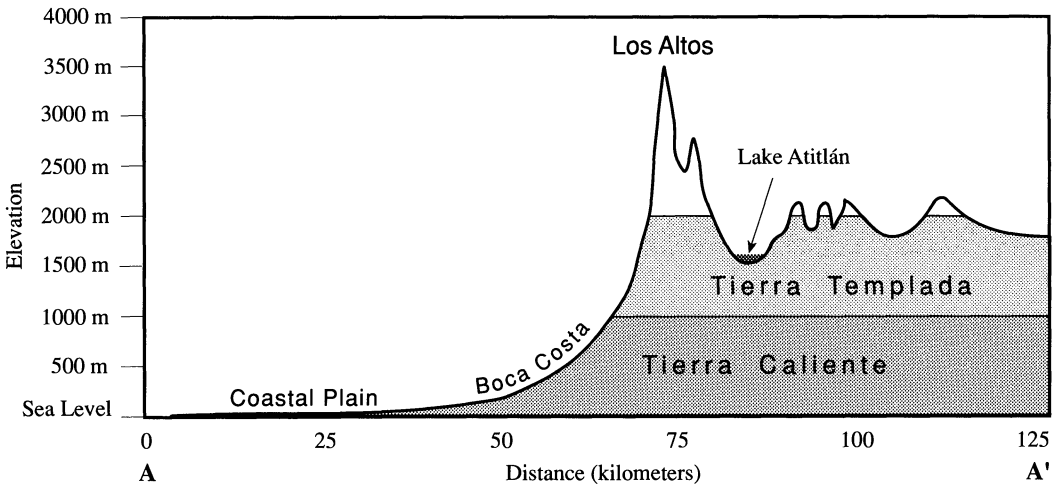

Figure 7. Alvarado Profile, showing vertical relief along A-A' transect, as noted in Fig. 6. Sources: based on Fig. 6.

which exceed 3000 m. Above the 1500 m contour and to the interior of the versant is *Los Altos,* the highland volcanic axis, composed of small depressions and calderas surrounded by volcanoes (more than twenty in Guatemala alone). Lake Atitlán occupies such a caldera at 1566 m. The peaks are in clouds and mist much of the time and average annual precipitation there reaches 3000 mm–4000 mm. To the northern end of the Alvarado transect the volcanic axis gives way to the lower-elevated and drier central highlands.

Boca Costa

Very little is known about Amerindian agriculture on the narrow coastal plain proper. In contrast, the Boca Costa was a zone so prized for its agricultural fertility that Amerindian groups vied with one another for its control. The southwest portion of the Boca Costa was part of the greater Soconusco (also spelled Soconosco, Xoconusco, and Xoconocho) region, extending into southeastern Chiapas state in Mexico. This region was renowned for producing and widely exporting the finest cacao in Mesoamerica (Bergmann 1969, 86; Gasco and Voorhies 1989, 289; MacLeod 1973, 68–79; Millon 1955, 702). Cacao is a delicate species that requires moist but well-drained soils, shade, protection from high winds, and warm temperatures (mean temperatures between 18° C and 32° C, without frost) (Gasco 1987, 157). Owing to these needs, major orchard zones were below 650 m (Orellana 1984, 70) where annual precipitation totals ranged between 1150 mm–2500 mm. Pronounced dry seasons necessitated irrigation. Cacao was commonly germinated using seedbeds (*almácigos*) and replanted to orchards (Rojas Rabiela 1988, 82). Another species, *Theobroma tricolor,* is hardier, but it is not clear that it was grown extensively in the Boca Costa. Major cacao began about 30 km inland on the alluvial fans. Bergmann (1969, 89) suggests that this interior location was a response to the drier conditions approaching the ocean, but it also corresponds with the well-drained agricultural soils of the alluvial fans characteristic of this piedmont.

Cacao was produced over a wide area, perhaps in an orchard or plantation-like pattern. The Spaniards referred to estates and gardens or orchards of cacao, terms that imply not only monocropping conditions but possibly irrigation as well (Armillas 1949, 88; Bergmann 1969, 90; Millon 1955; Rojas Rabiela 1988, 92; Zamora Acosta 1985, 182). Cacao was intensively tended, its care including the use of shade trees (e.g., *madera negra* [*Gliricidia maculata* H. B. and K.] or *coxote* [*G. sapium*]) and protection from predators and theft (Lange 1971, 240–44; Millon 1955, 704; Orellana 1984, 70; Stone 1977, 85–86; Rojas Rabiela 1988, 92).

The immense value of the cacao to Meso-

americans was in its use as a thick beverage or gruel. Such was the importance of this food that the cacao bean served as a medium of exchange in Mesoamerica, used in virtually any commodity or service transaction (Millon 1955; Bergmann 1969, 85–86). Elites controlled the production of and trade in cacao in the Boca Costa, although this control did not require actual occupation of the piedmont. Highland Maya communities governed some of the production in the Boca Costa, while Náhuatl-speaking groups within the piedmont may have served to ensure the flow of cacao to Aztec Mexico (Bergmann 1969, 89; Orellana 1984). At the time of the Spanish conquest, the Aztec extracted tribute from Soconusco and Boca Costa by taxing the towns controlling production, regardless of their location.

The Boca Costa also offered a full array of agriculture, producing other foods and fibers, Maize was double and even tripled-cropped in some locales (Fuentes and Guzmán 1882, 64; Zamora Acosta 1985, 182), undoubtedly through the use of irrigation. It is also possible that orchards producing other crops than cacao were present. The spatial extent of this production onto the southern versant proper (between the cacao zone and Los Altos) is not well understood. The slope is very steep and rugged, and it appears to have been sparsely occupied at contact relative to the lands above and below. The southern versant may have been used for extensive cultivation as a "spill-over" zone for farmers ascending from the Boca Costa or descending from Los Altos.

Los Altos

In addition to the ubiquitous house gardens, rainfed cultivation was practiced on both terraced and nonterraced fields in the slopes and depressions of Los Altos. Many slopes were intensively cultivated without terracing, particularly where mounding (*montones*) or ridging (*camellones* contouring the slope) were apparently sufficient to impede erosion (see Wilken 1987, 129–144). Although Alvarado spoke of a highly developed agriculture, Spanish descriptions of practices associated with *temporal* are vague, making it difficult to distinguish shifting from permanent cultivation (Zamora Acosta 1985, 178; Palerm and Wolf 1962, 336). The *Annals of the Cakchiquels* (ca. 1559–81) mentions cut-and-burn techniques, but not rotation of fields, leading to various interpretations about the implied frequency of cultivation (Feldman 1985, 29; Orellana 1984, 69). The apparently extensive use of mounding, along with the use of a hoe-like instrument and a scraper-like rake for weeding, led Feldman (1985, 29–30) to conclude that a rainfed system, more intensive than slash and burn, was prevalent in Los Altos.

