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The Neolithic Demographic Transition in Mesoamerica

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The Neolithic demographic transition in Mesoamerica was a gradual process that unfolded over most of the Formative period (1800 BC–AD 200). An analysis of published records of over 6,700 pre-Hispanic burials, focusing on changing proportions of juveniles 5–19 years of age, suggests that fertility rates rose steadily during both the second and the first millennia BC. The gradual pace of the demographic transition was probably related to the low initial productivity of maize.

Bocquet-Appel (2002, 2008, 2011) has developed a new perspective on the demographic transition associated with the emergence of agriculture, termed the "Neolithic demographic transition" (NDT). Building on the observation that shifts from hunting and gathering to agricultural economies stimulated population growth, Bocquet-Appel looks for the effects of higher birthrates in Neolithic cemeteries. The proportion of juveniles in a single-period cemetery provides clues to the age structure of the originating population. The focus is on individuals aged 5–19 years, because very young individuals (0–4 years) are often absent or underrepresented in prehistoric cemeteries (Bocquet-Appel and Naji 2006:341–342). The proportion of juveniles (5–19 years old) relative to all individuals five years or older is a paleodemographic indicator highly correlated with the birthrate (Bocquet-Appel 2002:638–643). In growing populations, the proportion of young individuals is high, whereas in shrinking populations it is low. Therefore, we would expect growing populations to generate cemeteries with high proportions of 5–19-year-olds, a statistic abbreviated as ${}_{15}p_5$. Stationary or declining populations would yield cemeteries with low values of ${}_{15}p_5$.

There is considerable noise in such data, but Bocquet-Appel was able to identify an NDT in prehistoric Europe by introducing a relative chronology based on the wavelike spread of agriculture across the continent. The absolute age of each cemetery was converted into a chronological position relative to the local arrival of the Neolithic (dt). The leading edge of the Neolithic expansion always corresponded to dt = 0. Values of dt for Mesolithic cemeteries therefore were negative, whereas those for Neolithic cemeteries were positive. With the data aggregated in this way, a distinct rise in values of ${}_{15}p_5$ with the initial Neolithic, signaling a rise in the birthrate, is identifiable (Bocquet-Appel 2002, fig. 4). Extensions of these techniques have identified similar demographic transitions in multiple world areas (Bocquet-Appel 2008), including the Levant (Guerrero, Naji, and Bocquet-Appel 2008), North America generally (Bocquet-Appel and Naji 2006), and the U.S. Southwest in particular (Kohler et al. 2008).

In this paper, we present a comparable analysis for Mesoamerica. Previous considerations of the NDT in this region did not involve an effort to assemble the skeletal evidence (Bandy 2005; Lesure 2008). Results suggest that the NDT in Mesoamerica was a gradual process that unfolded over the entire Formative period (1800 BC–AD 200).

Data and Methods

Our data set includes information on 2,250 Formative, 2,296 Classic, and 2,158 Postclassic burials compiled primarily from published records (see table 1; for references, see table A1; tables A1, A2 available online). Archaic burials (table A2) are too few for meaningful analysis. Figure 1 presents a simplified Mesoamerican chronology, and figure 2 gives a map of sites. In this section, we briefly summarize methodological issues and challenges.

Skeletal Samples

Pre-Hispanic cemeteries are rare in Mesoamerica. Burials were often around residences, resulting in small excavated assemblages. We have used particularly residential assemblages that include individuals of a range of ages. Following Kohler et al. (2008), we have in numerous instances pooled small samples from the same region and period (table A1). For comments on our rejection of certain cases, see section 1 of supplement A, available online.

For the Formative era, we set a minimum sample size at 11 because below that the expected number of juveniles (5–19 years) for a population with zero growth falls below 2. For urban communities of the Classic and Postclassic, a sample size of 11 hardly seemed acceptable. For those periods we required a minimum sample size of 22 (twice that for the Formative).

