Ethno-agriculture and Cultural Ecology in Mexico: Historical Vistas and Modern Implications

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ABSTRACT
Periodic review and assessment of research on central themes of interest to Latin Americanist Geographers serve to place a heterogeneous array of individual contributions, that often appear to lack cohesion, into a more integrated whole. Although that vision is particular to the individual reviewer, the themes identified and questions raised should challenge others to both retrospection and fresh initiatives. This examination of agroecology and its historical evolution focuses on the archaeological record of aboriginal agriculture in Mexico, the potential contribution of ethnohistorical sources to understanding the 16th century transition, and the Colonial archives as evidence for complex agricultural transformation that remains poorly understood. Basic themes include ecology, technology, and settlement, while the key processes involve intensification and transformation, in a context of ethnic confrontation, acculturation, and social change.

An overview and assessment of research on aboriginal and "peasant" cultural ecology in Mexico as of 1990 is a challenge, if for no other reason than that government efforts are strongly directed toward modernization. Traditional agricultural lifeways are on the defensive, with the many instruments of official policy favoring a maximization of productivity and profits in key, target areas and a more incremental transformation elsewhere. The basic issue for debate is long-term sustainability of yields, given the constraints of available capital, market conditions, and social and institutional structures. In those limited areas with good soils, level land, and sufficient water, high potential yields attract persistent capital investment. Elsewhere, soils are indifferent or erodible, and water localized or unreliable, so that capital assistance is sporadic and inconsistent, just enough to stimulate change but inadequate to deal with its consequences. It is here that traditional agroecology and its effectiveness over time assume critical importance, and that is the underlying question to which this review is directed.

The organization of the presentation includes: (1) the archaeological record and aboriginal agriculture; (2) the ethnohistorical sources illuminating an agrosystem in transition; (3) the colonial archives, as a source for deciphering the many strands of ongoing agricultural transformation; and (4) the ethnographic present, as a context for evaluation and application. Basic themes include ecology, technology, and settlement, while the key processes center on intensification and transformation, against a background of ethnic confrontation, acculturation, and social change. A number of attendant problems relevant to the final discussion are identified in appropriate places.

The Yucatan and Chiapas, areas with a somewhat different ecology or historical trajectory, are treated by Mathewson (this volume) in connection with Central America. But in view of only passing attention to Mexican agriculture or cultural ecology in earlier Benchmark reviews, I have drawn on selected sources from before 1980 that are pertinent to the discussion. I have also drawn freely from contributions by anthropologists and historians, as well as geographers, since the subject matter defies disciplinary categorization.

THE ARCHAEOLOGICAL RECORD: ABORIGINAL

A convenient centerpiece to begin a review of the archaeological contributions to Prehispanic agriculture is the 15-year Basin of Mexico Project (Sanders, Parsons, and Santley 1979). Although primarily directed to questions of sociocultural evolution across three millennia of prehistory, the underlying settlement survey, in conjunction with the published collection of detailed synoptic maps of settlement and resources, provides an invaluable research base for Central Mexico that subsumes a good deal of earlier work. Some of the methods and assumptions of the project may be faulted (Zeitlin and Zeitlin 1980), but these are more pertinent to the theoretical arguments offered than they are to the data base itself. The empirical information is succinctly reassembled by Sanders (1981).

The Late Aztec period (ca. 1350-1519), representing the best resolution as well as the apogee of Prehispanic agricultural and demographic development, serves well as an example. Sanders et al. (1979: map 18) **[end p. 139]** provide a detailed and densely-packed cartographic documentation (at about 1:128,000) showing supra-regional, regional, and provincial centers; large and small nucleated or dispersed villages; hamlets; large and small ceremonial precincts; and so forth. The map provides concrete settlement data to compare with Gibson's counterparts (1964: maps 3 and 5), compiled from ethnohistorical sources, and contributes to an understanding of land use under such themes as agricultural terracing, irrigation, soil quantity, and resource-subsistence reconstructions for both extensive and intensive agriculture.

The sequence of maps illustrates a slow and spatially disjunct growth of sedentary agricultural settlement over the 2000 years prior to "Classic" Teotihuacan (demographic growth rate only 0.09 percent annually when C^{14} dates are calibrated to absolute years). Yet locally the ecological impact was enormous, with strong pollen peaks of maize (to over 30 percent) (Niederberger 1987: Fig. 170). Around Lake Texcoco, a much more modest peak of maize and disturbance plants was delayed until the Teotihuacan phase (ca. A.D. 300-750) (González and Fuentes 1980). Population centers were, then, prone to shift over time, with long intervening periods of agricultural recession. That pattern is reflected in the overall population history.

For the early 1500s, extrapolating for the 20 percent or so of the arable lands not surveyed, a population of 800,000 to 1.2 million is suggested (Sanders 1981). This compares with 230,000 during the earlier maximum of the Teotihuacan era, which was followed by a protracted decline, to a low of only 130,000 between about A.D. 950-1150, a time of considerable settlement retraction in many areas and disintensification in some.