Terracing was practiced throughout the highlands (Orellana 1984, 27–29), although specific references to Los Altos are few. Remnants of pre-Hispanic terracing exist in the central highlands, and the practice may have been followed at the time of conquest (Guzmán 1962, 398). The distribution of the relic features may reflect soil distinctions between the volcanic axis of Los Altos and the more northerly central highlands or it may reflect differential Spanish impacts. Documentation of terrace remains in the volcanic axis zone is slim, however. Lothrop (1933) found relic terraces around Lake Atitlán but did not designate their function for agriculture as opposed to house sites.

Highland Maya terracing, in general, served the same functions as described in the Cortés transect. Where associated with the *tablón*, however, irrigation was common. The *tablón* (literally, plank) is a raised-garden plot (20–65 cm in height), usually rectangular in shape with inwardly sloping sides, accompanied by irrigation channels (Mathewson 1984; Wilken 1971, 435). If on a sufficient slope, the *tablón* is constructed on terraces with the irrigation channel located at the base of each terrace wall. *Tablones* in use today are especially frequent around the edges of Lake Atitlán and on the northern slopes above the lake, although they can be found elsewhere in the highlands (Altee 1968; Wilken 1987). While no direct evidence yet confirms the use of *tablones* in the pre-Hispanic highlands, two facts strongly suggest that they were a major component of highland Maya agriculture. The first is that each of the structural elements of *tablones* was known and used by the Maya; the second is that the current distribution coincides with contact-era social and environmental conditions that would have promoted their use (Mathewson 1984, 17–20; Orellana 1984, 69; Wilken 1971, 435–36). It is likely that *tablón* systems constituted many of the gardens described in Spanish accounts.

The principal crops grown were those prevalent throughout the highlands of Meso-

america. According to Feldman (1985, 26), at least seven varieties of maize, three of squash, nine of beans, tobacco, and, perhaps, sweet potato have been identified in Los Altos in prehistoric context. Studies of highland Maya communities by Stadelman (1940) and others indicate the presence of a much greater variety of maize, much of which is assumed to have been present in antiquity.

The Lake Atitlán Basin was a microcosm of the highland landscapes in general at contact times, including its occupation by at least three Maya groups: the Cakchiquel in the north and east sides, the Tzutujuil on the south side and Pacific slopes, and the Quiché on the north and west sides (Lothrop 1933, 3). The cultivated landscape here appeared as a mosaic of practices associated more with slope than with climatic variation or with elevation. The upper, broad slopes of the basin were apparently under intensive rainfed cultivation, complete with cascading *monotones* and *camellones*. Further down the basin, where drainage systems facilitated irrigation but the steepness of slope increased significantly (particularly on the northern side of the lake), ranks of terraced *tablones* continued down towards the lake. Near lake level, almost all the small deltas of the drainages were also converted into *tablones* (see Mathewson 1984).

The Fate of the Cultivated Landscapes

The repercussions of the Conquest spread swiftly throughout Mesoamerica during the first century of the Hispanic era, leaving few, if any, cultivated landscapes untouched (Butzer 1991). The conquerors reapportioned land and labor under conditions of rapid Amerindian depopulation and reconstituted agriculture through the introduction of European technologies and biota. The conquered retained, where possible and appropriate, their crops and cropping techniques. Ultimately, however, both conquerors and conquered borrowed extensively, if differentially, from one another, and the reconfigured landscapes that resulted were not so much one culture's cultivated landscape replacing another's but their union on "hybrid" landscapes.[8]

Causes of the Transformations

The Conquest of Mesoamerica set in motion a series of processes, intentional and otherwise, that penetrated every facet of the physical and spiritual world of the Amerindian, with many of the results having significant ramifications on cultivated landscapes. We cannot treat all of these processes here, but focus on three clusters of them that were especially significant in a direct way: the Amerindian depopulation, the introduction of exotic biota and technologies, and the reordering of land and the rural economy.

The scale of Amerindian depopulation that accompanied the introduction of Old World pathogens by the Spaniards is nothing short of phenomenal, remaining unparalleled in demographic history (see Lovell this volume).[9] This demographic tragedy affected agriculture in at least two ways. The landesque capital (terracing, irrigation, wetland systems) of the intensive cropping systems of the Amerindian could not be sustained with such losses in labor, leading to the decay of many cultivated landscapes (Cook and Borah 1979, 169), with the concomitant environmental degradation that typically follows from the lack of upkeep. This decay contributed to the larger process of land abandonment which, in turn, weakened Amerindian claims to land and led to Spanish land appropriation (e.g., Licate 1981).

The introduction of Old World biota and technologies, part of what Crosby (1972) calls the Columbian Exchange, had wide-ranging impacts on the landscape because of the new land-uses associated with them and the expansion of these uses into areas extensively utilized by Amerindians. Among the most dramatic were those of range livestock, previously unknown in Mesoamerica. The population explosion of grazing animals early in the sixteenth century is claimed by many to have contributed to accelerated erosion on agricultural lands, increased siltation, more frequent and profound flooding, and losses of harvests due to predatory herds and the physical trampling of the fields (Brand 1961, 133; Chevalier 1963, 93; Cook and Borah 1979, 169; Crosby, 1972, 76–77; Gibson 1964, 305; Morrisey 1951, 116; Simpson 1952; Super 1988, 26). Chevalier (1963, 93) claims that entire communities in the Mesa Central were forced to move, in part because of livestock damage to croplands, and the land

so abandoned may well have contributed to the growth in cattle and sheep *estancias* (ranches) during the early sixteenth century (Chevalier 1963, 83; Licate 1981, 114–15).

Such impacts may have been more short-lived than conventional wisdom asserts. Gibson (1964, 281), among others (e.g., Butzer and Butzer, personal communication), notes that the Spanish Crown invoked law and policy directed at preserving Amerindian lands and cultivation, although these efforts were apparently at odds with the forces of depopulation, resettlement, land abandonment, and local appropriation (Licate 1981, 113). Discovery of silver in the north and the cattle producers' adaptions of their production strategies to the new lands, led to a livestock industry that spread northward into lands that were less intensively used in pre-Columbian times, producing an economy that was relatively in tune with the environments in question (Butzer and Butzer).

The critical point for our discussion is that much land that was once under Amerindian cultivation (in the highland domain) or was sparsely utilized (north of Mesoamerica proper or in lands abandoned because of depopulation) was rapidly put to a new, exotic use. The land-cover impacts associated with this land-use change are vividly illustrated in the Gulf Coast area, where cattle and sheep production was pursued on pastures created by burning forest and on former wetland fields; in either case, these were formerly Amerindian cultivated landscapes, altered to new use (Siemens 1992).