Ages Estimates

Calculation of the paleodemographic indicator used to detect the NDT (${}_{15}p_5$) requires that ages 0–4 years be distinguished from 5+ years and that 5–19 years be distinguished from 20+ years. Many Mesoamerican burials are not published at the required level of detail. Published age breakdowns often

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Table 1. Samples used in the analysis

Sample code	Phase or period midpoint	Sites	Earliest ceramics in years BC (dt = 0)	n (5–19)	n (5+)	${}_{15}p_5$
Central Mexico:						
CM1	250 BC	Chupicuaro (20)	1000	64.4	311.4	.21
CM2	AD 650	La Mesa (40)	1700	14.15	46.8	.30
CM3	AD 1000	Tula (73)	1700	13.89	63.8	.22
CM5	AD 1210	Cholula (19)	1700	88.81	380.4	.23
CM6	650 BC	Chalcatzingo (14)	1800	13.8	100.8	.14
CM7	1100 BC	Chalcatzingo (14), Gualupita (32), Nexpa (46)	1800	4	23	.17
CM8	800 BC	El Arbolillo (27), Zacatenco (78)	1700	9	58	.16
CM9	400 BC	Buenaventura (9), Terremote-Tlatenco (64), Tlapacoya (70)	1700	20.54	113.2	.18
CM10	AD 425	Teotihuacan: various residential contexts (62)	1200	72.79	349.2	.21
CM11	400 BC	Ticoman (65)	1700	8.5	54.5	.16
CM12	1200 BC	Tlatilco (71)	1700	54	329	.16
CM13	AD 1423	Tenochtitlán (60)	1700	48.49	280.8	.17
CM14	AD 1300	Teotenango (61)	1700	89.59	391.2	.23
Western Mexico:						
WM1	AD 1200	Alta Vista (2)	600	2.87	23.5	.12
WM2	AD 685	Chalpa (15), Juana Gomez (37), Penales (48), Tecualilla (59)	1000	17.3	105.1	.16
WM3	AD 1050	Guadalupe (31)	1700	16.41	94.4	.17
WM4	1250 BC	El Opeño (28)	1700	29.5	250	.12
WM5	AD 1438	Urichu (75)	1000	7.35	30	.25
Guerrero:						
G1	700 BC	Chilpancingo (18), Tixtla (69)	1700	2.6	23.6	.11
Southern highlands:						
SH1	550 BC	Coatepec (21), Cuicatlan (24), Quachilco (51)	1700	2	14	.14
SH2	400 BC	Fabrica San Jose (29), Huitzo (34), Monte Albán (45), San Sebastian Abasolo (54), Tierras Largas (66), Tomaltepec (72)	1800	10.97	72.6	.15
SH3	AD 500	Monte Albán (45)	1800	26.31	131.1	.20
SH4	1400 BC	San Jose Mogote (52), various sites (54, 66, 72)	1800	10	97.17	.10
SH5	800 BC	Various sites (29, 34, 66, 72)	1800	5	35	.14
Eastern Mesoamerica:						
EM1	750 BC	Chiapa de Corzo (16), Mirador (43)	1700	2.5	15.5	.16
EM2	400 BC	Chiapa de Corzo (16), Mirador (43)	1700	11.2	53.2	.21
EM3	75 BC	Chiapa de Corzo (16)	1700	3	15	.20
EM4	AD 75	Chiapa de Corzo (16)	1700	8.1	52.1	.16
EM5	1500 BC	Chilo (17), Paso de la Amada (49), Vivero (76)	1900	4.97	30.4	.16
EM6	AD 1	Dzibilchaltun (26)	900	1.3	12.3	.11
EM7	AD 1300	Mayapan (42)	900	45.78	217.78	.21
EM8	AD 775	Dzibilchaltun (26), Oxkintok (47), Xuenkal (77), Tancah (57)	900	31.82	104.7	.30
EM9	AD 1492	Iximche (36)	1000	19.37	102.5	.19

