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Abstract

A key component of archaeological research in the Basin of Mexico was a series of systematic regional surveys conducted between 1960 and 1975. This essay discusses efforts to finalize settlement data generated by those surveys, and preliminary analyses of the resulting dataset that include geographic information system applications to examine patterns of settlement over time. The paper begins by reviewing the surveys and the information they produced for more than 3,900 sites. Analyses of demographics, settlement hierarchies, and environmental patterning reveal periods of slow population increase and decrease that indicate no major demographic events, but noteworthy shifts in settlement types and environmental focus. Analyses of spatial patterning reveal evidence of considerable geographic shifts in settlement over time, probable widespread reliance on irrigation throughout much of the pre-Columbian basin, likely major shifts in adaptation to the central lake system in the region, and intraregional migration as a key demographic process in settlement patterning. Amid growing understanding of pre-Columbian settlement patterns in the Basin of Mexico, this paper also defines key research problems involving demographic mobility, the role of water control in adaptation and sociocultural evolution, and implications of changing environmental emphasis in settlement patterning.

A REGIONAL FOCUS IN THE BASIN OF MEXICO

Archaeologists often use a regional focus to identify and examine a collection of sites and explore their possible roles in larger social and economic systems. It is easy to understand the importance of this perspective, particularly for complex societies where settlements function in *hierarchical systems* and have roles both as individual communities as well as parts of larger, multi-settlement entities (Haggett et al. 1977). Indeed, often it seems impossible to understand any individual site in such a sociocultural setting without understanding the role of that site in the broader geographic context. And yet this regional perspective is a relatively recent addition to archaeological inquiry, a perspective whose acceptance developed over time thanks in large part to a handful of key projects conducted in the second half of the twentieth century. Among these projects were the archaeological settlement pattern surveys in the Basin of Mexico.

Much of our understanding of the pre-Columbian Basin of Mexico rests on the collection and analysis of archaeological settlement data. Begun in the Teotihuacan Valley in 1960 (Sanders 1965), the surveys that generated these data included all portions of the basin accessible to surface examination—virtually the entire region with the exception of the area covered by Mexico City and associated sprawl in the southwestern portion of the basin and a relatively small area in the northern basin (Parsons 1974; Sanders 1981; Sanders et al. 1979). These studies provided insights on regional demographics and tendencies in settlement as they evolved over time. Recent completion of a computerized database of the survey data in geographic information system (GIS) format enables examination of such issues with finalized settlement pattern data. It also provides an opportunity to explore particular characteristics of the geographic arrangement of pre-Columbian settlement in the basin as it evolved over time.

The following essay examines some fundamental characteristics of pre-Columbian settlement patterns in the Basin of Mexico using GIS data for the region. The paper begins with a brief overview of the data, focusing on the results of intensive surface surveys of eight regions between 1960 and 1975 and the aggregation of settlement data into a single dataset. It then discusses data compilation, which occurred in two phases. I reexamine certain types of settlement pattern analyses, employing finalized datasets and in some cases considering different measures of demographic change and regional organization. I also analyze pre-Columbian settlement in the basin using various measures and cartographic presentations that are tied to the spatial component of the GIS data, the results providing new ideas about evolving geographic arrangement of settlement in this region. A discussion of shortcomings of the data currently available, and limitations of analyses based upon them, yields a sense of the insights possible from analyses of basin settlement. Finally, I suggest some next steps, both in regional analysis and other types of inquiries, to increase our understanding of changing settlement patterns and sociocultural evolution in the Basin of Mexico.

BASIN OF MEXICO ARCHAEOLOGICAL SETTLEMENT PATTERNS: SURVEYS AND DATA

Between 1960 and 1975, archaeologists conducted surface surveys of eight large tracts of land in the Basin of Mexico (Blanton 1972; Evans et al. 2000; Kolb and Sanders 1996; Marino 1987; Parsons 1971, 2008; Parsons et al. 1982; Sanders 1965; Sanders and

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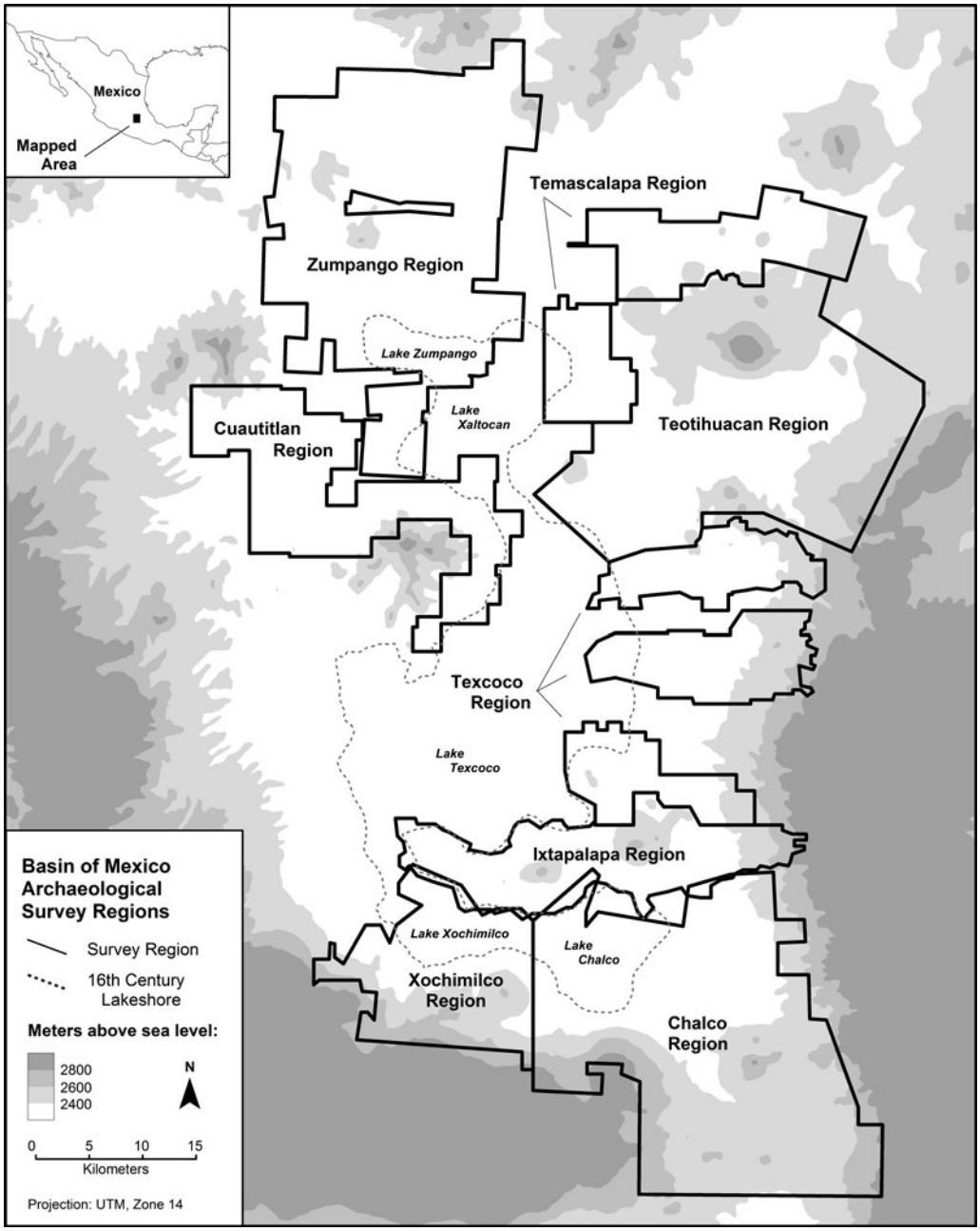

Figure 1. Settlement survey regions in the Basin of Mexico.

Gorenflo 2007; Sanders et al. 1975) (Figure 1). The goal of these surveys was to locate all archaeological sites in the Basin of Mexico, though with a distinct emphasis on sites with ceramics (Early Formative period and later), to serve as a basis for understanding how pre-Columbian complex societies evolved in the basin at a regional scale. To undertake this task, researchers defined separate geographic regions in the basin and conducted intensive surface surveys of each. With a few exceptions—for instance, narrow sections between main portions of the Texcoco region, and a few areas where field crews were not given access—the surveys examined every part of those regions not obscured by modern infrastructure, such as buildings or roads. In all, the settlement pattern surveys identified more than 3,900 archaeological sites in the Basin of Mexico dating between 1500 B.C. and A.D. 1519 (Gorenflo 2006).

The first settlement pattern survey in the Basin of Mexico occurred in the Teotihuacan Valley between 1960 and 1966, directed by William T. Sanders and inspired by both the pioneering archaeological work of Willey (1953) in the Viru Valley of Peru and the cultural geographical research of McBride in highland Guatemala (McBride and McBride 1942). Survey methods evolved during this project, with the approach that emerged serving as a template for surface reconnaissance in the remaining seven portions of the basin (Parsons 2015). Surveys involved crews typically composed of three to five people who walked over prescribed areas and recorded on aerial photographs the archaeological remains that they

encountered. Each site represented the physical evidence of past activity, usually occurring as a scatter of artifacts (often pottery sherds, occasionally including obsidian or other lithic material) and occasionally as mounds or other remnants of pre-Columbian structures. The assumption underlying the fieldwork in this and other survey regions was that most sites likely represent the remains of settlements where people lived, the main exceptions being a few isolated hilltop sites that may have served as loci of past ceremonial activity and sites that probably represented the locations of special activities (for example, quarries, irrigation canals). A description of the field methods used in the Basin of Mexico settlement pattern surveys appears in Sanders et al. (1979).

Beyond the initial inspiration to conduct a regional survey and integrate the survey with the cultural ecology of the area, one of the most important decisions of the Teotihuacan Valley project was to involve Jeffrey Parsons. Beginning as an undergraduate geology major (Parsons 2009, 2015), Parsons was a main contributor to the development of survey methods (Nichols 2006). He took the lessons learned in that initial survey and applied similar methods to survey in the Texcoco region (1967), Chalco and Xochimilco regions (1969 and 1972), and the Zumpango region (1973) (see Figure 1). Richard Blanton, a student of Parsons, surveyed the Ixtapalapa region using the same approach in 1969. Through the efforts of Parsons and Blanton, much of the Basin of Mexico accessible to survey was examined between 1967 and 1973.

Augmented by surveys led by Sanders of the Cuautitlan region (in 1974) and the Temascalapa region (in 1974 and 1975), by the mid-1970s nearly 3,100 km^2 of the Basin of Mexico had been explored by systematic, intensive surface surveys. Archaeological surveys in the basin recorded similar information for each site, which can be categorized generally as settlement data and environmental data (Gorenflo and Sanders 2007; Parsons et al. 1983).