The remarkable growth of the Late Aztec period is linked by Sanders to agricultural expansion and intensification. In Classic times, floodwater and canal irrigation had been limited to a small part of the basin, primarily around Teotihuacan. During the 150 years of Aztec rule, irrigated agriculture expanded greatly along the alluvial lowlands, up into the piedmont zone, while *chinampa* cultivation was developed in the Xochimilco-Chalco area, and hillslope terracing brought higher ground into cultivation. In other words, the elaborate system of intensified agriculture that characterized the basin in 1519 was of comparatively recent origin. Although Sanders prefers to see intensification and agricultural expansion as a response to growing population pressure, the three centuries or more of demographic decline after A.D. 750 shows that growth was not linear and that the systemic interactions were more complex. The several cycles of settlement nucleation evidently corresponded to times of administrative centralization and population growth, that were repeatedly terminated by periods of decentralization, with settlement dispersal and population decline. This suggests that systematic integration or dissipation, with increasing or decreasing energy (tribute) demands, must be considered as major factors in the equation.

The goodness-of-fit of Sanders' reconstructions of carrying capacity and population is pertinent to the controversy over pre-Contact population levels. Based on incomplete archaeological survey, settlement hierarchies, and estimates of "carrying-capacity" and nutritional needs, Sanders et al. (1979: chap. 6) derive a Late Aztec population of 800,000. But by re-evaluating the 16th century documentary evidence, Sanders (1976) estimates a Contact population of almost 1.2 million for the Basin of Mexico. This nonetheless is barely half that of the earlier 2.5 million estimate of Cook and Borah (based on extrapolation from an unconscionable manipulation of the *Suma de Visitas* tributary lists). Williams (1989) has reexamined Sanders' assumptions for one parish with unusual data control, concluding that Sanders' carrying capacity figures are generous, perhaps too much so. The known population of her community could only have been supported in the best of years by non-stop annual cultivation of all qualities of land, and by yields on third-quality land (i.e., thin, upper piedmont soils, mainly without irrigation) almost equal to those of second-quality soils. Given the recurrence of drought, and Aztec tribute demands beyond minimal subsistence needs, Williams' picture outlines a community stretching its resources to the limit. Yet Sanders (1976) had to raise his reconstructed archaeological estimate by 50 percent to match his conservative interpretation of a the documentary evidence.

In order to increase the population of the Basin of Mexico from 160,000 to 1.2 million between A.D. 1350 and 1500 requires a sustained annual growth rate of 1.0 percent over a span of 150 years, by itself quite remarkable. To reduce that population to 180,000 by 1595 requires a 1.9 percent negative rate, also notable, as is the fluctuation of the indigenous population from 1600 to 1750 at low levels intriguingly similar to those maintained during earlier, Post-Classic times. Following Williams (1989), it is indeed possible that, before the entry of Cortés, population pressures were placing increasingly impossible demands on the primary sector. The similarities of the population crash of Western Europe in response to the Black Death of the mid-1300s, following two centuries of sustained demographic growth, are therefore intriguing. More research on these themes is needed, including incorporation**[end p. 140]** of data from Old World pandemics and demographic experience on population rebound following periods of high mortality.

The Basin of Mexico Project, focusing on one changing landscape over time, can be compared with Doolittle's (1990) comprehensive study of the evolution of irrigation technology, based on a critical reevaluation of the archaeological record. Doolittle begins with a typology of headwater, canal, and field features associated with irrigation, and then examines these as interlinked phenomena. His study shows that technological innovation was more progressive than punctuated, increasing gradually in complexity and scale. From 1200-600 b.c. (1450-700 B.C. calibrated), irrigation was relatively small-scale, simple, and ephemeral. Substantial achievements are registered about 600-200 b.c., including masonry storage dams, with flood or sluice gates, excavation of canals, and channelization of stream beds to allow the cultivation of broad expanses of floodplain land. Between A.D. 300 and 800, technology *per se* changed little, but the *scope* of diversion dams, water conduction across ravines, and relocation of ephemeral streams into new channels increased substantially so as to expand irrigation significantly. Then, during the Late Aztec period, the *scale* of irrigation changed dramatically, to the point that most good agricultural land was irrigated in one form or another. By then, some of the larger canal networks went well beyond the scope of family or locally controlled units, to water several thousand hectares.

Although I still have some reservations as to how far the improvised and non-arched Prehispanic aqueducts were as effective as Old World counterparts, Doolittle (1990) does show that the capabilities of Aztec canal irrigation differed only in degree from the modified, Spanish versions of the late 16th century, which incorporated few major technological changes.[(1)] But this was not the case, at least as regards scale, during the earlier periods. As a result, studies of "traditional," contemporary irrigation technology and social organization, as potential models for the Prehispanic period (e.g. Kirby 1974; Enge and Whiteford 1989), need to be combined with archaeological evidence to avoid anachronistic reconstructions.

A comparison of the Basin of Mexico Project with the analogous study of settlement history in the Valley of Sonora by Doolittle (1988) illustrates notable differences of both analytical scale and methodology. The Sonora study, representing a decade of research, is smaller (2000km^2, compared with 5500 km^2), covers a time span of about 500 years (compared with 3 millennia), and involves a simpler archaeological record, in a relatively peripheral part of Mexico. The financial resources available also represent a small fraction of those expended in the Basin of Mexico.

Nonetheless, the integrative, geographical methodology that Doolittle (1988) applies, to bring together environmental factors, site location and delineation, irrigation phenomena, settlement networks, and demographic variables, also achieves a satisfactory understanding of what can be termed functional landscapes and their evolution over time. This shows that a direct ecological and spatial methodology can effectively decipher prehistoric landscapes. This is, in effect, the essence of geoarchaeology (see Butzer 1982).