EM10	AD 1	Tikal (67), Uaxactun (74)	1000	3	17	.18
EM11	AD 600	Tikal (67), Uaxactun (74)	1000	34.22	122.2	.28
EM12	AD 600	Tayasal (58)	900	5.69	35.38	.16
EM13	650 BC	Altar de Sacrificios (3), Seibal (55)	1000	4.34	21.34	.20
EM14	75 BC	Various sites (3, 50, 55)	1000	3.5	18.5	.19
EM15	AD 375	Various sites (3, 50)	1000	5.68	26.68	.21
EM16	AD 700	Various sites (3, 5, 25, 35, 41, 50, 55, 56, 1)	1000	19.7	149.7	.13
EM17	AD 850	Various sites (3, 25, 50, 55)	1000	12.51	95.51	.13
EM18	AD 50	Balberta (7)	1800	3	15	.20
EM19	700 BC	Cuello (23), K'axob (38)	1000	8	31	.26
EM20	325 BC	Cuello (23), K'axob (38)	1000	30.25	135	.22
EM21	AD 1450	San Pedro (53), Caye Coco (13)	1100	11.34	53.1	.21
EM22	AD 575	Caracol (11)	1100	33	173	.19
EM23	600 BC	Altun Ha (4), Barton Ramie (8)	1100	7.84	47.09	.17
EM24	AD 600	Various sites (5, 6, 8, 44, 10)	1100	55.15	309.2	.18
EM25	AD 1000	Various sites (4, 6, 8)	1100	8.27	36.52	.23
EM27	650 BC	Copan (22), Gordon's Cave 3 (3)	1700	8.99	38	.24
EM28	AD 550	Copan (22)	1700	16.95	151.5	.11

required probabilistic conversions of categories that cross one or both ends of the 5–19 interval. We developed a set of rules—inspired by those of Bocquet-Appel (2002, online supplement)—for calculating *n* for 5–19 years and *n* for 20+ years for the skeletal assemblages listed in tables 1 and A1. The rules are provided in supplement A (section 2). Also provided is a report on how changes to those rules would affect results (section 4).

Chronological Issues

In previous studies of the NDT, relative chronology makes the phenomenon detectable (Bocquet-Appel 2002; Bocquet-Appel and Naji 2006; Guerrero, Naji, and Bocquet-Appel 2008; Kohler et al. 2008). The use of relative chronology is most clearly appropriate for cases in which agriculture spread from an initial heartland. In such cases, a relative chronology aligns diverse sequences with respect to the phenomenon of interest, the transition to an agricultural economy. Bellwood (2005:237–244) proposes a plausible perspective on how the transition to maize as a staple in Mesoamerica might have generated population expansions from multiple heartlands. However, that scenario is not reliable enough to provide a relative chronology for present purposes. It is even debatable how to set the 0 point of the relative chronology for Mesoamerica (Lesure 2008:109), although in our view the only viable choice is the shift from Archaic to Formative, a moment that has the advantage of an identifiable proxy in the appearance of pottery (in each case, well-fired ceramic containers). That transition occurred simultaneously at 1800 ± 100 BC in numerous regions across Mesoamerica; however, in the Maya Lowlands it was delayed by some 700 years (Clark and Cheetham 2002, fig. 2).

In one version of our analysis, we use a relative chronology with dt = 0 for each region set at the time of the local appearance of ceramics. However, we argue that an absolute chronology produces more intelligible results. Kohler and Varien (2010, fig. 3.2) have also shifted to an absolute chronology in recent work on the NDT in the U.S. Southwest (cf. Kohler et al. 2008).

Phase (or period) beginning and ending dates for each sample are provided in table A1. Our calculations presented here use phase midpoints (table 1) to place samples in time. In supplement A (section 5) we report on experiments with alternatives to phase midpoints. Sometimes the phase of burials is uncertain; we have tended to use period designations (Classic, Postclassic, etc.) to allow for larger sample sizes. However, we have rejected burials classified only as Formative or Preclassic, insisting instead on divisions within that era—Early Formative, Middle Formative, and so forth.

Reporting of Results

Figures 3 and 4 are two visualizations of pre-Conquest Mesoamerican skeletal data, the former in relative time and the latter in absolute time. The *Y*-axis represents ${}_{15}p_5$. An important feature of the charts that will merit discussion below is the dotted horizontal line at the value of ${}_{15}p_5 = 0.17$. This we have adopted from Bocquet-Appel (2002, fig. 4). It represents the expected proportion of juveniles in cemeteries of a stationary population (Bocquet-Appel 2002:638–643).