- *Settlement data*: Site number (comprising identifiers for survey region and period of occupation, followed by a number), type classification, area (in hectares), population, and a listing of occupations from other periods that occur at the site locality, as well as bookkeeping information that includes the temporary site number assigned during original fieldwork or data compilation, the name of the individual originally recording the site survey information, and the year in which the site was recorded.
- *Environmental data*: Environmental zone, Universal Transverse Mercator map coordinates for the geographic centroid of each site, site elevation, average annual rainfall, modern soil depth, modern erosion, and modern land use.

Moreover, because the surveys used virtually identical methods, the data obtained by each can be aggregated into a database for the entire 3,100 km^2 of the basin surveyed. The result is systematic documentation of settlement patterns and regional demographics over three millennia, a database virtually unparalleled in its geographic breadth and time depth for a region that witnessed the evolution of some of the most important complex societies in the world.

If Parsons made an enormous contribution in his implementation of systematic surveys throughout much of the Basin of Mexico, he made a second in *systematic data compilation*. That effort, spurred in part by other researchers requesting data from his settlement pattern surveys, took the form of data tables summarizing information for the five regions surveyed by him and Blanton (Parsons et al. 1983). Inspired by Parsons' approach to assembling and presenting his data, Sanders and I developed similar tables for the Cuautitlan, Temascalapa, and Teotihuacan survey regions (Gorenflo and Sanders 2007). Because all of these data are associated with geographic coordinates, we also constructed a GIS database containing information on each site in the entire basin, along with its geographic location.

The resulting GIS database contains key information on all archaeological sites in the Basin of Mexico for eight periods of pre-Columbian occupation—Early Formative (1500–1050 B.C.), (Late) Middle Formative (900–650 B.C.), (Late) Late Formative (550–300 B.C.), (Late) Terminal Formative (100 B.C.– A.D. 150), Teotihuacan period (A.D. 150–750), Early Toltec (A.D. 750–1000), Late Toltec (A.D. 1000–1150), and Late Aztec (A.D. 1400–1519). Beyond providing the capability to develop very precise thematic maps showing the distribution of settlement and population in the region for various time periods (Figure 2), through integrating geographic space (location) explicitly into our data we introduce the potential for a number of types of analysis not possible, or at least not easily achievable, previously. I consider some of these investigations below, after first revisiting select previous analyses with these finalized data.

PRE-COLUMBIAN REGIONAL SETTLEMENT IN THE BASIN OF MEXICO

Demographics, Sites and Site Types, and Environmental Patterning

In their synthesis of Basin of Mexico settlement pattern data, Sanders, Parsons, and Santley conducted several analyses of these data to identify selected characteristics of settlement (Sanders et al. 1979). Although such analyses were not necessarily spatial, in the sense of explicitly considering the geographic arrangement of settlement, they are important to our understanding of how regional organization of the basin evolved over time. Nevertheless, the data examined by Sanders and colleagues were not yet finalized—interpretations of some archaeological data were incomplete (including identification of all other occupations), adjustments were necessary to ensure consistent treatment of sites in different survey regions, and all ancillary data (for example, environmental data) had not been identified or recorded. Before considering some new issues bearing on spatial parameters of pre-Columbian regional organization in the Basin of Mexico, I revisit here some key earlier analyses.

One of the most important issues that settlement pattern data address concerns regional demographics and population change over time. One gains access to such *big questions* through population estimates for thousands of individual sites, based on some conversion of pre-Columbian architecture (for example, domestic mounds), density of surface artifacts, or a combination of the two, into population figures. Based on survey data, population estimates for the pre-Columbian Basin of Mexico range from fewer than 1,000 people living in nine sites during the Early Formative occupation to more than 359,000 people living in nearly 1,600 sites during the Late Aztec period (Table 1). Basin population grew through the Teotihuacan period occupation and then declined during the Early Toltec and Late Toltec periods, rebounding substantially between the Late Toltec and Late Aztec occupations. As pointed out elsewhere (Gorenflo 2006), however, neither population growth nor population decline was of a magnitude that would necessarily mark some major event—say, massive in-migration from outside of the basin in the case of the former, or a surge in mortality due to widespread warfare in the case of the latter. This is not to say that such events did not happen. For example, the population

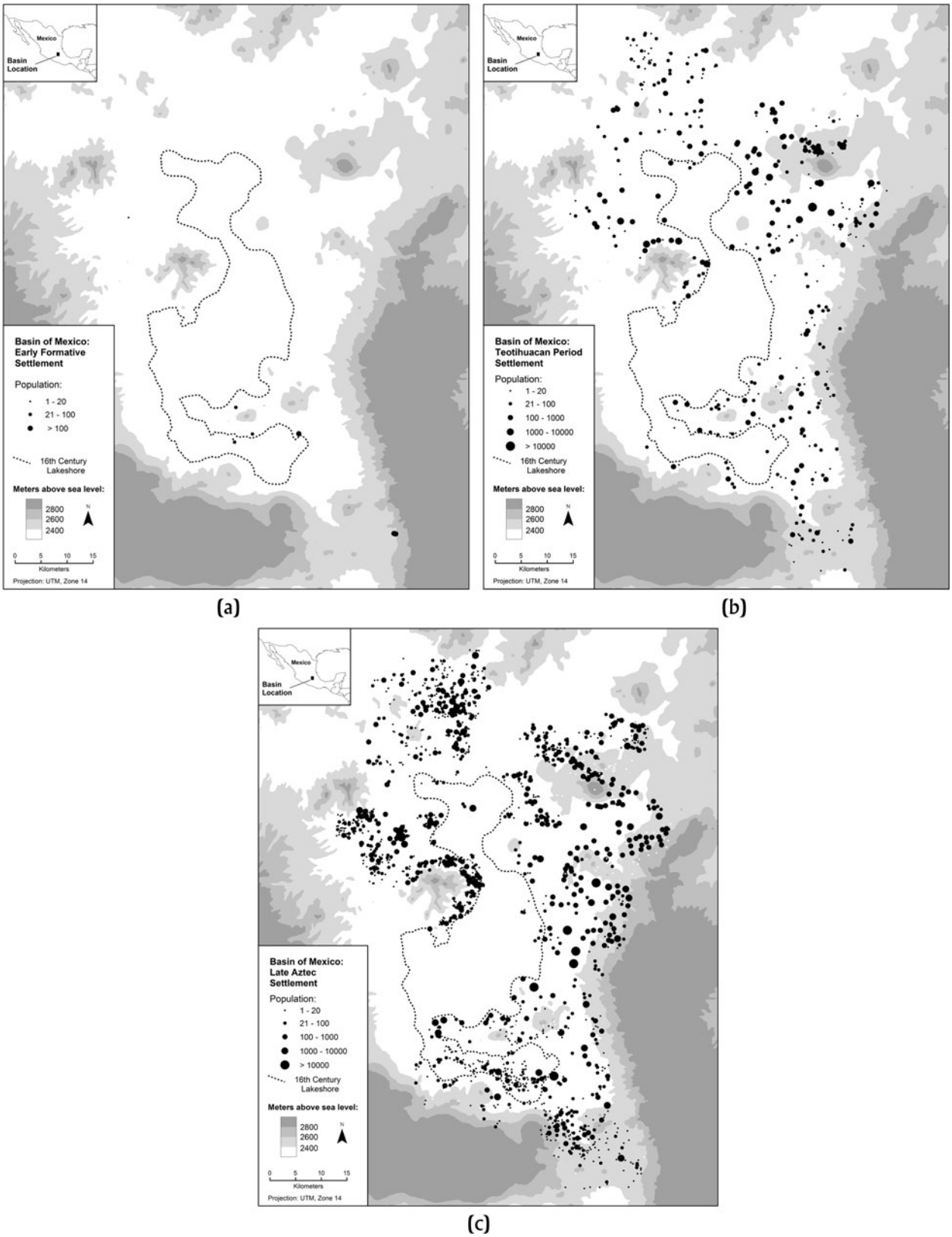

Figure 2. Archaeological settlement in the Basin of Mexico (shown as estimated populations): (a) Early Formative, (b) Teotihuacan period, (c) Late Aztec.

Table 1. Rates of change over time in the Basin of Mexico: Pre-Columbian population and total sites

	Total (number)		Average Annual Change (%)	
Chronological period[a]	Population	No. of Sites	Population	No. of Sites
Early Formative	959	9	–	–
Middle Formative	11,829	76	0.5	0.5
Late Formative	49,043	174	0.4	0.3
Terminal Formative	94,956	366	0.1	0.2
Teotihuacan	156,915	431	0.2	0.1
Early Toltec	98,358	240	−0.1	−0.1
Late Toltec	84,482	830	−0.1	0.6
Late Aztec	359,434	1,558	0.4	0.2

[a]Middle Formative, Late Formative, and Terminal Formative data are for late subphases of each period.

decline of more than 37% following the Teotihuacan period considers a total population estimate for the Teotihuacan period and a total estimate for the Early Toltec occupation. Since more than five centuries separate the mid-points of these two time periods, there would have been ample time for population to have declined markedly and then recovered, possibly repeating such a pattern several times while introducing other types of change as well, with any major event(s) lost in the archaeological record. Increased chronological control would contribute to our understanding of how pre-Columbian demographic processes contributed to regional settlement pattern change in the Basin of Mexico, though destruction of the archaeological record by development over the past five decades precludes reexamination of many sites discovered by the settlement pattern surveys. Ultimately, researchers likely will have to turn to alternative approaches to understand pre-Columbian demography, such as the application of DNA analysis to identify the role of migration in the arrangement of regional settlement (see, for example, Mata-Míguez et al. 2012).

As shown in Table 1, the total number of sites in the Basin of Mexico increased throughout the region's pre-Columbian past with one exception, between the Teotihuacan and Early Toltec periods. The types of sites present in any time period, however, varied considerably. The settlement pattern surveys classified archaeological sites into more than a dozen types. For purposes of this analysis and comparison, I have collapsed these categories into four types: hamlets, villages (including *barrios* of centers and isolated elite districts), centers, and other—the latter including ceremonial centers, quarries, irrigation canals, and other special-function sites, as well as sites where the type was unknown. For all periods of pre-Columbian occupation in the basin, hamlets comprised the largest number of sites, followed by villages and sites in the *other* category (Table 2). Sites categorized as centers, based on a combination of estimated population and the presence of public architecture, do not appear until the Late Formative period, and thereafter are consistently the least frequent site type present.