Hispanic crop introductions also redefined the lands to be cultivated and the form of cultivation on them (Hassig 1985, 221). The use of plow and draft animals, for example, placed a premium on level or gently sloped lands with good soil depth and drainage and large field size (Cook and Borah 1979, 171). In contrast, pre-Columbian *coa*-based cultivation was particularly suitable for use in shallow soils and small fields, and on steep slopes.[10] The shift to plow cultivation and the abandonment of cultivated lands owing to depopulation and resettlement may have altered the overall proportion of valley bottom to upper slope cultivation relative to pre-Hispanic times.

Spanish preferences for European foods also played a part. Wheat cultivation was carried across the *altiplano* from the Puebla basin to the northern silver mines (Gibson 1964, 322; Chevalier 1963, 51–54; Super 1988, 32) because of the demand for wheat bread. This pursuit led the Spaniards to introduce irrigation in the Bajío and other arid lands on the margins of Mesoamerica, and to rework Amerindian irrigation in the Basin of Mexico to allow winter (dry season) cultivation (Chevalier 1963, 70; Butzer and Butzer; Davis 1990). The environmental impacts of these shifts in agriculture are insufficiently documented so that more pointed assessments constitute speculation.

Plantation crops for trans-Atlantic commerce emerged in the lowlands, although large-scale plantations were not the norm (Butzer 1991, 210). The most important of the crops in terms of landscape change was sugarcane, which the Spaniards introduced wherever ecologically suitable (Chevalier 1963, 74). Cortés himself established a sugarcane plantation in the lowlands west of Tuxtla as early as 1528 (Barrett 1970, 11). For the most part, sugarcane production in the *tierra caliente* was undertaken on small estates, as was Spanish-controlled production of cacao, cotton, tobacco, and dyes (MacLeod 1973, 220–24). By the close of the sixteenth century, sugarcane production also spread into warmer upland locales, such as in Morelos where large-scale plantations were established (Barrett 1970, 4; Super 1988, 37), and where it may have helped to displace Amerindian cultivation (Chevalier 1963, 82).

These changes were intertwined with those stemming from the reordering of land and labor. By the mid-sixteenth century, significant land holdings had accrued to the Spaniards and, interestingly, to Amerindian elites in some areas (Gibson 1964; Licate 1981; Simpson 1952). Amerindian labor was siphoned off for work on large Spanish estates, and the *encomienda* (grants for the control of Amerindian labor) refocused production goals, and in some cases, the location of Amerindian settlements. After mid-century, full-blown resettlement schemes (the *congregación*) relocated much of the remaining rural population (Cline 1949). The impacts of these activities were to reduce Amerindian cultivation in some locales and increase land pressures on others.

Landscapes Transformed and Traditions Retained

Three very broad patterns of transformation of cultivated landscapes followed throughout

Mesoamerica and beyond. The humid *tierra caliente* (save the northern Yucatán) was virtually abandoned, allowing major forest regeneration. The few remaining Amerindians in these lowlands, armed with the introduction of steel cutting tools, increasingly moved towards labor-saving swidden cultivation. The Spaniards, on the other hand, introduced small-scale estates devoted to plantation crops, both introduced and native, followed by livestock production. The *tierra templada* witnessed wide-spread abandonment and destruction of Amerindian agricultural landscapes and the emergence of new ones. The general pattern of this transformation involved the disuse of some land, the disproportional redistribution of other lands to the Spaniards, and an investment in large-scale plow and wheat cultivation and livestock production drawing on Amerindian labor (see Prem, this volume). Finally, cultivation and livestock rearing expanded into the more arid segments of Mesoamerica and the lands beyond, especially to the north, and later into Central America.

Indigenous landscapes dominated by labor-intensive cultivation, especially terraces and wetland systems, were particularly affected. Terrace systems were abandoned throughout the upper piedmonts of the Mesa Central of Mexico (Cortés transect), Los Altos of Guatemala (Alvarado transect), and somewhat later in the piedmont of the Gulf Coast (Cortés transect) (Donkin 1979, 35–36). These extensively distributed systems of slope modification simply could not be maintained in the face of Amerindian depopulation and relocation (Cook and Borah 1979, 168; Donkin 1979, 36) and with the increasing focus of cultivation in valleys and lower basins.

Similarly, wetland agriculture, the productive heart of some pre-Columbian landscapes, also faded in significance. It did so for several reasons beyond those of population collapse and labor shortage. Indigenous wetland agriculture was not well understood by the Spaniards, was not central to their vision of appropriate land use, and was not suited for plow or wheat production. Moreover, it occupied lands potentially suitable for plow and livestock production, if properly drained (Cook and Borah 1979, 171; Hassig 1985, 221). Interestingly, deterioration of the Amerindian systems upslope lead to increased sedimentation and other problems that apparently degraded some wetland systems below (Gibson 1964, 305; López Ríos 1988). Owing to these and other factors, wetland agriculture almost disappeared from the Mesa Central (Cortés transect), except for the *chinampas* of Lakes Chalco and Xochimilco in the Basin of Mexico (which would decay slowly) and the drained fields in the Tlaxcalan valley. Wetland systems, other than ephemeral flood-recessional practices, also disappeared in the Gulf Coast Plain (Cortés transect), although their demise may have been underway previous to the Conquest.

In the Yucatán (Montejo transect), the Spaniards developed extensive cattle estates, utilizing both Maya agricultural lands and forest (Farriss 1984, 32).[11] This not only disrupted the well-developed cultivated landscape of the Maya, but, along with depopulation, the introduction of steel cutting tools, and Maya "escape" to the forests outside of Spanish control, probably led to the disintensification of Maya cultivation from rotational to shifting cultivation.[12] The rearranged landscape was composed of large estates interspersed with small villages, following a form of *milpa* cultivation that has continued to the present.

Most of the cultivated landscapes that escaped major change lay on the margins of Spanish interests or control. For example, agriculture in the expanse of the lowland tropical forest between the Maya highlands (Alvarado transect) and northern Yucatán (Montejo transect) remained more or less as it had been at contact, that is extensive swidden cultivation. One landscape prized by the Spaniards that survived more or less in its pre-Hispanic form, at least under the first phase of Spanish domination, was that of the cacao-producing Boca Costa and Soconusco (Alvarado transect). The Spaniards were quick to realize the importance of cacao among Mesoamericans and, later, its value for international trade (Hamilton 1976, 860–61). They took control of cacao producing zones largely through the *encomienda,* the effect of which was to leave the form of production largely intact.