Following previous studies of the NDT, we use a loess curve

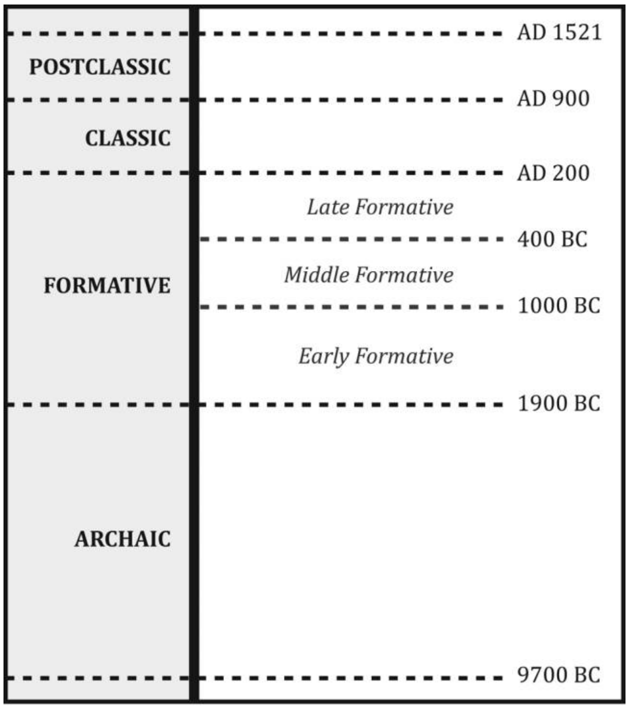

Figure 1. Chronology for ancient Mesoamerica.

(a weighted linear least squares regression that serves as a kind of moving average) to explore the relationship between variables (carried out using the local polynomial regression fitting [loess] function in R ver. 2.15.3). The regression curve is calculated using a locally weighted polynomial regression. A smoothing parameter (α) determines how much of the data is used to fit each local polynomial (see Kohler et al. 2008:651), taking into account the effect of outliers. Following Kohler et al. (2008), our curves are weighted by sample size. Also following Kohler et al. (2008), we compared the goodness of fit of the line in figure 4 ($\alpha = .5$) with a straight line ($\alpha = 1.0$; SAS ver. 9.4, PROC LOESS). Comparison yields an F (df = 2.4, 47.4) = 4.22, $P = .042$. The loess line displays a significantly better fit than a straight line through the data points.

Results

The plot in relative time (fig. 3) is most directly comparable to studies of the NDT in other world areas. The shape of the curve, with a steep rise in ${}_{15}p_5$ from dt = 0, follows expectations based on those studies (see Bocquet-Appel 2008, fig. 1; Kohler et al. 2008, fig. 4). A departure from results for other regions (evident as well in fig. 4) is that the Mesoamerican curves begin well below ${}_{15}p_5 = 0.17$, the value expected for a population with zero growth. We consider that issue below.

Our dissatisfaction with figure 3 is based on a more subtle observation. For the first 1,000 years after dt = 0, all the high values (>.17) of ${}_{15}p_5$ are samples from the first millennium BC that because of a later local start date for ceramics are placed alongside second millennium BC samples in the relative chronology. A Mann-Whitney U-test finds that first millennium BC samples with dt < 1,000 are significantly different from the second millennium BC sites at a 0.10 level but not at a 0.05 level ($N_{\text{first mil BC}} = 9$ with mean rank = 9.0; $N_{\text{second mil BC}} = 5$ with mean rank = 4.8; $U = 9$; $P < .083$). The first millennium BC samples with dt < 1,000 are, instead, collectively similar to the other first millennium BC samples—that is, those for which dt ≥ 1,000 ($N_{\text{dt} < 1,000} = 9$ with mean rank = 12; $N_{\text{dt} \geq 1,000} = 11$ with mean rank = 9.3; $U = 63$; $P > .33$).

We suggest that absolute time matters—that all the first millennium BC samples actually belong together. Collectively, they have a character distinct from the second millennium BC samples. Specifically, the upper range of ${}_{15}p_5$ values is higher in the first millennium than in the preceding second millennium. Some other variable besides relative time elapsed since the local shift to sedentism/pottery/agriculture may have affected birthrates during the Formative. The variable we suggest is changing productivity of the crop complex, in particular maize.