As I see the implications, such a methodology invites successful application to many more "regional" studies in Mexico with very modest funding. Large teams and huge annual research budgets are by no means essential to the implementation of important "historical" projects, and my own conviction is that tangible output is not proportional to the size of a grant. As other projects by archaeologically-oriented geographers working on Prehispanic landscape history in other parts of Latin America amply demonstrate, our profession has the capability of making substantial contributions that stand up well in comparison with those of mainline archaeologists.

A final range of themes concerning Prehispanic rural Mexico remains to be discussed. That is the matter of agricultural landforms, which include (a) the much-discussed *chinampas*, (b) agricultural terraces, and (c) other, in part related, types of "patterned" fields.

Firstly, in regard to *chinampas*, there are good reports of the Colonial era and some residual use, but as yet limited archaeological precision (Parson et al. 1985; Rojas 1983; Wilken 1985; Gómez-Pompa and Jiménez 1987; Niederberger 1987: 101-108, Figs 35-43). This reclamation technique drained water away through a grid of ditches, with the spoil of lake mucks spread over the plots so created. It is a ditched and raised field technique, first suggested by lacustrine settlement in Lake Chalco during the Teotihuacan era, could only be applied on a large scale after the periodic invasion of high waters from Lake Texcoco had been cut off by an elaborate causeway (dam), and its maintenance required repeated ditch cleaning, adding new organic mucks to the cultivated fields. Similarities with Medieval marsh drainage and the *plaggen* soil landscape of the Dutch-German borderlands are of interest here.**[end p. 141]**

Secondly, a major recent contribution to the study of agricultural terraces is the systematic work of Donkin (1979), who documented almost 75 localities in that part of the Mexican highlands under review, ranging from the valleys of Oaxaca and Tehuacan, the Mixteca Alta, the area of Texcoco and Teotihuacan, the Toluca Basin, and the valleys of Puebla, Tlaxcala, and Tula, as well as isolated areas of Michoacan. The agricultural landforms in question range from true rock-built, graded terraces, commonly linked with irrigation, to sloping semi-terraces retained by berms and vegetative barriers, used for dry-farming, and to various types of check- and valley-floor dams. Many of these features continue in use (see also Wilken 1987: 96-128; Patrick 1977; and Johnson 1977: chap. 3), but others may have been abandoned since the 16th century or earlier (Trautmann 1981: 52-58, 69-72), and even these probably represent only a palimpsest of the once-extant prehistoric terraces of the region.

Thirdly, the comprehensive study of Siemens (1989: chaps. 8-12, also 1983) brings together and synthesizes his earlier contributions that record and interpret raised fields and related phenomena of the coastal wetlands from the Pánuco to southeastern Veracruz. More than any other line of inference, these lowland features provide concrete evidence for high Prehispanic populations in the tropical low country.[(2)] That, in turn, again raises the enigmatic question of why lowland populations were so much more fragile than those of the temperate plateaus, pointing to the continuing need for a discriminating archival study of endemic and epidemic disease in the tropical lowlands during the 16 century.[(3)]

Although not generally a matter of agricultural landforms, other indigenous field patterns also deserve mention. In the Puebla-Tlaxcala Basin, Tichy (1974) and Werner (1986) note that the principal trend of rectilinear road and field patterns deviates 15-25 degrees from a west-east axis (effectively WNW-ESE), similar to urban grid orientations of the Early Classic. Locally, in the vicinity of monasteries or concentrations of Spanish land-grants (see also Prem 1978, 1984), orientations switch to those of the cardinal points. This ancient trace of the indigenous cultural landscape is amplified by the use of multiples of 20 in indigenous surveying and division of lots (Trautmann 1981: 42-49; Harvey and Williams 1980), providing another tool to identify relict indigenous features where field patterns are dominantly rectilinear.

THE ETHNOHISTORICAL SOURCES: TRANSITION

While archaeological and geoarchaeological evidence continues to provide the core of information on Prehispanic agricultural landscapes, it is complemented by equally critical ethnohistorical sources that illustrate the details of agricultural processes. Research in this direction has moved considerably beyond accessible publications of basic sources, such as the Florentine Codex of Sahagún (Anderson and Dibble 1963), to analytical interpretation and synthesis.

Understanding of the Prehispanic crop repertoire has been considerably enhanced not only by the paleoethnobotanical work of McClung de Tapia (1979) at Late Formative-Classic Teotihuacan, but also by the discriminating inventory of cultivars derived from 16th century ethnohistorical sources such as the Florentine Codex (1570s), by Torres (1985). In combination with the Aztec herbal (pharmaceutical) inventory--the Badianus Codex of 1552 (Badiano and Cruz 1940), it becomes apparent that this information base is about as rich and accessible as that for the Classical Mediterranean world.

Such sources have been employed by Rojas (1985, 1988) to outline the traditional indigenous agrosystem of the early 16th century: seedbed preparation, weeding, and harvesting; the distinction between fire clearance and extensive cultivation, on the one hand, and intensive cultivation, with use of documented or inferred fertilizers such as night soil, bat guano, green compost, transported alluvium, or mineral ash, on the other; varieties of polycropping with tree crops and field plants; the intercropping of maize, beans and squash; crop rotation; the use of terracing to stabilize soils and optimize water; a range of irrigation techniques, from opportunistic manipulation of flood waters to elaborate canal irrigation; the construction of *chinampas*; and the variety and uses of agricultural implements. As amplified by Williams' (1982) important work on Aztec soil categories and indigenous understanding of soil properties, there can be little doubt that indigenous understanding of agriculture at a conceptual level was sophisticated, sufficiently so to provide interesting comparisons with Classical and Islamic agronomy in the Old World.