In contrast to the total number of sites, the largest numbers of people in the pre-Columbian Basin of Mexico tended to live in centers (four periods of occupation) and villages (four periods, including two that featured no centers) (see Table 2). More than two-thirds of the Teotihuacan period and Early Toltec populations lived in centers, in contrast to barely one-third of the regional population during the Late Toltec occupation. In contrast, nearly 60% of the Late Formative population and almost half of the Late Toltec population lived in villages, though both of these periods also featured centers. Such differences in the allocation of population to site types likely reflect important differences in regional organization—the periods

Table 2. Pre-Columbian settlement in the Basin of Mexico by site type

		Percent			
Chronological period[a]	Total Sites	Hamlets	Villages	Centers	Other
Early Formative	9	55.6	33.3	–	11.1
Middle Formative	77	57.1	23.4	–	19.5
Late Formative	174	55.2	25.9	2.9	16.1
Terminal Formative	366	53.0	12.6	2.7	31.7
Teotihuacan	431	64.3	22.0	2.8	10.9
Early Toltec	240	53.3	24.6	5.4	16.7
Late Toltec	830	70.4	15.7	1.1	12.9
Late Aztec	1,558	68.0	20.0	1.8	10.2
		Percent			
Chronological period[a]	Total Population	Hamlets	Villages	Centers	Other
Early Formative	959	29.6	70.4	–	–
Middle Formative	11,829	12.3	87.3	–	0.5
Late Formative	49,043	5.5	59.5	35.1	–
Terminal Formative	94,956	4.9	33.2	59.0	2.9
Teotihuacan	156,915	6.2	25.2	68.5	0.1
Early Toltec	98,358	4.6	27.7	67.7	0.1
Late Toltec	84,482	19.5	46.7	33.8	–
Late Aztec	359,434	7.8	33.4	57.8	1.0

[a]Middle Formative, Late Formative, and Terminal Formative data are for late subphases of each period.

when villages were relatively more demographically important, possibly also marking occupations of dispersed settlement and less centralized political control, while periods when centers contained more population possibly indicating periods of more concentrated administration. Hamlets and sites categorized as *other* tend to be much less important demographically, the appearance of the latter as important during the (Late) Terminal Formative reflecting several uncategorized sites in the Cuautitlan region that almost certainly were villages (but which lack the data to support a precise classifications [see Sanders and Gorenflo 2007]).

An important focus of the Basin of Mexico settlement pattern surveys was an emphasis on cultural ecology—exploring how the pre-Columbian residents of the basin adapted to their natural environment, and how various adaptive strategies influenced sociocultural evolution. One means of incorporating an ecological focus into the analysis of survey data was to examine the occurrence of settlement with respect to major environmental zones. Archaeologists in the Basin of Mexico divided the region into 10 environmental zones (Sanders et al. 1979): lakebed, island, saline lakeshore, deep soil alluvium, thin soil alluvium, upland alluvium, lower piedmont, middle piedmont, upper piedmont, and sierra. For analytical purposes and ease of presentation, I collapse these zones into seven that would have presented similar adaptive challenges and opportunities: lakebed/island (localities within the bounds of the pre-Columbian lake), saline lakeshore, alluvium (thin and deep soil), Ameca subvalley (upland alluvium), lower piedmont (categorized as lower and middle piedmont in some surveys), upper piedmont, and sierra. For all periods of pre-Columbian settlement except the Early Formative (which contained only nine sites, precluding the identification of any environmental patterns in the arrangement of settlement), the largest number of sites occurred in the lower piedmont (Table 3). The second most frequent location for pre-Columbian sites in the basin tends to vary between the alluvium and lakeshore plain, with the sierra becoming important in the Late and Terminal Formative and lakebed/island locations becoming important during the Late Aztec occupation.

Excluding the Early Formative once again due to the small number of sites, the lower piedmont contained the largest pre-Columbian populations in the Basin of Mexico as well (see Table 3). Alluvium and lakeshore plain usually accounted for the second largest amounts of population in each period of pre-Columbian occupation, followed by smaller numbers of people in the remaining four environmental zones. Much of the importance of the alluvium in the Teotihuacan period, and to a lesser extent in the Terminal Formative, Early and Late Toltec, and Late Aztec periods, is due to the sprawling settlement of Teotihuacan. Although the spatial extent of Teotihuacan was less before and after the Teotihuacan period (Garraty 2006; Gorenflo and Sanders 2007; Nichols 2013; Robertson 2007), large areas of occupation occurred, in part, in the lower piedmont and, in part, in the deep soil alluvium. The recurring importance of the lower piedmont and, to a lesser extent, thin and (especially) deep soil alluvium, likely reflects the advantages that these zones offered to preindustrial agriculture, the combination of soil qualities, microclimate, and topography providing favorable conditions for growing maize and the other cultigens that formed the basis of the pre-Columbian basin economy. Occupations in other environmental zones, in turn, may indicate the importance of other resources and economic activities at various times in the pre-Columbian basin—for instance, the nearly 23% of Late Aztec population living within the bounds of the ancient lake system and on the lakeshore plain likely indicates the importance of a variety of lacustrine resources, including salt as well as various plants and animals (see Parsons 2006).

The settlement pattern database for the Basin of Mexico provides an opportunity to revisit some previous analyses conducted more than three decades ago with data that had not yet been finalized. It also provides an opportunity to examine shifts in the distribution of site sizes (populations) over time. Results indicate a slowly changing population over time, with some more dramatic changes in the allocation of people among various site types—the latter indicating important shifts in the political and economic organization of the basin. Regional settlement, with respect to the natural environment, similarly indicates a consistency over time, the persisting dominance of the lower piedmont modified with changing levels of importance of other environmental zones that may indicate modifications in economic activity, changes in sociopolitical organization, or some combination of the two. I turn to explore how these basic insights can benefit from complementary investigations using other perspectives.

The Arrangement of Regional Settlement in Geographic Space

The creation of a GIS database for pre-Columbian settlement in the Basin of Mexico introduces the possibility of integrating geographic space into our understanding of the evolution of regional demographics and sociocultural systems in this region. Two possible categories of initial analysis emerge: the relationship of settlements with respect to one another, and the relationship of settlements with respect to important environmental variables or characteristics. The range of potential inquiries is quite broad, well beyond that possible in this single paper. But one can provide a sense of the types of studies possible with the data available, the insights they provide on sociocultural evolution in the Basin of Mexico, and additional work needed to further our understanding of the role played by regional organization.

Let us begin with some simple mapping, to provide a better sense of the distribution of pre-Columbian population in the basin over time. The maps shown in Figure 2 are one approach to this task, with the presentation of settlements using symbols proportional to the population of each showing how this variable was arranged in geographic space. An alternative approach is to reflect population variation in the shading of grid cells, here 1×1 km in size (Figure 3). These maps follow an earlier effort to map population by 4-km square grid cell (Gorenflo 2006), the finer resolution here providing a better sense of regional demographics over time. Showing population in a grid portrays the spatial distribution of this variable across commensurate units—enabling one to examine the geographic arrangement of population in the pre-Columbian Basin of Mexico and how this arrangement evolved over time. Moreover, because the grid consists of 1 km^2 cells, this map presents population *density*, as persons/km^2, for the region as well.

Archaeologists contend that intensive agriculture provided the economic foundation for the pre-Columbian inhabitants of the region, certainly after the Middle Formative period of occupation (Sanders et al. 1979). In a region such as the Basin of Mexico, particular variables would have had an important influence on agriculture, including soil, topography, and climate (especially rainfall and microclimatic effects, such as frost). We can consider rainfall as an environmental characteristic that varied over space and that could have greatly influenced the placement of settlements in a society

Table 3. Pre-Columbian settlement in the Basin of Mexico by environmental zone

		Percent						
Chronological period[a]	Total Sites	Lakebed/Island	Lakeshore Plain	Alluvium	Ameca Sub-valley	Lower Piedmont	Upper Piedmont	Sierra
Early Formative	9	22.2	33.3	–	22.2	22.2	–	–
Middle Formative	77	2.6	11.7	14.3	–	66.2	5.2	–
Late Formative	174	3.4	11.5	6.3	2.9	60.3	15.5	–
Terminal Formative	366	0.5	10.1	12.8	1.1	64.2	11.2	–
Teotihuacan	431	0.7	11.1	14.8	1.4	65.2	6.5	0.2
Early Toltec	240	2.9	15.8	17.9	0.4	60.0	2.9	–
Late Toltec	830	1.8	12.9	13.0	0.7	66.5	4.9	0.1
Late Aztec	1,558	11.6	8.9	10.7	1.8	58.2	8.8	0.1
		Percent						
Chronological period[a]	Total Population	Lakebed/Island	Lakeshore Plain	Alluvium	Ameca Sub-valley	Lower Piedmont	Upper Piedmont	Sierra
Early Formative	959	9.4	41.7	–	46.9	2.0	–	–
Middle Formative	11,829	0.3	22.6	3.8	–	71.2	2.0	–
Late Formative	49,043	1.2	16.1	6.3	1.0	74.2	1.3	–
Terminal Formative	94,956	1.0	8.1	13.5	0.3	76.0	1.1	–
Teotihuacan	156,915	–	3.3	40.0	0.3	54.3	2.1	–
Early Toltec	98,358	3.9	7.9	20.0	–	68.2	0.1	–
Late Toltec	84,482	2.6	11.4	22.5	0.2	62.5	0.8	–
Late Aztec	359,434	4.9	18.0	14.3	2.9	53.3	6.6	–

[a]Middle Formative, Late Formative, and Terminal Formative data are for late sub-phases of each period.