Benz and Long (2000) and Benz et al. (2009) calculated rates of change in rachis diameter, row number, cupule width, and rachid length of accelerator mass spectrometry–dated maize cobs from dry caves in the Tehuacan Valley. Although results vary somewhat among the caves, the overall picture is that maize cobs in this region increased significantly in size in the Formative and later eras, suggesting increasing productivity. Rates of morphological change in the Formative through Postclassic were actually greater than or equal to those of the Late Archaic–Early Formative, and change may have accelerated in the first millennium BC in comparison with the preceding second millennium (Benz et al. 2009:90).

Indeed, there is growing evidence of the mixed character of subsistence during the second millennium BC. Wild foods were still important in relation to maize. It may be that it was not until after 1000 BC that maize truly became a dietary staple (Arnold 2009; Killion 2013; Smalley and Blake 2003; VanDerwarker 2006:37; Webster 2011).

The likelihood of change in the productivity of the agricultural package during the Formative prompts us to favor figure 4, which charts ${}_{15}p_5$ values in absolute time. The curve is simple. There is a gradual increase in ${}_{15}p_5$ throughout the two millennia of the Formative. The curve crosses ${}_{15}p_5 = 0.17$ at around 600 BC and peaks around AD 1. At that point, values stabilize.

Bocquet-Appel (2002) used simulated results based on 45 life tables with preindustrial mortality to show that ${}_{15}p_5$ could be used as a proxy for birthrate. Based on figure 4, then, we would postulate a gradual NDT in Mesoamerica that extended throughout most of the Formative, with birthrates steadily increasing. The first millennium BC emerges as a crucial era

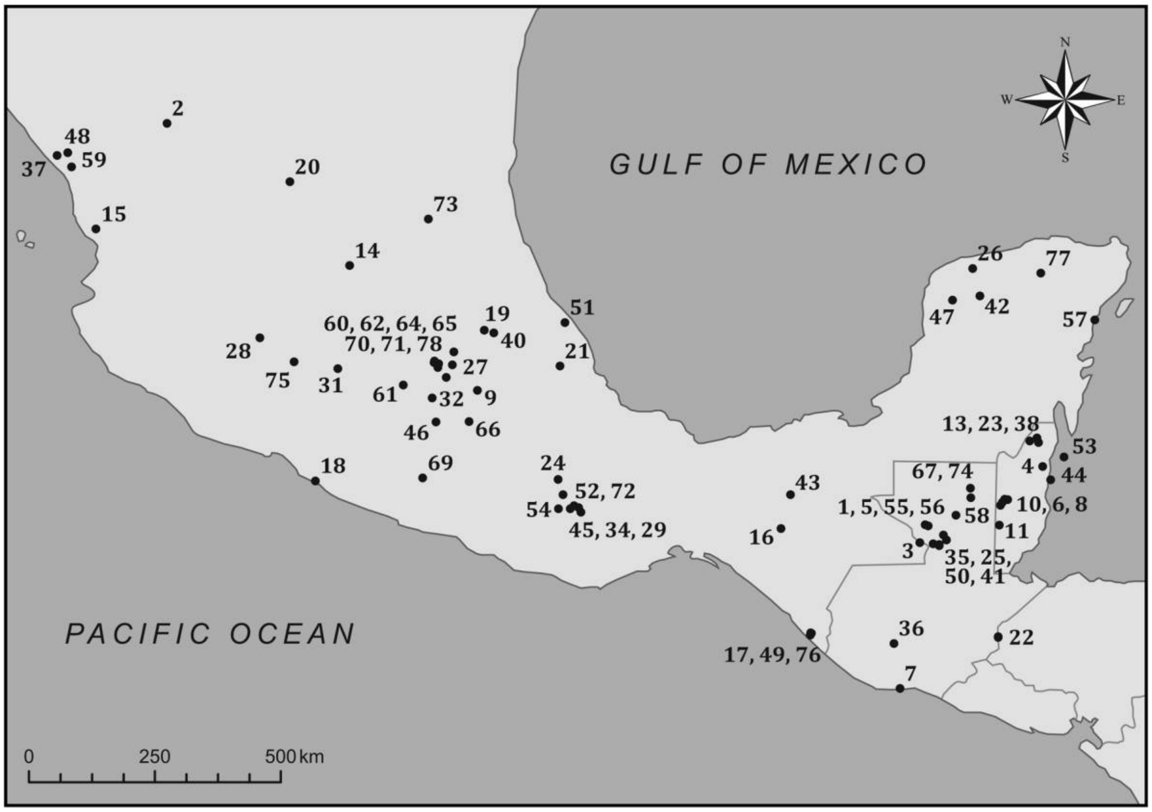

Figure 2. Location of sites used in analysis of Mesoamerican burials (for site names, see table 1).