The reconfiguring of the cultivated landscapes did not mean that Amerindian agricultural practices and technologies were lost; many survived as integral components of the new landscapes. Perhaps the most important of these was the omnipresent *calmil.* Small household gardens remained central to Amerindian and peasant agriculture throughout the contact

and colonial periods (and are still maintained), albeit with European additions. Field-scale surface modifications, especially *camellones* and *montones,* also endured well, especially where maize cultivation persisted without the plow. These features were so common in the *Mesa Central* in the sixteenth century that any parcel of cultivated land was referred to as a *camellón* and even abandoned lands were known as *"acamellonada"* (i.e., filled with planting mounds) (Rojas Rabiela 1988, 42–43). The *metapantli* (maguey-anchored terraces) also survived (Patrick 1977), perhaps because of the ease of upkeep of the retaining wall, although it was much more spatially restricted than in precontact times (Donkin 1979). Vestiges of drained fields, raised fields, and *tablones* also weathered the conquest, but in highly localized areas. The survival of the *tablón* in Guatemala (Alvarado transect) was due in part to its use on steep and narrow lands not suited for other forms of cultivation, and, as Mathewson (1984, 24–25) implies, because it may have been appropriated by the Spaniards for their own horticultural needs. Finally, various extensive rotational systems continued to be employed, especially in the *tierra caliente* and in areas that were and remained sparsely utilized. In some cases, extensive agriculture may have been introduced anew in so-called refuge areas—regions where the indigenous population fled to avoid Spanish laws, taxes, or culture, such as the sparsely inhabited interior of the Maya lowlands.

These Amerindian systems were combined with Hispanic ones to create the new cultivated landscapes of New Spain. In some cases, systems of either origin were distributed across a landscape according to the differing socioeconomic and environmental circumstances present (e.g., Spanish-dominated bottom lands and Amerindian-dominated slope lands). More common, however, the various systems themselves were modified by exchanges in biota and technology. The new cultivated landscapes, therefore, were a product of agricultural systems lost, added, modified through exchange, and redistributed across the terrain.

Transformations in Perspective

What became known as *La leyenda negra* (the Black Legend) encapsulated long-standing beliefs about Spanish civilization and its conquests in the New World, perhaps overstating its barbarism and brutality relative to other societies. In recent years, another legend related to the Columbian Encounter has emerged: what might be called *La leyenda verde.* This Green Legend mythologizes the achievements and qualities of Amerindian cultures, especially their agriculture. Such interpretations, especially in the popular literature (e.g., Sale 1990; Weatherford 1988), attribute Amerindian decision making in agriculture and landscape alterations to cultural values placed on the conservation of nature or on the need for harmony with nature as much as or more than to the need for food, fiber, and tribute, the desire for wealth, or the response to sociopolitical conflict and change. An idealized Amerindian experience of using nature in a benign way is contrasted with a European penchant for controlling or raping nature for profit. This polarization errs in several fundamental ways as applied to the cultivated landscapes of Mesoamerica and New Spain. It fails to appreciate sufficiently the nature and scale of agricultural production in preconquest Mesoamerica and, hence, the scale and magnitude of its associated environmental changes, and it tends to inflate the environmental damage associated with the cultivated landscapes of New Spain.

The peoples of Mesoamerica engineered nature into regional mosaics comprised of diverse systems of cultivation which contributed to extensive land modification and conversion. The particular systems and the landscapes in which they were embedded were the result of real and perceived needs in the context of the cultural and environmental constraints and opportunities. These systems served first to feed the large populations, but also to sustain elites and oppressive political structures, engage in commerce, and pay tribute. Polities fought one another for the control of the land and the wealth that came from its cultivation. Production shortfalls, even prolonged famines, were common throughout Mesoamerica (e.g., Hassig 1981), and changes in socioeconomic conditions led to localized decay, abandonment, and replacement of particular agricultural landscapes, ofttimes leading to environmental degradation (e.g., see Williams 1972).

The Columbian Encounter constituted an abrupt, even brutal, change in population,

biota, technological capacity (especially in transportation), and, to a much lesser extent, political economy that recast Amerindian cultivated landscapes. The swiftness of change as well as the changes themselves exacerbated environmental damage as some systems were abandoned and others reconstituted, but ultimately a series of *"mestizo"* cultivated landscapes emerged that were more or less ecologically sustainable. It is difficult to compare these pre- and post-Columbian landscapes in terms of such attributes as land and labor productivity or environmental damage. In general however, Amerindian systems may have been more land productive (output per unit area and time), while Spanish systems were higher in labor productivity. The exception to this characterization, of course, was Amerindian shifting cultivation.

This reality does not demean the accomplishments of the Amerindian cultivator, nor does it diminish the impact of the Columbian Encounter. Rather, it directs us to understand the Encounter from a position of balance. Both the pre- and postcontact landscapes of cultivation were constructed for the purpose of extracting from nature, and as the pressures for this extraction varied, so did the kind and scale of local landscape transformation. Where and when these pressures were high in Mesoamerica, extensive alterations of environments took place. The denudation of the tropical forests of the Maya lowlands before 1000 A.D. and the complete transformation of the Basin of Mexico, especially during Aztec times, are clear examples. We can assign the negative environmental impacts of the emergent landscapes of New Spain to an inherent view of nature embedded within Hispanic and European culture, only in a polemic that fails to understand the material circumstances that drive agricultural change. A more balanced view of this collision of worlds forces us to recognize that environmental degradation invariably follows the abandonment of well-adjusted intensive systems and the experimentation with rapidly evolving new systems. This was so before the Columbian Encounter and remains so today.

Acknowledgments

Much of the research behind this work was supported by a grant from the National Endowment for the Humanities. We are indebted to Karl W. Butzer, William M. Denevan, William E. Doolittle, Kent Mathewson, William B. Meyer, Ylena Ogneva, Alfred Siemens, Andrew Sluyter, and the anonymous reviewers for their comments and critiques of this manuscript during various stages of preparation. We thank Heather Henderson for assistance in preparing the final manuscript, and Patti Neumann for preparing the maps and figures.