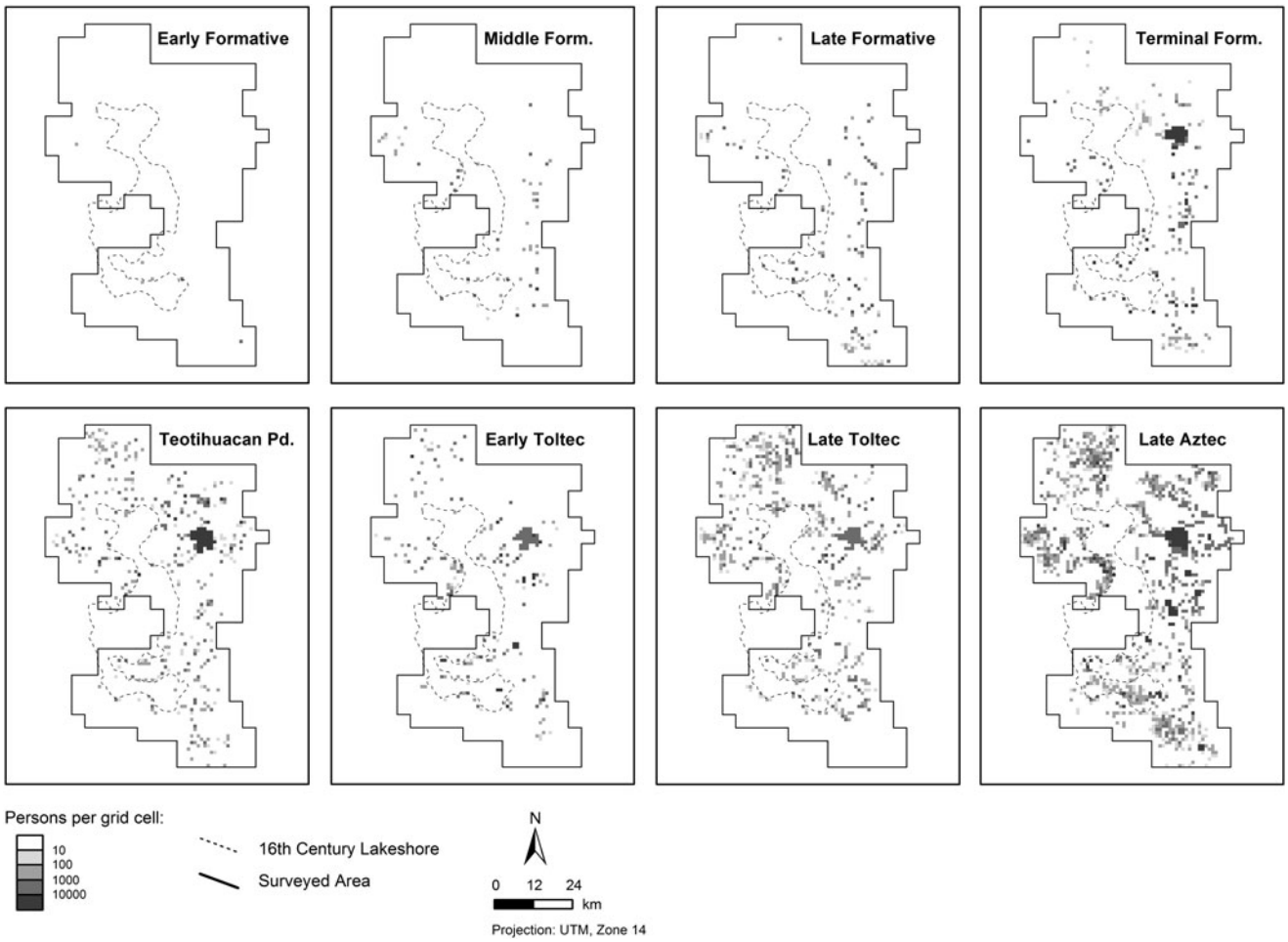

Figure 3. Pre-Columbian population in the Basin of Mexico (shown as 1-km square grid cells).

reliant on intensive agriculture. Through creation of a database with geographic coordinates, each site can be associated with an average annual rainfall value that provides a basis for examining the relationship between population and this essential environmental variable. Despite its potential role in crop production, rainfall appears to have had limited influence on settlement at any time in the basin with the possible exception of the Early Formative period, though once again it is difficult to identify any relationship with only nine sites (Figure 4). Middle and Late Formative settlement show a slight relationship between population and rainfall; the remaining periods show very little relationship between these two variables. Indeed, after the Late Formative period many of the largest sites in the region occur in localities receiving between 500 and 700 mm of rainfall annually, a very low amount to support maize agriculture. Research by Nichols (1980, 1987) in the Cuautitlan region showed how risky rainfall-based agriculture could be due to annual variation in amount and timing of rain, and hence the potential importance of irrigation in that portion of the basin. Sanders (1965; see also Sanders et al. 1979) has argued that Teotihuacan's emergence, and especially the concentration of population in Teotihuacan during the Early Terminal Formative (250–100 B.C.) and the Late Terminal Formative periods, was largely irrigation-dependent. The presence of a slight relationship between population and rainfall in the Early, Middle, and Late Formative may indicate a reliance on rain-fed agriculture until irrigation became more widespread and accessible, with the emergence of more complex societies in the Terminal Formative and later. The general lack of association between rainfall and population throughout much of the basin's pre-Columbian occupation may indicate a broader reliance on irrigation than previously believed, with the likelihood that most larger settlements relied heavily on some form of irrigation to supplement meager amounts of rainfall—particularly, though not exclusively, in the more arid northern parts of the region.

One of the most noteworthy features of Basin of Mexico physical geography was the system of shallow lakes in the center of the region. Ethnohistoric and ethnographic data indicate that the lake system played an important role in the region's economy (Gibson 1964; Parsons 2006), while other research proposes that the lake system would have been essential to the transportation of food and other bulky materials in the basin in the absence of beasts of burden (Gorenflo and Gale 1990; Hassig 1985; Sanders and Santley 1983). One means of assessing the importance of this feature to regional organization is to examine the arrangement of sites in terms of proximity to the lakeshore. Although lakeshore proximity is not absolutely essential in indicating how important the lakes were in regional settlement, a tendency for population to concentrate near the lakes would support the contention that they were an important component of regional organization (Gorenflo and Garraty 2016). Examining the occurrence of sites in 1-km strips, or buffers, around the likely sixteenth century lakeshore

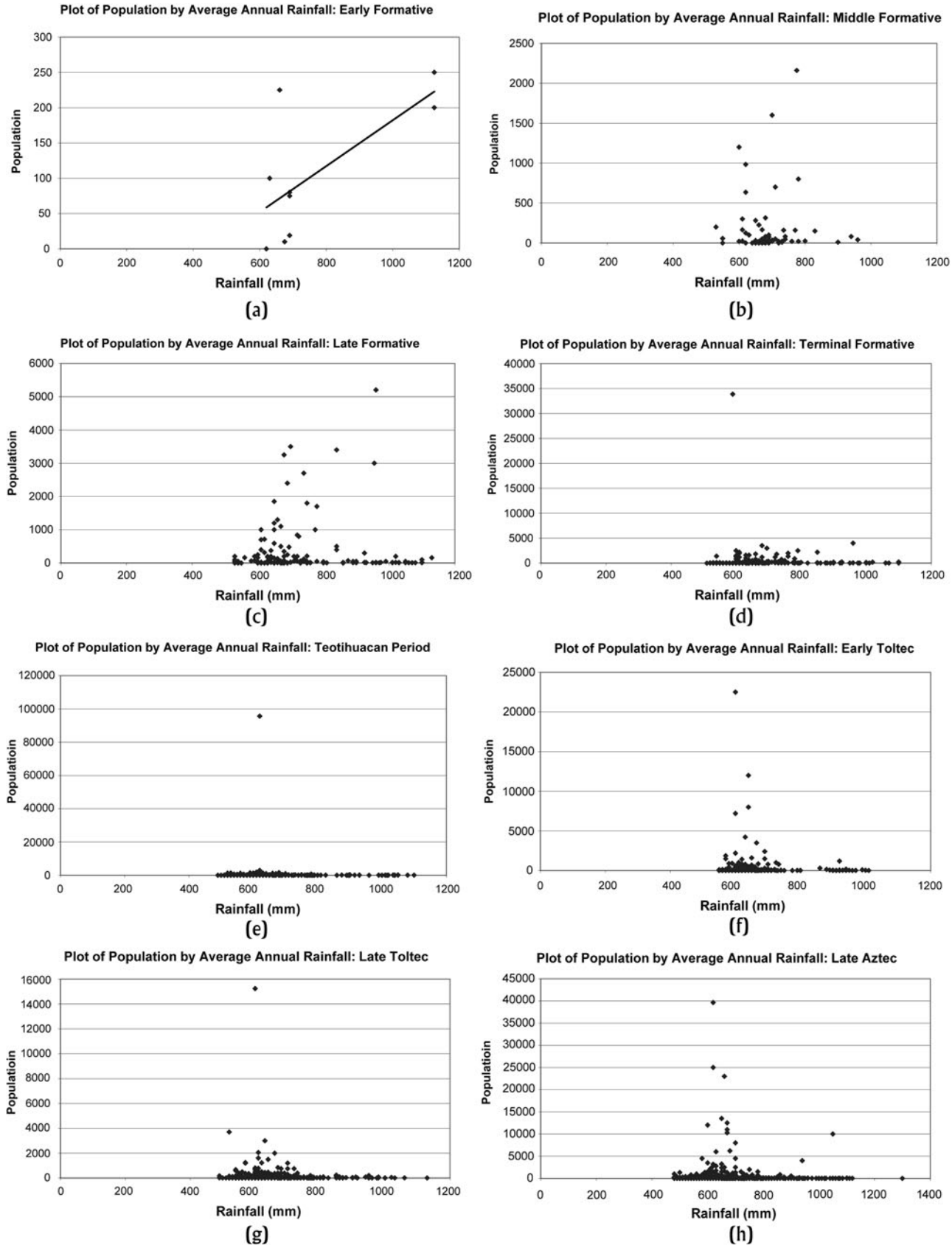

Figure 4. Scatter plots of pre-Columbian population and average annual rainfall in the Basin of Mexico: (a) Early Formative, (b) (Late) Middle Formative, (c) (Late) Late Formative, (d) (Late) Terminal Formative, (e) Teotihuacan period, (f) Early Toltec, (g) Late Toltec, (h) Late Aztec.

(defined by the 2,238 m contour; see Sanders et al. 1979) indicates some inclination to place settlements within the bounds of the lakes or nearby, beginning in Early Formative period and continuing throughout the region's pre-Columbian occupation (Figure 5). Nevertheless, this tendency is not particularly strong and tends to be less so from the Terminal Formative period onward—though larger numbers of people lived within the bounds of the lakes or near the lakeshore in later periods of occupation. Settlement densities within the 1 km-wide buffers tend to be modest near the lakes, only twice exceeding 35 persons/km^2 until the Late Aztec period, when the 1 km-wide strip adjacent to the lakeshore reached 139 persons/km^2 and the strip 1–2 km from the lakeshore reached 117 persons/km^2. These striking differences in population density contrast with the percentage of total population living near the lakeshore, which was minimally twice as high during the Early through Late Formative occupations as during the Late Aztec period. Lake-oriented adaptation during the Formative occupations in the basin have received relatively little attention compared to their Late Aztec counterpart, though in relative terms they may indicate considerable importance of lake proximity.