of the Mesoamerican NDT. Fertility rates were higher at this time than in the preceding second millennium BC.

Supporting Evidence from Regional Surveys

A lengthy NDT for Mesoamerica would be consistent with patterns in other core regions of the development of agriculture (Bellwood and Oxenham 2008:30; Bocquet-Appel and Naji 2006:347; Guerrero, Naji, and Bocquet-Appel 2008:75). The idea that the first millennium BC was crucial in the demographic transition is also consistent with the observation, based on surveys across Mesoamerica, that it is particularly during the Middle Formative (1000–400 BC) that there is an explosion of population in one region after another.

Using a formula introduced by Bandy (2005) for investigating the NDT based on population data from regional surveys, figure 5 quantifies growth rates (not raw populations) over the course of the Formative for three parts of the Basin of Mexico, the Amatzinac Valley (Morelos), the Tepeaca region (Puebla), two sets of subregions in the Valley of Oaxaca, and Kaminaljuyu (Guatemala). Only growth rates greater than 0 are shown. Results are calculated by phase, making the curves a series of horizontal plateaus. Because the formula for calculating population growth involves dividing the estimated population of a given phase by the population of the previous phase, each curve begins with the second local Formative phase. Because the time of initial settlement in each area is nevertheless of interest, we have introduced a dotted line in each case from the beginning of each curve down to a value of zero growth at the beginning of the local Formative; it should be remembered that the actual value for growth in each initial phase is unknown. Castanzo (2002) did not identify any Early Formative occupation in the Tepeaca region but estimated 14,557 people in the Middle Formative; in order to register this remarkable growth, we have assumed that he missed a population of 200 in the Early Formative.

The cases illustrated reveal explosive growth during the Middle Formative, generally tapering off before the end of the first millennium BC. For the Valley of Oaxaca (cases 6 and 7), Bandy's (2005) proposed Early Formative NDT—signaled by a rise and subsequent drop in growth rate—is evident, as are the higher Middle Formative growth rates previously remarked on by Lesure (2008:131–133); both episodes should now be seen as part of an extended NDT. Middle Formative growth was particularly explosive in areas adjacent to centers of Early Formative population concentration (cases 1, 2, 5, and perhaps 7). It is noteworthy, however, that even in Early Formative "heartlands" (cases 3, 4, 6), the Middle Formative witnessed a significant additional phase of growth