Nonetheless, I am left with lingering doubts as to just how effective Aztec fertility maintenance was, because none of the techniques outlined by Rojas (1988) could be applied on a large scale, i.e., beyond the immediate house gardens. To fertilize extensive cultivated lands, manure from Spanish-introduced livestock was **[end p. 142]** essential, and even the much-maligned Mediterranean plow served to mix a deeper tilth. With the exception of the areally-restricted *chinampas*, there is no direct evidence for improvement of outlying cultivated fields, nor was there a technology to do so successfully. Given the pressures on land discussed earlier, and the palynological evidence for very short periods with large-scale, continuous regional cultivation (Brown 1985; González and Mata 1980; González and Montúfar 1980; Niederberger 1987: Fig. 10), it is doubtful whether such agrosystems were sustainable in the long run. This negative view is supported by the mounting body of evidence for Prehispanic soil erosion in central Mexico (García Cook 1986; Werner 1986; Klaus and Lauer 1983).

One aspect of traditional indigenous agriculture that has been neglected is the role of non-food plants as the basis for important cottage industries, namely textiles. So, for example the *Suma de Visitas* (1547-51) itemizes the traditional Aztec tribute liabilities for cloth, clothing, or blankets of various shapes or sizes, made from fine henequin fiber produced in the Valley of Mezquital, or cotton grown in the tropical low country (see Berdan and Durant 1980). Such localized raw materials supplied countless villages from Morelos to the Pánuco with the wherewithal for a tradition of textile manufacturing that was subsequently exploited by the

Spaniards.

Niederberger (1987) has compiled early Colonial pictorial representations as well as maps to reconstruct indigenous land use in the lacustrine world of the Basin of Mexico. Also noteworthy is the recent publication of a good edition of the complete *relaciones geográficas* of 1577-85 by Acuña (1984-88) in eight volumes (apart from those for the Yucatan and Guatemala), finally making accessible a vast body of primary data for most parts of central and southern Mexico. Assembled by local officials with the participation of indigenous informants, the *relaciones* offer a relatively systematic body of information on a wide array of themes, including agriculture and environmental resources, in conjunction with a good number of informative, pictorial maps.[(4)] As ethnohistorical documents, the *relaciones* help illuminate the transfer of cultivars between Indian and Spaniard, during a period of transition and interactive acculturation.

Some of these reports indicate that Prehispanic agriculture and subsistence patterns continued with little change, while others suggest a limited acceptance of some Spanish vegetables and fruit trees, and a more wholehearted adoption of Castilian chickens, that were hardier and more prolific than turkeys, and convenient to meet tribute demands. Indigenous raising of sheep, goats, and pigs, or the growing of wheat, was a localized phenomenon, as can be read form the often-nuanced *relaciones*. Diffusion of the Spanish agrosystem to indigenous communities was, as of about 1580, still quite incomplete, contrary to the implications of writers such as Moreno (1968). Much the same can be inferred from Mota y Escobar (1604 [for Nueva Galicia] and 1623 [for the diocese of Tlaxcala-Puebla]). The small monastery gardens of the mendicant orders, with their microcosm of Spanish-mediterranean *frutales* and *hortalizas* (see Ciudad Real 1591), certainly provided convenient models and contacts for acculturation, but apparently this did not lead to a rapid and wholesale diffusion of European plants, animals or technology. This was not just a matter of dietary preference but also of perceived or real productivity differences,[(5)] transport costs, and market uncertainties. Future studies should therefore include more attention to the dynamics of exchange, experimentation, and acceptance or rejection.

The archaeological and ethnohistorical materials reviewed here represent a great deal more than building blocks for an esoteric reconstruction of a "time-slice" of pristine New World agriculture on the eve of the Conquest. First, and perhaps foremost, they serve as examples of the intricate and flexible anchoring of New World land use into a mosaic of highly differentiated environments. Second, they illustrate the interlinkage of technology, subsistence, settlement patterns, and demography in the stop-and-go process of intensification. Third, they at least identify the alternating centripetal and centrifugal role of institutions and social organization in controlling systemic energy flux, so creating an ebb and flow not only of labor investment and productivity, but also of agricultural settlement expansion or contraction. And fourth, they lay the groundwork for a renewed, inductive investigation of the resilience of the indigenous agrosystem in the face of changing economic demands, alternative agronomic information, and rapid population decline after the Spanish Conquest.

THE COLONIAL ARCHIVES: TRANSFORMATION

The Conquest adds two major sources for historical investigation of Mexican agriculture. On the one hand, the ethnohistorical records, in the form of commissioned collections, individual treatises, or official inventories, provide a heterogeneous corpus of information on a lifeway or *genre de vie* in a state of patent transition. On the other, the new bureaucracy produced an almost unlimited wealth of atomized archival data that are gradually being woven **[end p. 143]** into a more coherent picture of change. Two themes need to be disentangled from this skein of interrelated issues. One is the process of Spanish colonization, and its implications for the competition between, and the eventual fusion of, the two juxtaposed agrosystems. The second is the modification, survival, and eventual transformation of the indigenous lifeway, in greater or lesser proximity to the forces of change unleashed by the Conquest.