Notes

1. See the Montejo Transect for descriptions of swidden or slash-and-burn cultivation (also called *tumba y roza,* signifying long fallow, and *barbecho,* signifying short fallow).
2. This section is based largely on information from two large city-state provinces encountered along the Cortés route, Tlaxcala and Cholua (in the present Mexican states of Tlaxcala and Puebla), and from the Basin of Mexico (including parts of the present day Mexican states of México and the Distrito Federal) (Fig. 2).
3. For the details of the construction, morphology, and functioning of most the systems described for the Mesa Central, see Wilken's (1987) thorough assessment of modern-day systems, many, if not most, of which have their origins in pre-Columbian times, and Rojas Rabiela's (1988) excellent treatment of early postcontact indigenous systems.
4. The construction of *chinampas* has been the subject of considerable discussion, because few, if any, have been built in modern times. No less an authority than Humboldt refers to "the chinampas, that Europeans call floating gardens. There are two types: some are moveable . . . others are closely fixed to the margins" (1966, 134). Some have interpreted references to "floating gardens" as references to *chinampas* proper, while others believe that they refer to the canoes filled with transplantings (on route to *chinampas*) or to gathered vegetation floated across the lakes for various purposes. See the following for details and more on the *chinampa* dispute: Apenas 1943, Bancroft 1914 [1887], Bernal 1973, de Acosta 1604, Gibson 1964, Leicht 1937, López Ríos 1988, and Wilken 1985.
5. Spanish documents notwithstanding, the northern Yucatán is not generally considered to have been a major source of cacao (*Theobroma cacao* or *T. bicolor*) at contact times (Bergmann 1969). Indeed, the Yucatán's hydrological conditions seem unsuitable for extensive production. The sole direct evidence of cacao from the Yucatán is a rare variety only known in the Lacandon region of Mexico (Gómez-Pompa, et al. 1990).
6. Landa (Tozzer 1941, 196) mentioned the presence of root crops, probably *jicama* (*Pachyrihizus erosus L.*), but the significance of root crops in the north at contact times is suspect. The soils of the plains are extremely thin, incapable of supporting adequate root and tuber growth. No reports of the use of mounding (*montones*), which might indi-

cate major root crop cultivation, exist for the lowland Maya realm at this time.

7. For descriptions of contemporary swidden agriculture throughout the Maya lowlands, see Carter 1969; O. Cook 1921; Emerson and Kempton 1935; Hester 1954; Higbee 1948; Redfield and Avilla 1934; Roys 1943.
8. Licate (1981, 1, 133) refers to this hybridization as giving rise to "Mexican" landscapes in the Mesa Central. We have refrained from using this term because two of our transects deal with cultural or political units that are not Mexican.
9. Perhaps fueled by the controversy that still surrounds the scale of the Amerindian depopulation, the literature related to the Amerindian population decline is too large to fully cite here. See Denevan (1976, 1992) for a useful bibliography and a thorough overview of the issue. Simulation exercises indicate that depopulation probably approached 90 percent by 1600 (Whitmore 1991, 1992).
10. A prevalent theme asserts that Amerindians typically favored wetlands and slopes because noninundated, level terrain (between slope and shore) was not suited to their nonplow cultivation technologies. This assessment is too simple. Nonplow cultivators are known to have cultivated almost every conceivable terrain (Turner and Brush 1987), given the need to do so.
11. The development of agricultural estates for the monocropping of *henequen* (sisal) did not emerge in the Yucatán until the nineteenth century (Farriss 1984, 34).
12. We are not certain of the impact of metal tools on the frequency of swidden or *milpa* cultivation in the region. One argument holds that the ease of cutting trees with steel tools promoted more extensive systems of cultivation, and that the more strenuous labor involved in felling trees with stone tools would have favored more frequent cultivation of the same plot. Incidentally, Landa (Tozzer 1941, 121) reported that the Maya had metal hatchets, but it is not certain that they were used in agriculture.

References

Acosta, Joseph de. 1880 [1590]. *The natural and moral history of the Indies.* London: Hakluyt Society. 1880.

Alcorn, Janice B. 1984. *Haustec Mayan ethnobotany.* Austin: University of Texas Press.

Altee, Charles B., Jr. 1968. *Vegetable production in Guatemala.* Washington: U.S. Agency for International Development.

Andrews, Anthony P. 1983. *Maya salt production and trade.* Tucson: University of Arizona Press.

Apenas, Ola. 1943. The pond in our backyard. *Mexican Life* 19(60):15–18.

Armillas, Pedro. 1949. Notas sobre sistemas de cultivo en Mesoamérica. *Anales del Instituto Nacional de Anthropología e Historia* 3:85–113.

———. 1971. Gardens on swamps. *Science* 174(4010):653–61.

———**; Palerm, Angel; and Wolf, Eric R.** 1956. A small irrigation system in the valley of Teotihuacan. *American Antiquity* 21(4):396–99.

Bancroft, Hubert H. 1914 (1887). *The history of Mexico, being a popular history of the Mexican people from earliest primitive civilization to the present time.* San Francisco: Bancroft Co.

Barlow, R. H. 1949. *The extent of the empire of the Culhua Mexica.* Ibero-Americana 28. Berkeley: University of California Press.

Barrett, Ward. 1970. *The sugar hacienda of the Marqueses del Valle.* Minneapolis: University of Minnesota Press.

Bergmann, John F. 1969. The distribution of cacao cultivation in pre-Columbian America. *Annals of the Association of American Geographers* 59:85–96.

Bernal, Ignacio. 1973. *Mexico before Cortez: Art history and legend.* New York: Doubleday Anchor Press.

Brand, Donald D. 1961. The early history of the range cattle industry in northern mexico. *Agricultural History* 35(3):132–39.

Butzer, Karl W. 1991. Spanish colonization of the new world: Cultural continuity and change in Mexico. *Erdkunde* 45(3):204–19.

———. 1992. Transfer of the Mediterranean livestock economy to New Spain: Adaptations and consequences. Paper presented at the SCOPE Scientific Symposium on Principles, Patterns, and Processes: Some Legacies of the Columbian Encounter, Sevilla, Spain.

——— **and Butzer, Elisabeth.** 1992. Personal communication, January.

Calneck, Edward E. 1972. Settlement patterns and chinampa agriculture at Tenochtitlán. *American Antiquity* 37(1):104–15.

Carter, William E. 1969. *New lands and old traditions: Kekchi cultivators in the Guatemalan lowlands.* Latin American Monograph 6. Gainesville: University of Florida Press.

Chamberlain, Robert S. 1948. *The conquest and colonization of Yucatan, 1517–1550.* Publication 582. Washington: Carnegie Institution of Washington.

Chase, Arlen F., and Rice, Prudence M. 1985. *The lowland Maya postclassic.* Austin: University of Texas Press.

Chevalier, F. 1963. *Land and society in colonial America,* ed. L. B. Simpson; trans. by A. Eustis. Berkeley: University of California Press.

Clendinnen, Inga. 1987. *Ambivalent conquests: Maya and Spaniard in Yucatan, 1517–1570.* Cambridge: Cambridge University Press.

Cline, H. F. 1949. Civil congregations of the Indians in New Spain, 1598–1606. *The Hispanic American Historical Review* 29(3):349–69.

Coe, M. D. 1964. The chinampas of Mexico. *Scientific American* 211(1):90–98.