To close this brief examination of the Basin of Mexico settlement patterns using the GIS database, let us consider possible mechanisms underlying the changing arrangement of people throughout the region's pre-Columbian past. Examining the gridded population distributions presented in Figure 3 indicates considerable changes in regional settlement over time. Beyond the previously documented shift in emphasis from the southern Basin of Mexico during the early occupations to the north by the Terminal Formative period, by comparing grids one finds evidence for considerable movement throughout the region from one period of settlement to another (Figure 6). Here I consider two different indicators of mobility: grid cells unoccupied in one period that were occupied in a succeeding period, where the only explanation is migration from elsewhere (see Gorenflo 2006); and grid cells occupied in one period that were unoccupied in a succeeding period, possibly indicating that a resident population died out but more likely abandonment of one location for another. Two other indicators of change, when the population in a particular grid cell increased or decreased from one period to the succeeding period, also may indicate mobility or natural population increase or decrease associated with changing balance between mortality and fertility. A preliminary analysis of pre-Columbian population estimates for the basin using 4-km square grid cells indicated considerable movement between major periods of occupation (Gorenflo 2006). This higher resolution analysis indicates even greater occurrence of movement, in addition to other reasons for geographic shifts in settlement, across much of the region—with well-known instances of migration, such as apparent movement into Teotihuacan between Late and Terminal Formative occupations and increasing settlement of the basin between the Terminal Formative and Teotihuacan period augmented with evidence of local shifts and other apparent patterns throughout the region. Analyses of correlations between succeeding periods for grid cells that registered at least one populated site (thereby indicating a potential for occupation) revealed relatively few significant results and generally quite low correlation measures, suggesting that the pattern of occupation in one period had limited effect on the pattern in the succeeding period (Table 4). The reasons for such widespread mobility remain unknown, but the frequency with which it occurred indicates a fundamental process in basin settlement that deserves further attention.

The above analyses of the GIS settlement database for the Basin of Mexico represent a preliminary set of inquiries on the regional arrangement of population, how this arrangement changed over time, and possible reasons for these changes. We see evidence for a remarkably mobile population whose geographic arrangement at any point in time represents the results of people moving *from* other localities in the basin or beyond, and people moving *to* other localities inside or beyond the region as well. Reasons for *frequent* movement—acknowledging that we are looking at several centuries of human occupation here—remain uncertain, though given the central role of agriculture in the pre-Columbian economy of the basin soil management or other related considerations may have played an important role. Despite this tendency for geographic adjustment, rainfall apparently had surprisingly little effect on where people lived, particularly in the case of larger sites—in all likelihood indicating that the residents of the Basin of Mexico in many cases could compensate for lack of adequate rainfall with irrigation. Orientation toward the central lake system, an important source of resources and an important means of transporting resources over longer distances, varied considerably between periods, larger percentages of the regional population living within the bounds of the lakes or nearby earlier in the pre-Columbian sequence and higher densities living within or near the lakes later in the sequence. These shifts may indicate changes in regional economies, changes in local adaptation, or some combination of the two with respect to placement of settlement near the lakes.

IN SEARCH OF FURTHER UNDERSTANDING: DATA SHORTCOMINGS AND NEXT STEPS

Research on pre-Columbian regional settlement patterns in the Basin of Mexico has come a long way since those early days of the Teotihuacan Valley survey in 1960. In addition to having compiled data on more than 3,900 separate archaeological sites in the basin, basic analyses provide insights on how settlement patterns in the region evolved over time and space. But there is much work to be done. Some of this additional effort concerns further enhancements of existing datasets and the analyses possible with them. Other efforts concern research yet to be conducted, including that on the natural environment. Finally, we face inherent limitations of regional analysis of archaeological data, and these limitations need to be acknowledged and compensated for, when possible.

The biggest enhancement of existing GIS data involves the development of *polygon* GIS data for all known archaeological sites. With few exceptions—primarily the sites located within the bounds of urban Teotihuacan for various time periods—sites analyzed in the research presented here have been *point* data, representing the geographic centroids of all known sites in the Basin of Mexico. For small sites, covering a limited geographic area, the analytical discrepancy between point data and polygon data is similarly small. For larger sites, more precise boundaries showing the geographic shape of each site is important. For instance, in measuring the distance of sites to the lakeshore, portions of each site will be closer than its centroid, altering the results of analyses of proximity to this important geographic feature. In the search for broad patterns in regional settlement pattern data, polygon data will not substantially change any of the results presented here. Nevertheless, in the interest of conducting the most precise analyses possible, augmenting existing information with polygons for each site is important. Precise boundaries exist for all known

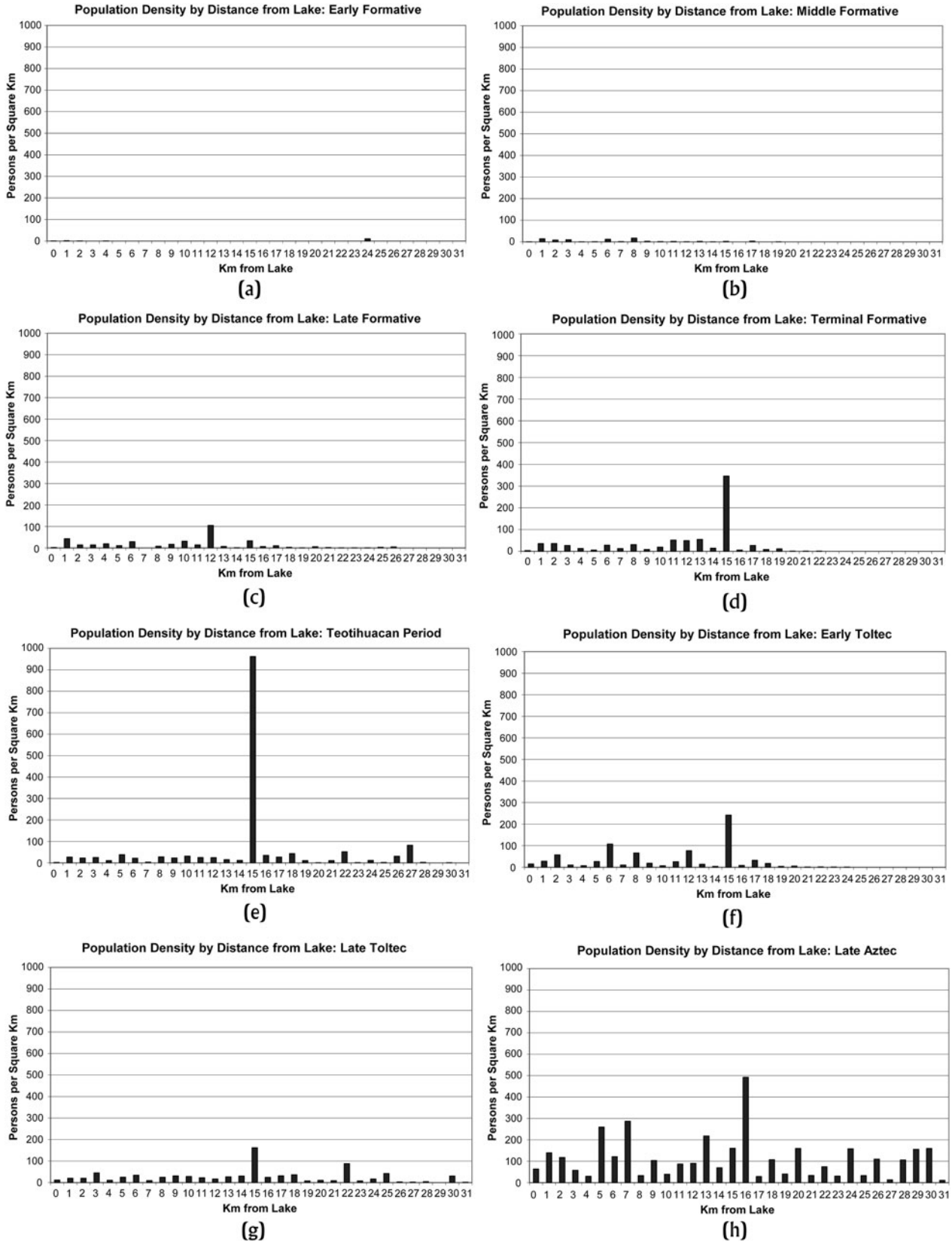

Figure 5. Estimated pre-Columbian population density by distance from the pre-Columbian lakeshore in the Basin of Mexico: (a) Early Formative, (b) (Late) Middle Formative, (c) (Late) Late Formative, (d) (Late) Terminal Formative, (e) Teotihuacan period, (f) Early Toltec, (g) Late Toltec, (h) Late Aztec.