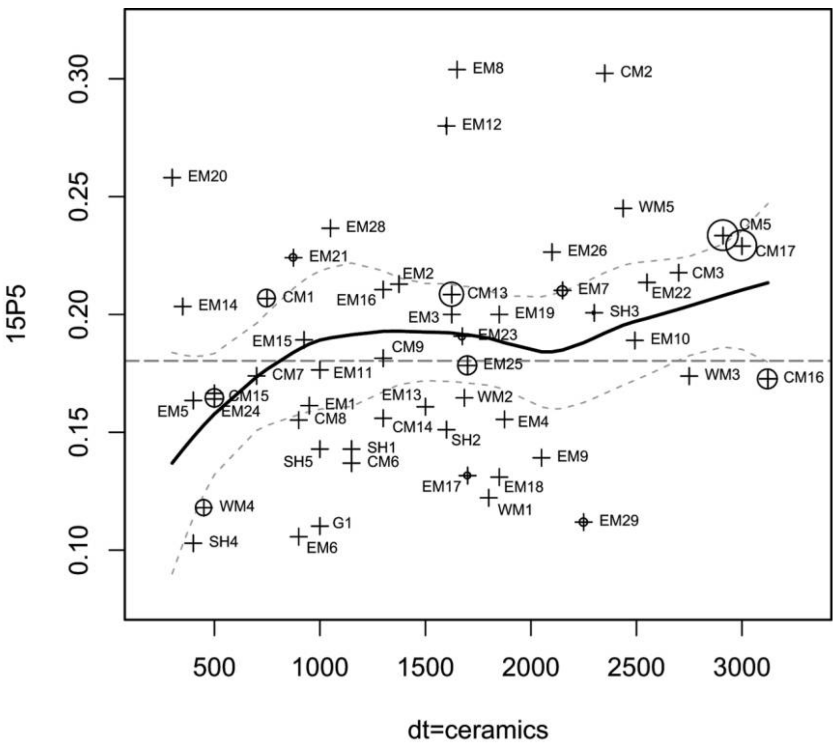

Figure 3. Observed profile of ${}_{15}p_5$ on a relative chronology from the adoption of ceramic technology. Relationship fitted using a loess fitting procedure (α [smoothing parameter] = .5; *n* observations = 52).

that outstripped any rates registered before 1000 BC. Overall, the cases examined support the idea of a lengthy NDT with the first millennium BC a key era in the demographic transition.

Low Proportions of Juveniles

In sum, interpretation of figure 4 as a general representation of changing birthrates in pre-Conquest Mesoamerica and evidence of a lengthy demographic transition extending throughout the Formative fits with other Mesoamerican data. There remains, however, the puzzle that the actual values observed for ${}_{15}p_5$ in Mesoamerica are persistently below those observed for other world regions (fig. 6). Early Formative Mesoamerican values begin well below the value expected of a stationary population (the horizontal dotted line). During the course of the NDT, they rise to a level only modestly above that. If we were to postulate that the low Early Formative values from Mesoamerica constitute a sampling error, with actual values around 0.17, then we would essentially wipe out any trace of an NDT signature for the Formative.

Could there be a pervasive, systematic bias in our data resulting in artificially low values of ${}_{15}p_5$ for Mesoamerican burial assemblages? Certainly there are reasons for caution concerning the quality of the available data (see supplement A for details). Age classifications in published reports are often crude. In the later Formative and Classic periods, excavations biased toward monumental site centers or elite contexts may yield assemblages in which adults are overrepresented. Still, given the momentous social changes in Mesoamerica from initial Formative to Late Postclassic and the diversity in burial practices between regions and time periods, we find it implausible that a single biasing factor such as a systematic underrepresentation of children could uniformly pervade the entire pre-Hispanic burial record.

Let us instead reconsider ${}_{15}p_5 = 0.17$ as the expected value in a stationary population and more generally the relation between ${}_{15}p_5$ and the growth rate. Bocquet-Appel's simulated stationary populations suggested that ${}_{15}p_5$ could be used as an estimator of both birthrate and growth rate; the value of 0.17 for a growth rate (r) of 0 derives from the equation generated in that study, $r = -0.05389 + 0.12555 \times ({}_{15}p_5)0.47788$ (Bocquet-Appel 2002, table 2). However, the relation between ${}_{15}p_5$ and growth rate is likely to be more complicated than originally postulated. Bocquet-Appel (2008:46–52) seems to admit as much in a later publication, when he suggests that increased mortality balanced the Neolithic increase in fertility to yield growth rates of 0.1%–0.2%, much more modest than values generated in the formula for r given variation in ${}_{15}p_5$ from the 2002 publication. This suggestion undermines confidence in the value of 0.17 as a lower threshold for ${}_{15}p_5$ in stationary populations because there is no systematic relation between ${}_{15}p_5$ and mortality (Bocquet-Appel 2008:48).