The Spanish quest for land that brought new settlers into direct collision with indigenous farmers began in the 1530s, as a consequence of the expanding herds of cattle and sheep (Matesanz 1965; Chevalier 1952; Dusenberry 1963; Doolittle 1987). By Spanish-Mediterranean customary law, unused lands or *tierras baldías* were open to grazing, and livestock could, with permission of the communities, graze on field stubble after the harvest season (Schell 1985; Butzer 1988). By initially granting grazing rights to what were uncultivated, communal lands, and subsequently converting these into property rights, the Viceroy allowed stockraisers to penetrate deeply into interstices between tracts of indigenous cultivation, leading to repeated depredations of standing crops by uncontrolled herds. During the 1570s, the herds multiplied beyond the capacity of available range land to support them (Melville 1990). Stock now competed for scarce communal water sources in semiarid regions, as well as for woodlands formerly reserved for fuel gathering or timber, exacerbating the pressures on indigenous agriculture.

Spanish agricultural colonization followed, as the demand for wheat by the growing European colony in metropolitan Mexico could no longer be adequately met by imports from Spain. By the 1570s, wheat farms were being established on an increasingly large scale, especially in the areas of Tecamachalco, Atlixco, and Huejotzingo (Licate 1981; Prem 1978, 1984). Some of these areas had not been cultivated, while elsewhere land was illegally purchased, through bribery or collusion with local elites or simple coercion, or they were usurped. But these sectors of Colonial encroachment were sharply delimited to specific centers of colonization, mainly in the modern states of Puebla and Mexico. In Oaxaca, Michoacan, and parts of Hidalgo, most of the cultivated lands remained in the hands of Indians (see Simpson 1952; Taylor 1972; López Lara 1973; Osborn 1973).

A number of exemplary regional studies now serve to illustrate the changing agricultural landscape of the late 16th century. The colonization of the Atlixco is admirably illustrated by Prem (1984). The same author provides a milestone study of the same process in the Huejotzingo Basin, together with a sequence of maps, with approximate positions of the land grants, as well as a discriminating analysis of the processes of Indian dispossession (Prem 1978). For the region of Tecamachalco, Licate (1981) offers a multi-level, conceptual analysis of changing settlement and land use that captures the spirit of the ethnohistorical sources, while also utilizing the archival materials. Agricultural and social change in the face of Spanish pressures in southeastern Hidalgo State are informatively explored by Ruvalcaba (1985), an analysis that is paralleled by the investigation of Piñon (1984) in northwestern Michoacan. For studies of the later, mining frontier in the northwest, see Gerhard (1982) and Swann (1982, 1989).

One regional study deserves particular attention. Starting with precocious study of Cook (1949), Melville (1983, 1990) has examined the environmental impact of Spanish stockraising in the Valley of Mezquital (Mexico State-Hidalgo). The presentation was modelled on the impact of sheep overstocking in New South Wales in the early 19th century, and is also influenced by Cronon's (1983) study of conflicting British and Indian ecologies in New England. Melville's argument is that sheep pastoralism was initially restrained by Otomí occupance, but that as the Indian population declined to low levels after 1565, uncontrolled expansion led to severe degradation of pastures, vegetation change, soil erosion, and falling water tables with spring failure. By the early 1600s this environment had been devastated. Although the basic case of Melville, an anthropologist, is valid, it is based on archival source interpretation without field confirmation.[(6)]

Whereas these works favor the indigenous perspective, Spanish agricultural colonization of the Bajío "frontier" is painstakingly developed from the archival sources by Murphy (1986); his emphasis is on the development of irrigation and the conflicts between large and small farmers, in a setting often assumed to have been the exclusive purview of great stockraisers. The exceptional role of smallholders in parts of the eastern Bajío draws attention to the limited econiche open to Spaniards of modest means outside of the mining and urban centers of New Spain. Another unique aspect of Murphy's study is the analysis of Spanish water law in the New World, and matters of Indian litigation to retain their water rights (see also Meyer

1984). This important monograph is complemented by the broader framework of Spanish-Indian interaction and competition in the same region presented by Urquiola and Samperio (1989: vol. 1). **[end p. 144]**

For the 17th and 18th centuries, the Spanish role in agriculture is subsumed in the substantial body of literature dealing with the growth of great estates, a theme in some ways peripheral to this review. Five studies can be singled out here. One is that of Wobeser (1983), who published a wide selection of maps and plans from the archives to illuminate settlement layouts, irrigation networks, and the like, in conjunction with a thoughtful discussion. Another is the unusually informative example of hacienda evolution and operation in Puebla-Tlaxcala, from the 16th century to the Revolution and beyond, by Nickel (1978), with a detailed outline of the social processes involved. Particularly interesting as well is Lucas' (1984) study of day-to-day agricultural management of a typical hacienda. Ewald (1976) analyzes several Jesuit-run haciendas in the Puebla area during the 18th century, discussing Jesuit agronomic practices, soil erosion, and transhumance. Last but not least is the comprehensive study of Trautmann (1981) on the changing cultural landscape of Tlaxcala, from indigenous agriculture in the 16th century to the hacienda domain of the 18th, focusing on a range of specific concerns in human and economic geography.

A central question is regard to the growing dominance of Spanish estates in the rural landscape of Mexico (Ewald 1977) is the degree to which indigenous agricultural lifeways survived. The answer is complex, because there were marked differences in regional evolution as well as differences over time (see Altman and Lockhart 1976; Van Young 1982). Focusing on settlement, Borah (1980) argues that there was an essential continuity despite apparent discontinuity.