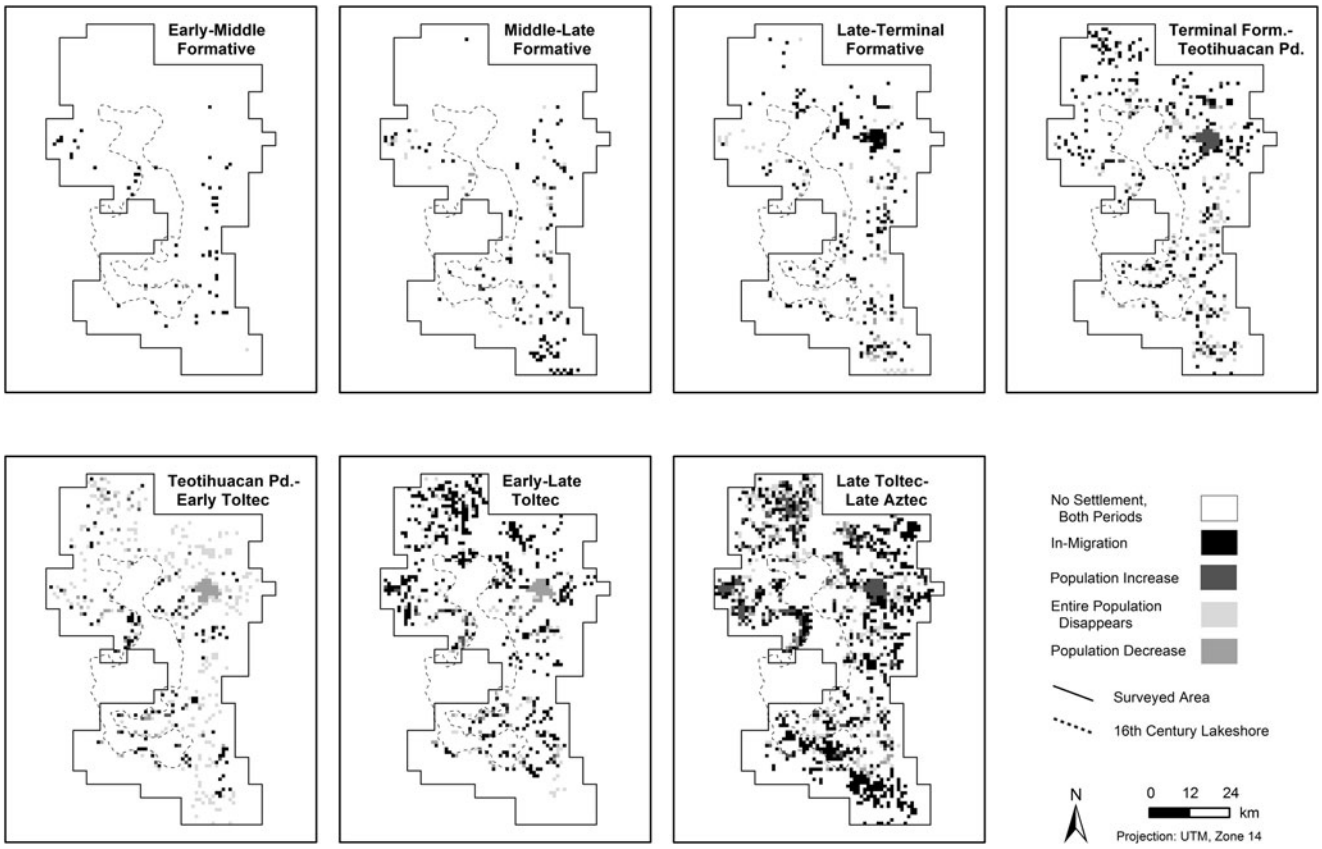

Figure 6. Pre-Columbian population change in the Basin of Mexico between successive periods of occupation (shown as l-km square grid cells).

archaeological sites in the basin, mapped by hand in the process of compiling settlement pattern data. Recent efforts led by Kenneth Hirth for the data collected by Parsons and Blanton have produced polygon data for a large part of the basin—those five regions surveyed by University of Michigan projects. Ongoing efforts for the data collected on surveys directed by Sanders will provide similar data for the remainder of the basin in the next year.

One of the most deficient pieces of information on regional settlement in the Basin of Mexico concerns data on the natural environment to which past societies adapted. A central component of the cultural ecological research that has dominated settlement surveys and analyses, our understanding of the natural environment, is based on a setting—the modern basin—greatly altered through pre-Columbian, historic, and modern activity. Nichols (1980, 1987) identified the presence of considerable erosion from the piedmont into the alluvial plain below as early as the Late Middle Formative period, indicating the early emergence of substantial human impacts on the natural environment that more recent research has supported (Cordova 1997; Cordova and Parsons 1997; Frederick 1997; Frederick et al. 2005). Propositions of change during pre-Columbian occupations in the natural setting, and the presence of complex interactions between human land use and natural processes, are well-documented historically in the general region. Working in the Mezquital drainage north of the Basin of Mexico, Melville (1994) documented a number of dramatic environmental changes that accompanied Spanish colonial settlement and land use, including enormous amounts of erosion associated with herding sheep and the associated deterioration of Aztec terrace systems. Broad expanses of Colonial period erosion in the basin have been discussed previously (Cook 1949), providing further evidence of a need to explore this problem. Ultimately, what we have examined in the Basin of Mexico is pre-Columbian adaptation to a natural environment defined in large part on modern conditions. Certain characteristics important to the inhabitants of the region

Table 4. Correlations of gridded population in one period of occupation with that in the preceding period

Correlation Measure	Middle Formative	Late Formative	Terminal Formative	Teotihuacan period	Early Toltec	Late Toltec	Late Aztec
Pearson's R	.039[a]	.010	−.001	−.003	−.002	−.002	−.005
Kendall's Tau	.265[a]	.144[a]	.019	.053[a]	.102[a]	.040[a]	.017
Spearman Rho	.266[a]	.145[a]	.020	.054[a]	.103[a]	.042[a]	.018

[a]Significance at .01

likely remained unchanged—for instance, frost patterns and topography. But others, such as soil depth and quality, vegetation, hydrology, and key aspects of the climate, have changed considerably between the various periods of pre-Columbian occupation and the mid-twentieth century and probably within the pre-Columbian period as well (see McClung de Tapia 2012; McClung de Tapia and Adriano-Morán 2012; McClung de Tapia and Martínez Yrizar 2005; McClung de Tapia et al. 2003; Morehart and Frederick 2014). We need to reexamine these characteristics of the natural environment to define its configuration in the past, to provide a more accurate picture of possibilities and constraints that basin biogeography posed at the time of pre-Columbian occupations. One approach is through efforts to document the paleoenvironment, such as studies conducted by McClung de Tapia (for example, McClung de Tapia and Adriano-Morán 2012; McClung de Tapia and Sugiura 1999). Much of the effort might be focused on assembling key information from studies already conducted. Recent research, including that in the Teotihuacan Valley (McClung de Tapia et al. 2003, 2004, 2005), however, indicates that in many cases changes appear to have been localized—suggesting that understanding regional patterns of ecological adaptation will require considerable effort to control local paleoenvironmental conditions.

A main problem in analyzing archaeological settlement patterns is the equation of resulting data with pre-Columbian *settlement systems*. Archaeologists often treat settlement pattern data as snapshots of regional organization, and the patterns of sites, site sizes and types, regional demographics, and so on as representing coeval data (see, for example, Gorenflo 1996). This is, of course, both incorrect and obviously an oversimplification to anyone interested in the analysis of pre-Columbian regional settlement. The challenge is how to deal with this problem. Some have argued for analytical solutions (see Dewar 1991; Kintigh 1994), incorporating length of time period and related considerations to address the issue of contemporaneity. Other solutions may relate to further refinement of chronology, both for the Basin of Mexico as a whole (see Cowgill 1996; Parsons et al. 1996) and for individual sites, though in truth the potential of reanalyzing artifact collections for surveyed sites, where collections exist, will be limited given the non-systematic nature of the collections themselves. Ultimately neither solution will address the fundamental problem of determining which sites were occupied at a given time, and the number of people likely living in each—both questions frequently associated with regional survey data and important liabilities in any attempt to understand pre-Columbian regional organization.

A final problem, and something that one must live with in analyzing pre-Columbian settlement patterns in the Basin of Mexico, is incomplete regional coverage. Sanders and Parsons lamented about this shortcoming for years, with the latter writing (Parsons 2015) that had they known the sprawl from Mexico City would have been so rapid and at such a large scale they would have begun their surveys in the southwestern basin. As shown in Figure 1, although the largest portion of the basin not surveyed is indeed in the southwest—the area covered by Mexico City and related settlement—other small uncovered sections exist as well, mainly in the north (between the Temascalapa and Zumpango regions) and in the east (between the three sections of the Texcoco survey region). The area in the southwest is particularly concerning, with lack of data undermining our understanding both for the Terminal Formative period and the role of Cuicuilco as a major competitor with Teotihuacan for regional dominance (see Sanders et al. 1979), and for the Late Aztec settlement system with its geographic base at Tenochtitlan in the unsurveyed area. Salvage archaeology has provided some clues to pre-Columbian settlement in this area, as have ethnohistoric data for Tenochtitlan and surrounding environs (see, for example, Calnek 1976, 2001). Nevertheless, these substantial gaps in data pose major problems, and will continue to compromise our understanding of Basin of Mexico settlement and regional organization.

Solutions to the above shortcomings are not simple, but they are in some cases possible. Efforts to define each site as a polygon in a GIS database currently are underway with data that already exist. Reconstructing the paleoenvironment, although challenging and requiring a serious commitment of time and resources, similarly is occurring; improving our understanding of the past environment in the basin appears to be possible with existing data, though further research will be needed to generate a working understanding of this critical issue. Improving chronological control of regional data ultimately is limited by the nature of those data, but some improvement may be possible. Mining data on the salvage archaeology in Mexico City, as Bill Sanders was in the process of completing when he died, can help to fill in small parts of that substantial data gap, though other portions of the basin not surveyed likely will remain unknown because of modern impacts on the archaeological record. Of course, one of the greatest contributions to understanding regional settlement in the Basin of Mexico would be through more primary research, particularly excavation of selected sites to improve both chronological control and our understanding of site function in a regional context. Unfortunately, due to growing human population in the basin and increasingly destructive agricultural practices over the past five decades, many sites that might have been of interest for excavation no longer exist. For sites that do persist, settlement data could be used to select those whose excavation would address one or more of the shortcomings in our current understanding of sociocultural evolution in this important region. When excavation is not immediately possible at a remaining important site, steps should be taken to conserve that site to make it available for further inquiries in the future.

CONCLUSIONS

Research on the regional patterning of pre-Columbian settlement in the Basin of Mexico has evolved from early, tentative steps to a basin-wide dataset that covers virtually the entire region that could be surveyed prior to 1975. Although there has been considerable delay in generating the final settlement pattern database for the entire region, we have benefited greatly from the increases in technology and analytical methods that have enabled us to improve both the presentation of these data and their investigation. One group of methods that have greatly improved over the past two decades are those related to GIS technology. It is important to see GIS for what it is—not some magical source of insight to past regional organization, but rather a collection of tools for storing, manipulating, analyzing, and presenting data that requires researchers to identify pertinent questions of the data available. Nevertheless, GIS technology provides enormous potential for the analysis of settlement pattern data in the Basin of Mexico, enabling researchers to address a variety of questions through exploratory geospatial analysis that will improve our understanding of sociocultural evolution in this region.

Regional settlement in the Basin of Mexico evolved in fascinating ways over three millennia of pre-Columbian occupation. Based on settlement survey data, population changed slowly. Despite these

slow rates of change, major shifts occurred in the types of settlements present and the arrangement of settlements with respect to environmental zones, both likely indicating important sociocultural changes accompanying, or accompanied by, shifts in settlement type and location. Moreover, with few exceptions, residents of the Basin of Mexico did not identify favorable locations that persisted over time. Rather, they shifted their locations from period to period of pre-Columbian occupation. These shifts occurred with surprisingly little regard to rainfall in the case of many larger sites, indicating a reliance on water control that was more geographically widespread than previously imagined. Settlement with respect to the most dominant physical geographic feature of the basin, the central lake system, varied over time as well, with changes in proximity measured in relative and absolute terms likely indicating shifts in importance of lacustrine proximity currently not well understood.