Cook, O. F. 1921. Milpa agriculture: A primitive tropical system. *Annual Report of the Smithsonian Institution,* 1919:302–26.

Cook, Sherburne F., and Borah, W. 1979. Indian food production and consumption in Central Mexico before and after the conquest (1500–1650). In *Essays in population history, Mexico and California.* vol. 3. Berkeley: University of California Press.

Cortés, Hernán. 1945. *Cartas y relaciones.* Buenos Aires: Emecé Editores, S.A.

Crosby, Alfred W., Jr. 1972. *The Columbian exchange: Biological and cultural consequences of 1492.* Contributions in American Studies 2. Westport, CT: Greenwood.

Culbert, T. Patrick. 1973. *The classic Maya collapse.* Albuquerque: University of New Mexico Press.

Davis, Clint. 1990. Water control and settlement in colonial Mexico's first frontier: The bordo system of the eastern Bajío. *Yearbook, Conference of Latin Americanist Geographers* 16:73–81.

Denevan, W. M. 1992 [1976]. *The native population of the Americas in 1492.* Madison: University of Wisconsin Press.

Diaz del Castillo, Bernal. 1956. *The discovery and conquest of Mexico,* trans. A. P. Maudslay. New York: Farrar, Straus and Giroux.

Donkin, R. A. 1979. *Agricultural terracing in the aboriginal New World.* Tucson, AZ: University of Arizona Press for the Wenner-Gren Foundation for Anthropological Research, Inc.

Doolittle, William E. 1990. *Canal irrigation in prehistoric Mexico. The sequence of technological change.* Austin: University of Texas Press.

Emerson, R. A., and J. H. Kempton. 1935. Agronomic investigations in Yucatan. *Yearbook of the Carnegie Institution of Washington* 34:138–42.

Evans, Susan T. 1990. The productivity of maguey terrace agriculture in central Mexico during the Aztec period. *Latin American Antiquity* 1(2):117–32.

Farriss, Nancy M. 1984. *Maya society under colonial rule: The collective enterprise of survival.* Princeton, NJ: Princeton University Press.

Feldman, Lawrence H. 1985. *A tumpline economy. Production and distribution systems in sixteenth-century eastern Guatemala.* Culver City, CA: Labyrinthos.

Finch, William A. Jr. 1965. The karst landscape of Yucatan. Ph.D. dissertation, University of Illinois.

Folan, W. J.; Fletcher, L. A.; and Kintz, E. R. 1979. Fruit, fiber, bark, and resin: social organization of a Maya urban center. *Science* 204:697–701.

Freidel, David A., and Leventhal, Richard M. 1975. The settlement survey. In *A study of changing pre-Columbian commercial systems: The 1972–1973 season at Cozumel, Mexico,* ed. J. A. Sabloff, and W. L. Rathje, pp. 60–76. Monograph 3. Peabody Museum of Archaeology and Ethnology. Cambridge: Harvard University.

Fuentes y Guzmán, D., and de Francisco, Antonio. 1882. *Historia de Guatemala, o recordation florida. Natural vecino y regidor perpetuo de la cindad de Guatemala.* Madrid: Biblioteca de los Americanistas.

García Cook, Angel. 1985. Historia de la tecnología agrícola en el altiplano central desde el principio de la agricultura hasta el siglo XIII. In *Historia de la agricultura. Epoca prehispánica-siglo XVI,* ed. Teresa Rojas Rabiela, and William T. Sanders, pp. 7–75. Mexico City: Instituto Nacional de Antropología e Historia.

Gasco, Janine. 1987. Cacao and the economic integration of native society in colonial Soconusco, New Spain. Ph.D. dissertation, University of California, Santa Barbara.

——— **and Barbara Voorhies.** 1989. The ultimate tribute: The role of the Soconusco as an Aztec tributary. In *Ancient trade and tribute,* ed. by Barbara Voorhies, pp. 48–94. Provo: University of Utah Press.

Gibson, Charles. 1964. *The Aztec under Spanish rule: A history of the Indians of the valley of Mexico 1519–1810.* Stanford, CA: Stanford University Press.

Gómez-Pompa, Arturo; Flores, Jose Salvador; and Sosa, Victoria. 1987. The "pet kot": A man-made tropical forest of the Maya. *Interciencia* 12(1):10–15.

———; ———; **and Aliphat Fernández, Mario.** 1990. The sacred cacao groves of the Maya. *Latin America Antiquity* 1(3):247–57.

Gutiérrez Ruvalcaba, Ignacio. Forthcoming. Ecología y agricultura en Metztitlán, siglos XVI y XVII. In *Agricultura indígena: Pasado y presente,* ed. by Teresa Rojas Rabiela. Mexico City: CIESAS, Editiones de las Casa Chata.

Guzmán, Louis E. 1962. Las terrazas de los antiguos mayas montañeses. *Revista Interamerican de Ciencias Sociales,* 2nd epoch, vol. 1(3):398–406.

Hamilton, Earl J. 1976. What the new world gave the economy of the old. In *First images of America,* vol. 2, ed. Fredi Chiappelli, Michael J. B. Allen, and Robert L. Benson, pp. 853–84. Berkeley: University of California Press.

Hassig, Ross. 1981. The famine of one rabbit: Ecological causes and social consequences of a pre-Columbian calamity. *Journal of Anthropological Research* 37:171–82.

———. 1985. *Trade, tribute, and transportation. The sixteenth-century political economy of the*

valley of Mexico. Norman: University of Oklahoma Press.

Hester, Joseph A. 1954. Natural and cultural bases of ancient Maya subsistence. Ph.D. dissertation, University of California, Los Angeles.

Higbee, Edward. 1948. Agriculture in the Mayan homeland. *Geographical Review* 48:457–64.

Humboldt, Alexander von. 1966. *Ensayo politico sobre el reino de la nueva España,* ed. Juan A. Ortega y Medina. Mexico City: Editorial Porrua, S.A.

Jones, Grant D. 1989 *Maya resistance to Spanish rule: Time and history on a colonial frontier.* Albuquerque: University of New Mexico Press.

Killion, T. Forthcoming. *Gardens in prehistory.* University, AL: University of Alabama Press.

Landa, Diego de. 1937 [1566]. *Yucatán before and after the conquest.* Trans. W. Gates. New York: Dover Publications.

Lange, Frederick W. 1971. *Culture history of the Sapoa river valley of Costa Rica.* Occasional Papers in Anthropology 4. Beloit, WI: Logan Museum of Anthropology, Beloit College.

Leicht, Hugo. 1937. Chinampas y almácigos flotantes. *Anales del Instituto de Biología (UNAM)* 5(3):375–86.