Based on research in the eastern Bajío, a preliminary model can be proposed along the following lines:

> (1) At the time of the Conquest, the eastern Bajío lay beyond the so-called Mesoamerican Line and was occupied mainly by the Pamé Chichimecs. It is becoming increasingly plausible that some of the Pamé groups were semi-agricultural (see Davis and Moguel 1989), and groups of "Chichimecas de la paz" are commonly referred to between the 1550s and 1580s (e.g., Wright 1988, 1989), typically located next to new Otomí settlements,[7] founded during the 1520s and 1530s by farmers and traders from the Valley of Mezquital. The Spaniards, in turn, appear to have located their first estancias next to Otomí hamlets, presumably for access to labor and good water sources (Butzer 1989a).
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> (2) The earliest permanent Indian pueblos, with their own autonomous governing bodies (***repúblicas de indios***), gelled out during the Chichimec Wars, before 1590, and survived the settlement consolidation (*congregaciones*) of the next 15 years (see Urquiola and Samperio 1989: vol. 1: 201-297). Their number was later augmented, especially around 1700, by population growth (Butzer 1989a).
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> (3) The period from 1620-1820 saw the accretion of large Spanish estates and ongoing conflict between the haciendas and pueblos. The Indian population increased steadily after the 1690s, augmented by in-migration from the southern Bajío and the Mezquital, attracted to the urban textile centers, but also by increasing rural employment (Brading 1978; Morin 1979; Hurtado 1974; Butzer 1989a, 1989b). The lands originally assigned to the pueblos were inadequate to support the growing populations, and in some cases had already been usurped by the estates (see Urquiola and Samperio 1989: vol. 2). Indians still litigated to hold onto their water rights during the 1600s (Murphy 1986), but by the mid-18th century even the respected Otomí *principales* of Querétaro had lost their last land holdings (Butzer 1989a).
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> (4) As the pueblos became increasingly marginalized, their inhabitants drifted off to new Indian

barrios in the cities or to dependent ranchos on the Spanish estates, where the main hacienda workforces were housed. Here, living mainly as sharecroppers, the Indians developed new communities, physically characterized by random clusters of houses within interlocking fence-rings of rock and organ-pipe cactus, usually next to a rustic chapel and surrounded by some irregularly-bounded fields (Butzer 1989b). By 1810, the bulk of the rural Indian population lived in such satellite ranchos, rather than in pueblos. Amidst the maze of land holdings in the Bajío, some Indian smallholders did retain original properties (Brading 1978), but they were insignificant as a group.

(5) The steady increase of silver extraction after 1715 created an accelerating flow of capital to the Bajío and increased demands for agricultural production. In response, the estates expanded their agricultural activities (Davis and Moguel 1989) and moved towards greater intensification (Butzer 1989a). Superimposed upon this trend of economic growth were repeated secular variations related to harvest failures, epidemics, and prices (Florescano 1969; Garner 1985), as well as more complex fluctuations in mining production (Bakewell 1987). Labor now was superabundant, due to sustained population growth, and by 1800 landlords began to exact higher rents from their tenants and to expect more work from their sharecroppers (Tutino 1979). The standard of living declined, setting the stage for the wars of independence.

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(6) Independence did not, however, terminate the processes set in train during the late 1700s, even though the economy was stagnant due to declining mining revenues. The ranchos, with their dependent sharecroppers, continued to develop as the major focus of rural Indian and Mestizo settlement. In Guanajuato, the number of ranchos grew from 416 in 1810 to 3134 in 1900, and 53 percent of the population of Queretaro and 60 percent of that of Guanajuato lived on haciendas or ranchos in 1910 (Nickel 1978: Appendices).

This model for the eastern Bajío represents only a single case study that serves to illustrate the complexity of settlement, agroecological, and social change. With a relative decline of the indigenous population in the Bajío from about 85 percent in 1630 to 45 percent in 1793, this example represents a fairly extreme case of transformation and, implicitly, deculturation, amid the different regional patterns of social evolution in Mexico. Yet, similar basic processes, operating at various levels of intensity and with different outcomes, affected most regions of Colonial New Spain: settlement relocation; changes in land tenure and labor relations; an increasingly "directed" and superimposed Colonial rural economy; market demands shaped by increasingly non-indigenous food preferences; boom and bust cycles controlled by the interdigitated variables of a proto-industrial economy; and, above all, ethnoracial shifts, deculturation, migration, and fundamental social change. This is an arena where sociodemographic studies, based on the early parochial registers (see Robinson 1980) and on the Colonial census tracts (Robinson 1989; Swann 1989) can provide incisive information.

To attempt to generalize about this Colonial transformation would be premature at this time. But is was complex indeed, and the degree and direction of transformation varied greatly from region to region at the time of Independence.

THE ETHNOGRAPHIC PRESENT: EPILOGUE

Mexico after Independence has received less historical attention than has the Colonial era, and studies of agroecological evolution are few, especially compared with the volume of literature on industrialized haciendas prior to the Revolution or on agricultural modernization. In default of a viable perspective on historical cultural ecology for the period after 1810, research has focused on traditional survivals in the ethnographic "present" (e.g. Pennington 1983; Gómez-Ponpa and Jiménez 1987; Bye et al. 1989) or the interplay of tradition and development (e.g., Doolittle 1980, 1983, 1984).