One of the great unrealized potentials for regional settlement data from the Basin of Mexico is to guide future research, something the researchers who led surveys of the region always envisioned. In the simplest form, this might occur as identifying sites in particular categories—for example, certain site types or sites in particular locations—for further investigation. In its more complex form, this might occur as identifying sites whose study could answer key questions that emerge from the study of settlement patterns—such as sites that occur in natural settings that could not easily support the population they apparently contained. The clear problem in guiding future research is that many of the most important potential candidates for such inquiries no longer exist, or have been adversely affected such that their study would yield, at best, limited insights. Even personal experience tells a grim tale here: Tepetlaoztoc, a Late Aztec site in the Texcoco region with remarkably detailed ethnohistoric documentation, found to be virtually destroyed by eucalyptus reforestation when Sanders and I visited it in the mid–1990s (Sanders 1996); TM-Cl-38, a Teotihuacan Period site in a particularly remote portion of the Temascalapa region, destroyed by a golf course; the virtual eradication of archaeological remains in the Cuautitlan region due to sprawling settlement from Mexico City during the 1970s–1990s (see Sanders and Gorenflo 2007); and the loss of key sites throughout the basin, revealed through a reconnaissance by Jeff Parsons and myself in 2008 and 2009 (currently being augmented by more recent data and written up). Nevertheless, the possibility certainly exists that key archaeological remains from an inventory that numbered more than 3,900 individual sites have persisted despite the pressures of modern development. The challenge that faces us is to appreciate how such settlements fit into the regional organization of the Basin of Mexico over time, and to identify clues in what remains to help understand the evolution of pre-Columbian complex societies in the basin as a whole.

RESUMEN

Uno de los componentes más importantes de la investigación arqueológica en la cuenca de México ha sido una serie de recorridos de superficie regionales llevados a cabo entre 1960 y 1975. Este artículo discute los esfuerzos para completar los datos de los asentamientos generados por esos recorridos y resumir los análisis preliminares de la base de datos resultante que incluye aplicaciones de sistemas de información geográfica para examinar los patrones de asentamiento a través del tiempo. El trabajo inicia revisando brevemente los recorridos de las siete regiones de la cuenca, iniciando con el reconocimiento de superficie de la región de Teotihuacan hecho entre 1960 y 1965 bajo la dirección de William Sanders. Los recorridos subsecuentes, dirigidos por Sanders, Jeffrey Parsons y Richard Blanton generaron información de más de 3,900 sitios arqueológicos precolombinos, fechados para periodos de tiempo que van desde el periodo formativo temprano (1500–1050 a.C.) al Azteca tardío (1400–1519 d.C.). Cubriendo la mayor parte de la cuenca de México, con la excepción principal de la porción suroeste de la región obscurecida por los asentamientos modernos de la ciudad de México, estos datos proporcionan una imagen extraordinariamente detallada de esta importante región.

El análisis de los datos demográficos revela generalmente un incremento y disminución poblacional lentos que no indican eventos demográficos importantes. Sin embargo, la falta de controles cronológicos más estrechos puede obscurecer instancias más dramáticas de crecimiento o descenso poblacional que no pueden ser detectados en los datos del asentamiento regional a partir de como está definido actualmente. Los recorridos identificaron varios tipos de sitios, que para los propósitos actuales se resumen en cuatro grupos: aldeas, pueblos, centros y *otros* (por ejemplo, centros ceremoniales, yacimientos, canales de irrigación, y otros sitios de funciones especiales, así como sitios en los que sus tipos son desconocidos). Para todos los periodos de tiempo, las aldeas son el tipo de sitio encontrado más frecuentemente. En contraste, en los periodos de tiempo en los que hubo centros, éstos contienen frecuentemente la mayor parte de la gente, con la excepción del periodo formativo tardío (tardío) (550–300 a.C.) y el periodo Tolteca tardío (1000–1150 d.C.) cuando los pueblos albergaban grandes poblaciones, marcando muy probablemente periodos cuando la organización regional no estaba tan estrechamente controlada por la administración central de la región. Este estudio también examina los asentamientos de acuerdo a su zona medioambiental a partir de las siguientes categorías: lecho del lago/isla (localidades dentro de los límites del lago precolombino), orilla salina del lago, aluvión (suelo delgado y profundo), subvalle de Ameca (aluvión de montaña), piamonte bajo (categorizado como piamonte bajo y medio en algunos recorridos), piamonte alto y sierra. El piamonte bajo tendió a contener tanto el mayor número de sitios como las poblaciones más grandes, consistentes con las ventajas que proporciona esta zona ambiental para la agricultura precolombina del maíz.

Organizar los datos de asentamiento de la cuenca de México en un sistema de información geográfica permite el análisis de varias cuestiones asociadas con el papel del espacio geográfico en la organización regional. Al examinar la incidencia de los sitios arqueológicos con respecto al promedio anual de precipitación se observa una asociación limitada entre estas variables a través del periodo formativo tardío (tardío) y una asociación aún menor en el resto de los asentamientos de los otros periodos precolombinos. La aparición de grandes poblaciones en zonas de baja precipitación sugiere que la irrigación pudo haber jugado un papel más importante a través de la cuenca de lo que anteriormente se pensaba. El análisis de los asentamientos con respecto a la proximidad del sistema del lago que dominaron la porción central de la cuenca de México precolombina revela una tendencia a establecerse cerca de la orilla del lago. La influencia del sistema del lago en los asentamientos es particularmente aparente durante el periodo formativo temprano-tardío (tardío) (como se mide en términos de porcentaje poblacional en la cuenca). Trazando la población en mapas con una retícula de cuadros de 1 km proporciona una imagen más clara del arreglo geográfico de la población regional a través del tiempo. También indica el grado en que la ubicación de la gente cambió con el tiempo, en muchos casos moviéndose hacia emplazamientos donde no habían vivido en periodos de tiempo anteriores, en otros casos probablemente abandonando localidades que fueron ocupadas anteriormente.

Persisten ciertas deficiencias claves en los datos de asentamiento de la cuenca de México que limitan nuestro entendimiento respecto al cambio de la organización espacial en esta importante región. Algunas de esas deficiencias pueden abordarse. Se están realizando esfuerzos para representar

todos los asentamientos precolombinos como polígonos, en vez de puntos, permitiendo así análisis más precisos de los patrones espaciales. Además existen datos para mejorar nuestra comprensión del medioambiente precolombino de la cuenca y de como cambió este medioambiente a través del tiempo, lo cual proporcionará un importante entendimiento de la ecología cultural de la organización de asentamientos a escala regional. Hay otros problemas inherentes en el análisis de los datos de asentamientos arqueológicos, en particular el desarrollo de una imagen clara de asentamientos contemporáneos en ausencia de un mejor control cronológico. Sin embargo, los análisis de esta extremadamente rica base de datos proporcionan importantes ideas respecto al asentamiento regional precolombino y a como la disposición del asentamiento pudo haber afectado, o ha sido afectado, por las sociedades complejas desarrolladas en esta porción clave de mesoamérica.

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REFERENCES

Blanton, Richard E.
1972 *Prehispanic Settlement Patterns of the Ixtapalapa Peninsula Region, Mexico*. Occasional Papers in Anthropology, No. 6. Department of Anthropology, Pennsylvania State University, University Park.

Calnek, Edward.
1976 The Internal Structure of Tenochtitlan. In *The Valley of Mexico: Studies in Pre-Hispanic Ecology and Society*, edited by Eric R. Wolf, pp. 287–302. School of American Research Press, Albuquerque.
2001 Tenochtitlan-Tlatelolco (Federal District, Mexico). In *Archaeology of Ancient Mexico and Central America*, edited by Susan Toby Evans and David L. Webster, pp. 719–722. Routledge, New York.

Córdova, Carlos E.
1997 *Landscape Transformation in Aztec and Spanish Colonial Texcoco, Mexico*. Ph.D. dissertation, Department of Anthropology, University of Texas, Austin. University Microfilms International, Ann Arbor, MI.

Córdova, Carlos E., and Jeffery R. Parsons
1997 Geoarchaeology of an Aztec Dispersed Village on the Texcoco Piedmont of Central Mexico. *Geoarchaeology* 12:177–210.

Cook, Sherburne F.
1949 *Soil Erosion and Population in Central Mexico*. Ibero-Americana, Vol. 34. University of California Press, Berkeley and Los Angeles.

Cowgill, George L.
1996 Discussion. *Ancient Mesoamerica* 7:325–331.

Dewar, Robert E.
1991 Incorporating Variation in Occupation Span into Settlement-Pattern Analysis. *American Antiquity* 56:604–620.

Evans, Susan Toby, William T. Sanders, and Jeffrey R. Parsons
2000 The Teotihuacan Valley Project: Aztec Period Site Descriptions. In *The Teotihuacan Valley Project Final Report, Vol. 5. Teotihuacan Period Occupation of the Valley, Part 1: Natural Environment, 20th Century Occupation, Survey Methodology, and Site Descriptions*, edited by Susan Toby Evans and William T. Sanders, pp. 85–499. Occasional Papers in Anthropology, No. 25, Part 1. Department of Anthropology, The Pennsylvania State University, University Park.

Frederick, Charles D.
1997 *Landscape Change and Human Settlement in the Southeastern Basin of Mexico*. Unpublished manuscript on file, Department of Archaeology and Prehistory, University of Sheffield, Sheffield.

Frederick, Charles D., Barbara Winsborough, and Virginia S. Popper
2005 Geoarchaeological Investigations in the Northern Basin of Mexico. In *Production and Power at Postclassic Xaltocan*, edited by Elizabeth M. Brumfiel, pp. 71–115. University of Pittsburgh and the Instituto Nacional de Antropología e Historia, Pittsburgh and Mexico City.

Garraty, Christopher P.
2006 *The Politics of Commerce: Aztec Pottery Production and Exchange in the Basin of Mexico,* A.D. *1200–1650.* Ph.D. dissertation, School of Human Evolution and Social Change, Arizona State University, Tempe. University Microfilms International, Ann Arbor, MI.

Gibson, Charles
1964 *The Aztecs Under Spanish Rule*. Stanford University Press, Stanford.

Gorenflo, L. J.
1996 Regional Efficiency in Prehispanic Central Mexico: Insights from Geographical Studies of Archaeological Settlement Patterns. In *Arqueología Mesoamericana: Homenaje a William T. Sanders*, edited by Alba Guadalupe Mastache, Jeffrey R. Parsons, Robert S. Santley, and Mari Carmen Serra Puche, pp. 135–159. Instituto Nacional de Antropología e Historia, Mexico City.
2006 The Evolution of Regional Demography and Settlement in the Prehispanic Basin of Mexico. In *Urbanism in the Preindustrial World: Cross Cultural Approaches*, edited by Glenn R. Storey, pp. 295–314. University of Alabama Press, Tuscaloosa.