Licate, Jack A. 1981. *Creation of a Mexican landscape: Territorial organization and settlement in the eastern Puebla basin 1520–1605.* Department of Geography Research Papers 201. Chicago: University of Chicago.

López de Gómara, Francisco. 1964. *Cortés. The life of the conqueror by his secretary.* Trans. and ed. Lesley Byrd Simpson. Berkeley: University of California Press.

López Ríos, Georgina Florencia. 1988. *Sistema agrícola de chinampa: Perspectiva agroecológica.* Mexico City: Universidad Autonoma Chapingo.

Lothrop, Samuel K. 1933. *Atitlán. An archaeological study of ancient remains on the borders of Lake Atitlán,* Guatemala. Publication 444. Washington: Carnegie Institute of Washington.

MacLeod, Murdo J. 1973. Spanish central America: Socioeconomic history, 1520–1720. Berkeley: University of California Press.

Mathewson, Kent. 1984. *Irrigation horticulture in highland Guatemala: The tablón system of Panajachel.* Boulder, CO: Westview.

Means, Philip A. 1917. *History of the Spanish conquest of Yucatán and of the Itzás.* Papers of the Peabody Museum of American Archaeology and Ethnology, Harvard University, vol. 8. Cambridge, MA.

Millon, René F. 1957. Irrigation systems in the valley of Teotihuacán. *American Antiquity* 23(2):160–66.

———. 1955. Trade, tree cultivation, and the development of private property in land. *American Anthropologist* 57(4):698–712.

Moriarty, J. R. 1968. Floating gardens (chinampas) agriculture in the old lakes of Mexico. *America Indígena* 28(2):461–84.

Morrisey, Richard J. 1951. The northward expansion of cattle ranching in New Spain, 1550–1600. *Agricultural History* 25(3):115–21.

National Geographic Society. 1989. *Land of the Maya* (map). Washington.

———. 1980. *Mexico and Central America* (map). Washington.

Orellana, Sandra L. 1984. *The Tzutujil Mayas. Continuity and change, 1250–1630.* Norman: University of Oklahoma Press.

Palerm, Angel. 1955. The agricultural bases of urban civilization in Mesoamerica. In *Irrigation civilizations: A comparative study,* ed. by J. H. Steward, pp. 28–42. Pan American Union Social Science Monographs 1. Washington.

———. 1973. *Obras hidráulicas prehispánicas en el sistema lacustre del valle de Mexico.* Cordoba, Mexico: Instituto Nacional de Anthropología e Historia.

——— **and Wolf, Eric.** 1962. Potencial ecológico y desarrollo cultural de mesoamerica. *Revista Interamerican de Ciencias Sociales,* 2nd epoch, 1(2):322–45.

Parsons, Jeffery R. 1971. *Prehistoric settlement patterns in the Texcoco region, Mexico.* Memoirs of the Museum of Anthropology 3. Ann Arbor: University of Michigan.

———. 1976. The role of chinampa agriculture in the food supply of Aztec Tenochtitlán. In *Cultural change and continuity: Essays in honor of James Bennett Griffin,* ed. by Charles E. Cleland, pp. 233–57. New York: Academic Press.

Patrick, L. 1985. Agave and zea in highland central Mexico: The ecology and history of the Metepantli. In *Prehistoric intensive agriculture in the tropics,* vol. 2, ed. I. S. Farrington, pp. 539–46. Oxford: B.A.R. International Series, 232.

———. 1977. A cultural geography of the use of seasonally dry, sloping terrain: The metepantli crop terraces of central Mexico. Ph.D. dissertation, University of Pittsburgh.

Pohl, Mary. 1985. An ethnohistorical perspective on ancient Maya wetland fields and other cultivation systems in the lowlands. In *Prehistoric lowland Maya environment and subsistence economy,* ed. M. D. Pohl, Papers of the Peabody Museum of Archaeology and Ethnology, Harvard University, vol. 77, pp. 35–45. Cambridge, MA.

Redfield, Robert, and Avila, R. 1934. *Chan Kom: A Maya village.* Publication 488. Washington: Carnegie Institution of Washington.

Rojas Rabiela, Teresa. 1985. La technología agrícola mesoamericana en el Siglo XVI. In *Histo-*

ria de la agricultural epoca prehispánica-siglo XVI, ed. Teresa Rojas Rabiela and William T. Sanders, pp 129–232. Mexico City: Instituto Nacional de Antropología e Historia.

———. 1988. *Las siembras de ayer: La agricultura indígena del siglo XVI.* Mexico City: Secretaría de Educación Pública y Centro de Investigaciones y Estudios Superiores en Antropología Social.

———. Forthcoming. Historia de la agricultura. Epoca prehispanica. In *La agricultura en tierras mexicanas. De las origenes del siglo XX.* Mexico City: Editorial Grijalbo S.A.

Roys, Ralph L. 1943. *The Indian background of colonial Yucatan.* Publication 548. Washington: Carnegie Institution of Washington.

Sale, Kirkpatrick. 1990. *The conquest of paradise: Christopher Columbus and the Columbian legacy.* New York: A. Knopf.

Sanders, William T. 1972. The agricultural history of the basin of Mexico. In *The valley of Mexico,* ed. Eric R. Wolf, pp. 101–59. Albuquerque: University of New Mexico Press.

———. 1981. Ecological adaptation in the basin of Mexico: 23,000 BC to present. In *Archaeology. Handbook of middle American Indians,* ed. J. A. Sabloff, pp. 147–97. Austin: University of Texas Press.

———**; Parsons, J. R.; and Santley, R. S.** 1979. *The basin of Mexico: Ecological processes in the evolution of a civilization.* New York: Academic Press.

Sauer, Jonathan D. 1976. Changing perception and exploitation of New World plants in Europe, 1492–1800. In *First images of America* vol. 2, ed. Fredi Chiappelli, pp. 813–32. Berkeley: University of California Press.

Schmidt, Peter J. 1977. Un sistema de cultivo intensivo en la cuenca del río Nautla, Veracruz. *Boletín del Instituto Nacional de Anthropología e Historia* 3(20):50–60.

Scholes, France V., and Roys, Ralph L. 1968 [1948]. *The Maya Chontal Indians of Acalan-Tixchel: A contribution to the history and ethnography of the Yucatan peninsula.* Norman: University of Oklahoma Press.

Siemens, Alfred H. 1982. Modelling pre-hispanic hydroagriculture on levee backslopes in northern Veracruz, Mexico. In *Drained field agriculture in Central and South America,* ed. J. P. Darch, pp. 27–54. Oxford: British Archaeological Reports International Series 189.

———. 1983. Oriented raised fields in central Veracruz. *American Antiquity* 48(1):85–102.

———. 1990. *Between summit and sea. Central Veracruz in the nineteenth century.* Vancouver: University of British Columbia Press.