A key work in this retrospective evolution has been that of Aguirre and Pozas (1954: vol. 2, 54-108), who identified the survival of Prehispanic agronomic methods in parts of Mexico, basically equating conservatism with inefficiency. The counterpoint to this position has been effectively delivered by González Jácome (1984) and subsequently by Wilken (1987). In his comprehensive *Good Farmers*, Wilken argues that traditional, small-scale farming in Mexico is closely adapted to the constraints of the biophysical environment, and has the ability to deliver sustainable yields, with minimal capital investment.

The dichotomy of positions so defined epitomizes the polarization of centrally-directed modernization policies and the uphill efforts of cultural ecologists to optimize on "the best of the old," not only in Mexico, but in most countries of the Developing World (see Butzer 1989c).

Just how one implements a maxim such as "the best of the old" poses a more difficult problem. For Otomí villages of the northern Mezquital, Johnson (1977: esp. chap. 3 and 7) argues for the advantages of the traditional, ethnoscience approach over techno-development, and skillfully reconstructs a system of conservationist agriculture. But the study fails to develop either the ethnohistorical context of the Otomí or the evolution of land use patterns from before to after the Revolution of 1910. As a result past links to the hacienda economy and possible access of estate herds to commonage or stubble remain unknown. This part of Hidalgo now has a degraded vegetation and minimal soils, and lies amid the bleak landscape that Melville (1983, 1990) believes was devastated by Colonial pastoral activities. How does one reconcile these apparent contradictions?

The only herds that have utilized this environment since 1910 are small numbers of sheep and goats, locally or communally owned. After at least 80 years of low grazing pressures, why has the vegetation not recovered more noticeably? These small herds are today moved annually through a 3-stage local transhumance cycle (Johnson 1977: Fig. 3.11) and can probably not be blamed for the arrested biological recovery. Is the sheep explosion of the 16th century somehow still at fault? Or is the evident denudation of Hidalgo due to prehistoric land use or even natural processes of the late Quaternary that have been "fixed" by a semiarid climate in the rainshadow of the sierra? Neither the Johnson nor the Melville study provide solutions to this dilemma. **[end p. 146]**

It is becoming increasingly apparent from palynological evidence that the Spaniards colonized a landscape already heavily transformed (see Brown 1985). A detailed pollen core from the floodplain at Tula, in the heart of the Mezquital, shows that the basic vegetation has not changed significantly since the first appearance of maize pollen (at -155 cm in the profile) and that, more recently (at -25 to -5 cm), grass pollen has peaked, at the expense of Chenopodiaceae and Compositae (see González and Montúfar 1980).[(8)] Except for yucca, the pollen of spiny and succulent plants, all present in the area since before the appearance of maize, have not increased. In effect, at the macro-scale there is no evidence of ecological disaster in the Mezquital during the Colonial period. However, Toltec and Aztec Tula did experience deterioration of vegetation quality: a decline of pine, a gradual local disappearance of bald cypress, accompanied by massive increases of Compositae, ragweed (*Ambrosia*), and Chenopodiaceae. Estimating sedimentation rates from the indirect archaeological dating, these increased more than fourfold, from 0.45 to 2.0 mm/year, during Toltec Tula, then declined, and increased again to 1.4 mm/year in Aztec Tula, remaining at 0.65mm/year thereafter. However, a decline in riverine genera such as cottonwood, ash, alder, and willow, together with formation of a calcareous soil about midway during postconquest time (González and Montúfar 1980), suggests channel deepening and changing flood regimes (see also Butzer 1989b). This supports Melville's (1983) and Cook's (1949) evidence for some Colonial gully development and lower water tables, but it places the major period of degraded ground cover and topsoil-stripping squarely into the *Prehispanic* period, as Cook (1949) had already surmised.

Much detailed work remains to be done in the Mezquital but this sobering inference should caution against drawing intuitively-appealing but deductive conclusions about the effectiveness of conservationist, traditional or aboriginal agriculture. Our earlier question about the sustainability of intensive, Aztec agriculture before 1519 now gains added significance.

Current views of introduced, Spanish agrotechnology and even modernization are indeed colored by stereotypic biases. So, for example, the negative aspects of sheep grazing should not distract from the positive qualities of small stock in reducing subsistence risk for rural folk, and the steady supply of manure that sheep provide constitutes the only means of fertility maintenance that poor people can afford in marginal agricultural environments (Rincón 1988; Butzer 1990). I remain deeply suspicious of misguided techno-development in such environments that ignores ethnoscience. But we also risk costly mistakes if we allow ourselves to get carried away by idealized or naive preconceptions of ethnoscience as a system, rather than as a source for selected, beneficial techniques or better-adapted strains of crops. Historical monitoring of land use and landscape change provides a vital, critical tool to evaluate the long-term impacts of traditional, agroecological components. We need to make much more and systematic use of such an approach, at whatever time scale, in order to truly understand what we perceive today.

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Notes

1. This is not to dispute the singular importance of Spanish introductions such as the animal-driven ***noria***, capable of tapping extensive aquifers in basins of unconsolidated sediment, or the *galería infiltrante (qanat)*, a system of tunneling to intersect aquifers at the foot of mountain slopes (see Wilken 1990).

2. A pollen core from southern Veracruz lends support to considerable Prehispanic cultivation in the area (Late Classic-Post Classic) (Byrne and Horn 1989). The key indicators are maize, long-spine compositae, and *Ambrosia cumanensis* (ragweed), coincident with a substantial reduction of oak pollen.