Gorenflo, L. J., and Nathan D. Gale
1990 Mapping Regional Settlement in Information Space. *Journal of Anthropological Archaeology* 9:240–274.

Gorenflo, L. J., and Christopher P. Garraty
2016 Aztec Regional Settlement History and Chronology. In *Oxford Handbook of the Aztecs*, edited by Deborah L. Nichols and Enrique Rodríguez-Alegría. Oxford University Press, New York. In press.

Gorenflo, L. J., and William T. Sanders
2007 *Archaeological Settlement Pattern Data from the Cuautitlan, Temascalapa, and Teotihuacan Regions, Mexico*. Occasional Papers in Anthropology, No. 30. Department of Anthropology, Pennsylvania State University, University Park.

Haggett, Peter, Andrew D. Cliff, and Allan Frey
1977 *Locational Analysis in Human Geography*. 2nd ed. Wiley, New York.

Hassig, Ross
1985 *Trade, Tribute, and Transportation: The Sixteenth Century Political Economy in the Valley of Mexico*. University of Oklahoma Press, Norman.

Kintigh, Keith.W.
1994 Contending with Contemporaneity in Settlement-Pattern Studies. *American Antiquity* 59:143–148.

Kolb, Charles C., and William T. Sanders
1996 The Surface Survey. In *The Teotihuacan Valley Project Final Report, Vol. 3. The Teotihuacan Period Occupation of the Valley, Part 3: The Surface Survey*, edited by William T. Sanders, pp. 485–653. Occasional Papers in Anthropology, No. 21, Part 3. Department of Anthropology, The Pennsylvania State University, University Park.

Marino, Joseph D.
1987 The Surface Survey. In *The Teotihuacan Valley Project Final Report, Vol. 4. The Toltec Period Occupation of the Valley, Part 2: Surface Survey and Special Studies*, edited by William T. Sanders, pp. 381–516. Occasional Papers in Anthropology No. 15, Part 2. Department of Anthropology, Pennsylvania State University, University Park.

Mata-Míguez, Jaime, Lisa Overholtzer, Enrique Rodríguez-Alegería, Brian M. Kemp, and Deborah H. Bolnick
2012 The Genetic Impact of Aztec Imperialism: Ancient Mitochondrial DNA Evidence from Xaltocan, Mexico. *American Journal of Physical Anthropology* 149:504–516.
McBride, George M., and Merle A. McBride
1942 Highland Guatemala and its Maya Communities. *Geographical Review* 32:252–268.
McClung de Tapia, Emily
2012 Silent Hazards, Invisible Risks: Prehispanic Erosion in the Teotihuacan Valley, Central Mexico. In *Surviving Sudden Environmental Change: Understanding Hazards, Mitigating Impacts, Avoiding Disasters*, edited by Jago Cooper and Payson D. Sheets, pp. 143–165. University Press of Colorado, Boulder.
McClung de Tapia, Emily, and Carmen C. Adriano-Morán
2012 Stable Carbon Isotopes Applied to Landscape Reconstruction in the Teotihuacan Valley, Mexico. *Boletín de la Sociedad Geológica Mexicana* 64:161–169.
McClung de Tapia, Emily, and Diana Martínez Yrizar
2005 Paleoethnobotanical Evidence from Postclassic Xaltocan. In *Production and Power at Postclassic Xaltocan*, edited by Elizabeth M. Brumfiel, pp. 207–232. University of Pittsburgh and the Instituto Nacional de Antropología e Historia, Pittsburgh and Mexico City.
McClung de Tapia, Emily, and Yoko Sugiura
1999 Prehispanic Life in a Man-Made Island Habitat in Chignahuapan Marsh, Santa Cruz Atizapan, State of Mexico, Mexico. Report submitted to the Foundation for Advancement of Mesoamerican Studies, Inc. (FAMSI). Electronic document, http://www.famsi.org/reports/98024/index.html, accessed March 2015.
McClung de Tapia, Emily, Irma Domínguez-Rubio, Jorge Gama-Castro, Elizabeth Solleiro, and Sergey Sedov
2005 Radiocarbon Dates from Soil Profiles in the Teotihuacan Valley, Mexico: Indicators of Geomorphological Processes. *Radiocarbon* 47:159–175.
McClung de Tapia, Emily, Elizabeth Solleiro-Rebolledo, Jorge Gama-Castro, José Luís Villalpando, and Sergey Sedov
2003 Paleosols in the Teotihuacan Valley, México: Evidence for Paleoenvironment and Human Impact. *Revista Mexicana de Ciencias Geológicas* 20:270–282.
McClung de Tapia, Emily, José Luís Villalpando, Elizabeth Solleiro, and Jorge Gama
2004 Prácticas agrícolas prehispánicas en el valle de Teotihuacan, Estado de México: Evidencias químicas y morfológicas. In *Homenaje a Jaime Litvak*, edited by Antonio Benavides, Linda Manzanilla, and Lorena Mirambell, pp. 63–80. Instituto de Investigaciones Antropológicas, Universidad Nacional Autónoma de México, and the Instituto Nacional de Antropología e Historia, Mexico City.
Melville, Elizabeth G. K.
1994 *A Plague of Sheep: Environmental Consequences of the Conquest of Mexico*. Cambridge University Press, Cambridge.
Morehart, Christopher T., and Charles Frederick
2014 The Chronology and Collapse of Pre-Aztec Raised Field (*Chinampa*) Agriculture in the Northern Basin of Mexico. *Antiquity* 88:531–548.
Nichols, Deborah L.
1980 *Prehispanic Settlement and Land Use in the Northwestern Basin of Mexico, the Cuautitlan Region.* Ph.D. dissertation, Department of Anthropology, Pennsylvania State University, University Park. University Microfilms International, Ann Arbor, MI.
1987 Risk, Uncertainty, and Prehispanic Agricultural Intensification in the Northern Basin of Mexico. *American Anthropologist* 89:596–616.
2006 Archaeology on Foot: Jeffrey Parsons and Anthropology at the University of Michigan. In *Retrospectives: Works and Lives of Michigan Anthropologists*, edited by Derek Brereton, pp. 106–135. Michigan Discussions in Anthropology, No. 16. Department of Anthropology, University of Michigan, Ann Arbor.
2013 In the Shadow of the Pyramids: The Postclassic Teotihuacan Valley. *Journal of Cultural Symbiosis Research* 8:65–82.
Parsons, Jeffrey R.
1971 *Prehistoric Settlement Patterns in the Texcoco Region, Mexico*. Memoirs of the Museum of Anthropology, No. 3. University of Michigan, Ann Arbor.
1974 The Development of Prehistoric Complex Society: A Regional Perspective from the Valley of Mexico. *Journal of Field Archaeology* 1:81–108.
2006 *The Last Pescadores of Chimalhuacan, Mexico: An Archaeological Ethnography*. Anthropological Papers, No. 96. Museum of Anthropology, University of Michigan, Ann Arbor.
2008 *Prehispanic Settlement Patterns in the Northwestern Basin of Mexico: The Zumpango Region*. Memoirs of the Museum of Anthropology, No. 45. University of Michigan, Ann Arbor.
2009 Reflections on My Life in Archaeology. *Ancient Mesoamerica* 20:3–13.
2015 An Appraisal of Regional Surveys in the Basin of Mexico, 1960–1975. *Ancient Mesoamerica* 26:183–196.
Parsons, Jeffrey R., Elizabeth M. Brumfiel, and Mary G. Hodge
1996 Developmental Implications for Early Aztec in the Basin of Mexico. *Ancient Mesoamerica* 7:217–230.
Parsons, Jeffrey R., Elizabeth M. Brumfiel, Mary H. Parsons, and David J. Wilson
1982 *Prehispanic Settlement Patterns in the Southern Valley of Mexico: The Chalco-Xochimilco Region*. Memoirs of the Museum of Anthropology, No. 14. University of Michigan, Ann Arbor.
Parsons, Jeffrey R., Keith W. Kintigh, and Susan A. Gregg
1983 *Archaeological Settlement Pattern Data from the Chalco, Xochimilco, Ixtapalapa, Texcoco, and Zumpango Regions, Mexico*. Technical Report, No. 14. Museum of Anthropology, University of Michigan, Ann Arbor.
Robertson, Ian G.
2007 Prehispanic Settlement at Teotihuacan. In *Archaeological Settlement Pattern Data from the Cuautitlan, Temascalapa, and Teotihuacan Regions, Mexico*, pp. 277–279. Occasional Papers in Anthropology, No. 30. Department of Anthropology, Pennsylvania State University, University Park.
Sanders, William T.
1965 *The Cultural Ecology of the Teotihuacan Valley, Mexico*. Department of Sociology and Anthropology, Pennsylvania State University, University Park.
1981 Ecological Adaptation in the Basin of Mexico: 23,000 B.C. to the Present. In *Archaeology*, edited by Jeremy A. Sabloff, pp. 147–187. Supplement to the Handbook of Middle American Indians, Vol. 1, Victoria Bricker, general editor. University of Texas Press, Austin.
1996 Tepetlaoztoc Project: Archaeological Investigations. Report to the Foundation for the Advancement of Mesoamerican Studies, Inc. (FAMSI). Electronic document, http://www.famsi.org/reports/95047/index.html, accessed January 28, 2010.
Sanders, William T., Jeffrey R. Parsons, and Robert S. Santley
1979 *The Basin of Mexico: Ecological Processes in the Evolution of a Civilization*. Academic Press, New York.
Sanders, William T., and L. J. Gorenflo
2007 *Prehispanic Settlement Patterns in the Cuautitlan Region, Mexico*. Occasional Papers in Anthropology, No. 29. Department of Anthropology, Pennsylvania State University, University Park.
Sanders, William T., Michael West, Joseph D. Marino, and Charles Fletcher
1975 *The Teotihuacan Valley Project Final Report, Vol. 2: The Formative Period Occupation of the Valley*. Occasional Papers in Anthropology, No. 10. Department of Anthropology, Pennsylvania State University, University Park.
Sanders, William T., and Robert S. Santley
1983 A Tale of Three Cities: Energetics and Urbanization in Prehispanic Central Mexico. In *Prehistoric Settlement Patterns: Essays in Honor of Gordon R. Willey*, edited by Evon Z. Vogt and Richard M. Leventhal, pp. 243–292. University of New Mexico Press, Albuquerque.
Willey, Gordon R.
1953 *Prehistoric Settlement Patterns in the Virú Valley, Peru*. Bureau of American Ethnography, Bulletin 155. Smithsonian Institution Press, Washington, DC.