———. 1992. Land use succession in the Gulf lowlands on Mexico: A long view. Paper presented at the SCOPE Scientific Symposium on Principles, Patterns, and Processes: Some Legacies of the Columbian Encounter. Sevilla, Spain.

———**, et al.** 1988. Evidence for a cultivar and a chronology from patterned wetlands in central Veracruz, Mexico. *Science* 242:105–07.

Simpson, L. B. 1952. *Exploitation of land in central Mexico in the sixteenth century.* Ibero-Americana 36. Berkeley: University of California Press.

Sluyter, Andrew. 1990. Vestiges of upland fields in central Veracruz: A new perspective on its Precolumbian human ecology. M.A. thesis, University of British Columbia.

Stadleman, Raymond. 1940. *Maize cultivation in northwestern Guatemala.* Contributions to American Anthropology and History. Publication 523, pp. 83–263. Washington: Carnegie Institution of Washington.

Stark, Barbara L. 1974. Geography and economic specialization in the lower Papaloapan, Veracruz, Mexico. *Ethnohistory* 21(3):199–221.

———. 1978. An ethnohistoric model for native economy and settlement patterns in southern Veracruz, Mexico. In *Prehistoric coastal adaptation: The economy and ecology of maritime Central America,* ed. Barbara L. Stark and Barbara Voorhies, pp. 211–38. New York: Academic Press.

———. 1990. The Gulf coast and central highlands of Mexico: Alternative methods for interaction. *Research in Economic Anthropology* 12:243–85.

Stevens, Rayfred L. 1964. The soils of Middle America and their relation to Indian people and cultures. In *Natural environments and early cultures,* vol. 1, Handbook of Middle American Indians, ed. Robert C. West, pp. 265–315. Austin: University of Texas Press.

Stone, Doris. 1977. Pre-Columbian man in Costa Rica. Cambridge: Harvard University Peabody Museum Press.

Super, John C. 1988. *Food, conquest, and colonization in sixteenth-century Spanish America.* Albuquerque: University of New Mexico Press.

Tozzer, Alfred M. 1941. *Landa's relación de las cosas de Yucatán.* Peabody Museum, Paper 18 (translation). Cambridge: Harvard University.

Turner, B. L. II. 1983a. Comparisons 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* ed. A. G. Miller, pp. 13–47. Washington: Dunbarton Oaks Research Library and Collection.

———. 1983b. *Once beneath the forest: Prehistoric terracing in the Río Bec region of the Maya lowlands.* Dellplain Latin American Series 13, Boulder, CO: Westview Press.

———. 1990a. Population reconstruction for the central Maya lowlands: 1000 BC to AD 1500. In

Precolumbian population history in the Maya lowlands, ed. T. P. Culbert and D. S. Rice pp. 301–24. Albuquerque: University of New Mexico Press.

———. 1990b. The rise and fall of population and agriculture in the central Maya lowlands: 300 BC to present. In *Hunger in history: Food shortage, poverty, and deprivation,* ed. L. F. Newman, pp. 178–211. Cambridge, MA: Basil Blackwell.

——— **and Brush, S. B.** 1987. *Comparative farming systems.* New York: Guilford Press.

——— **and Miksicek, Charles H.** 1984. Economic plant species associated with prehistoric agriculture in the Maya lowlands. *Economic Botany* 38:179–93.

U.S. Defense Mapping Agency. 1978. *Operational navigational chart, K-25.* Washington.

———. 1974. *Operational navigational chart, J-24.* Washington.

———. 1965. *Operational navigational chart, J-25.* Washington.

Vivió Escoto, Jorge A. 1964. Weather and climate of Central Mexico. In *Natural environment and early cultures,* vol. 1, Handbook of Middle American Indians, ed. Robert C. West, pp. 187–215. Austin: University of Texas Press.

Weatherford, Jack. 1988. *Indian givers: How the Indians of the Americas transformed the world.* New York: Fawcett Columbine.

West, Robert C. 1964a. The natural regions of middle America. In *Natural environments and early cultures.* vol. 1, Handbook of Middle American Indians, pp. 363–83. Austin: University of Texas Press.

———. 1964b. Surface configuration and associated geology of Middle America. In *Natural environments and early cultures,* vol. 1, Handbook of Middle American Indians, pp. 33–83. Austin: University of Texas Press.

——— **and Pedro Armillas.** 1952. Las chinampas de México. Poesía realidad de los "jardines flontates." *Cuadernos Americanos* 50:165–82.

Whitmore, Thomas M. 1991. A simulation of the sixteenth-century population collapse in the Basin of Mexico. *Annals of the Association of American Geographers* 81(3):464–87.

———. 1992. *Disease and death in early colonial Mexico: Simulating Amerindian depopulation.* Dellplain Latin American Geography Series. Boulder, CO: Westview Press.

Wilhelmy, Herbert. 1981. *Welt und umwelt der Maya.* Munich: R. Piper and Co. Verlag.

Wilken, Gene C. 1969. Drained field agriculture: An intensive farming system in Tlaxcala, Mexico. *The Geographical Review* 59:215–41.

———. 1971. Food-producing systems available to the ancient Maya. *American Antiquity* 36:xx.

———. 1979. Traditional slope management: An analytical approach. In *Hill lands: Proceedings of an international symposium,* pp. 416–21. Morgantown: West Virginia University Books.

———. 1985. A note on bouyancy and other dubious characteristics of the "floating" chinampas of Mexico. In *Prehistoric intensive agriculture in the tropics,* ed. I. S. Farrington, pp. 31–48. International Series 232. Oxford: British Archaeological Reports.

———. 1987. *Good farmers: Traditional agricultural resource management in Mexico and Central America.* Berkeley: University of California Press.

Wilkerson, S. Jeffrey K. 1983. So green like a garden: Intensive agriculture in ancient Veracruz. In *Drained field agriculture in Central and South America,* ed. J. P. Darch, pp. 55–90. International Series 189. Oxford: British Archaeological Reports.

Williams, Barbara J. 1972. Tepetate in the Valley of Mexico. *Annals of the Association of American Geographers* 62(4):618–26.

Wilson, Eugene M. 1980. Physical geography of the Yucatán peninsula. In *Yucatán, a world apart,* ed. E. H. Moseley and E. D. Terry, pp. 5–40. University, AL: University of Alabama Press.

Wolf, Eric C., and Palerm, Angel. 1955. Irrigation in the old Acolhua domain, Mexico. *Southwestern Journal of Anthropology* 11:265–81.

Zamora Acosta, Elias. 1985. *Los Mayas de las tierras altas en el siglo XVI. Tradición y cambio en Guatemala.* Sevilla: Diputación Provincial de Sevilla.