3. Such examination should not be limited to the earliest incidence of Old World tropical disease vectors but should also search for evidence of other mortality factors. Even in Prehispanic times the Veracruz lowlands apparently were periodically depopulated by epidemics that required recolonization from the highlands (Gerhard 1972: 360). **[end p. 147]**

4. In regard to the value of these early maps, that accompanying the *relación* for Tequizistlan (Acuña 1986: vol. 7, facing p. 214) shows the complex irrigation system extending from Teotihuacan to the shores of former Lake Texcoco in 1577; its features can be transposed to the modern 1:50,000 topographic maps, greatly augmenting the fragmentary archaeological evidence. Several of the pictorial maps illustrate the contemporaneous vegetation of large areas, e.g., San Miguel Allende or Zempoala. In conjunction with other reports of the period, such as the *Suma de Visitas* (1547-51) and the boundary trees identified in the land grants (*mercedes*), the evidence invariably shows that basic physiognomic vegetation beyond the floodplains has changed but little since the mid to late 1500s.

5. So, for example, the basic unit of agricultural land or *caballería* (42.8 ha) established by 1567 was normed (with the Castilian penchant for duodecimal conversions) to 12 *fanegas de sembradura* of maize (the area that

could be sown with a *fanega* [55.5 liters] of seed). The equivalent for wheat was 69 *fanegas de sembradura* (see Galvan 1849: 75); in other words, maize was 5 times more productive, confirming repeated Colonial reports that the seed: yield ratio for maize was 4 to 5 times better than for wheat.

6. The argument hinges around a large selection of incidental comments as to vegetation cover, stoniness, or unproductive landscapes found in descriptions of land grants or litigation about estates (see Melville 1983: 181-206). Some of these citations can be better interpreted as descriptions of regenerating secondary vegetation, following Indian depopulation, and 48 of 518 grants 1580-1600 are specifically located on the lands of abandoned villages. Other citations can in part be explained by land grants on increasingly marginal lands after the better areas had already been assigned; thus 331 (64 percent) of 518 specified sites granted 1580-1600 are on *cerros* or *lomas* (mountain or hill terrain). Here an understanding of the vegetation ecology is critical. The central Mexican variant of mesquite has mesic demands and is not an invader of disturbed areas, a role instead played by the *pirúl*; the yucca palm and *cardonal* in semiarid parts of Hidalgo only compete successfully on well-drained, stony outcrops, and take decades, if not centuries to establish themselves; and wild maguey and nopal are economic plants that form natural replacements for the almost ubiquitous maguey and nopal stands reported here by the *Suma de Visítas* (1547-51). Melville's photo (1983: 5.3) of a roadcut with "tepetate" (calcrete) is no more than an example of the indurated Plio-Pleistocene basin fills characteristic of the region, and references to *barrancas* and stony or denuded surfaces must be evaluated in the field. Finally, the high stocking densities inferred (up to an average of one sheep per 8 ha) are circumstantial and ignore that many of these grants were originally awarded as much larger cattle *sitios*, that herds were commonly grazed well beyond property lines, and that a well-established transhumance pattern kept the sheep out on distant pastures for 6 months of the year. In this regard, Melville (1986: 86) unfortunately confuses transhumance (*agostadero*) with mid-winter grazing on stubble (*rastrojo*). In effect, Melville's study serves as an important challenge for an interlinked field investigation.

7. A potential model for such a semi-agricultural economy is given by the description of Mota y Escobar (1604: 168-171) for the mountain Indians who settled along the former Laguna de Parras (Coahuila) during the 1580s or 1590s. These groups lived mainly from fishing and processing wild plant foods, but also planted maize and periodically hired out to work in the harvest of Spanish farms in distant Durango.

8. The Tula pollen core of González and Montúfar (1980) has no absolute dates, but the detailed record of maize and grain amaranth (Fig. 7) with their two coincident peaks suggests a close comparison with the settlement history of Healan (1990; see also Sanders et al. 1979). The first traces of maize (-155 cm) suggest correlation with the first regional record of agricultural settlement (Late Formative, about 2100 years ago), the major double-peak (-110 to -70 cm) almost certainly pertains to the zenith of Tula about A.D. 950-1175, while the second peak (-50 to -30 cm), can be correlated with the Late Horizon (about 1375-1519), since the indigenous population declined rapidly thereafter. Thus the pollen spectra at -5, -15, and -25 cm, marked by a rapid decline of maize and amaranth, can be safely attributed to the Colonial and later era. Although the pollen core was taken from a marshy area 600 m from the archaeological site, **[end p. 148]** the urban strata which begin locally about A.D. 900 are all above the meter-thick, black organic soil found at -192 to -232 cm in the core, while a light soil formed later than the Toltec occupation (compare Healan 1989: 248, with González and Montúfar 1980: Fig 1). This provides a reasonable chronological framework for the pollen profile. The first evidence of vegetation disturbance, an explosion of Compositae tubuliflorae (from 2 to 63 percent), begins between -135 and -125 cm., and the sum of all Compositae and Chenopodiaceae exceeds the Gramineae up to the -35 cm sample. However, in the higher units grass pollen averages 37.8 percent, Compositae 17.5 percent, and Chenopodiaceae 5.6 percent, showing that pasturage improved notably during colonial times, when an open oak-savanna was characteristic.

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