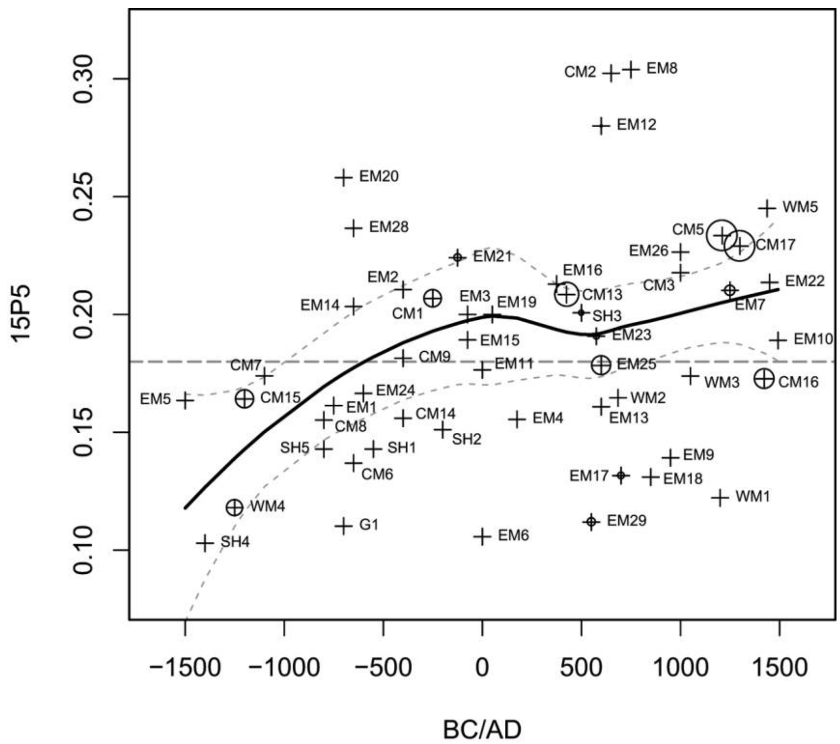

Figure 4. Observed profile of $_{15}p_5$ on an absolute chronology (BC/AD). Relationship fitted using a loess fitting procedure (α [smoothing parameter] = .5; *n* observations = 52).

We propose to accept $_{15}p_5$ values from Mesoamerica as a proxy for birthrates but not growth rates. The unusually low values of $_{15}p_5$ in Early Formative assemblages (in comparison to early Neolithic values from other world areas) may be a symptom of lower productivity of the Mesoamerican agricultural package, particularly in its early stages. However, there is a remaining problem to be addressed: why does the NDT curve for the U.S. Southwest diverge so dramatically from that for Mesoamerica?

Mesoamerica and the U.S. Southwest

The $_{15}p_5$ curve for the U.S. Southwest falls in among Old World cases, while $_{15}p_5$ values for Mesoamerica are distinctly lower (fig. 6). At first glance, this result seems to undermine our suggestion that low values for Mesoamerica were the result of the modest expansionary potential of the initial agricultural package. Because the Southwest received its important crops from Mesoamerica, it is tempting to treat the crop complexes in the two cases as essentially the same. But were they really the same? We suggest that the agricultural packages that fueled NDTs in the two cases were not the same. A significant difference was that the two NDTs drew on the shared crop complex at different points in absolute time and therefore different moments in the development of the crops.

Figure 7 places the two curves together on an absolute timescale. The Southwest data are from Kohler et al. (2008, table 1), with the addition of a single first millennium BC sample from La Playa, Sonora (Watson 2005). In the Southwest case, we have eliminated samples with $n\ (5+) < 11$, the rule we have used to screen our Formative samples. In the figure, the NDT in the Southwest is clearly evident, beginning approximately AD 500 and thus some 2,300 years after the initiation of a much more gradual NDT, with lower associated birthrates, in Mesoamerica.

The NDT in Mesoamerica began at the Archaic-Formative transition based on relatively unproductive maize with small cobs (Kirkby 1973:126; see also Benz and Long 2000; Benz et al. 2009). Fertility increased slowly from the initial Formative. In the U.S. Southwest before about AD 500, values of $_{15}p_5$ coincide with those of the same era in Mesoamerica. It is only with the onset of the NDT that values soar rapidly. We conclude that the NDT in the Southwest, beginning about AD 500, started from a fertility baseline that was essentially the same as that of contemporary sites in Mesoamerica. In the more marginal desert environments of the Southwest, the shared agricultural package of the second and first millennia BC was probably not sufficiently productive to fuel even a gradual NDT such as transpired in Mesoamerica. It was only with the development or introduction of new varieties of maize in the first millennium AD—along with other developments such as pottery, locally effective storage techniques,

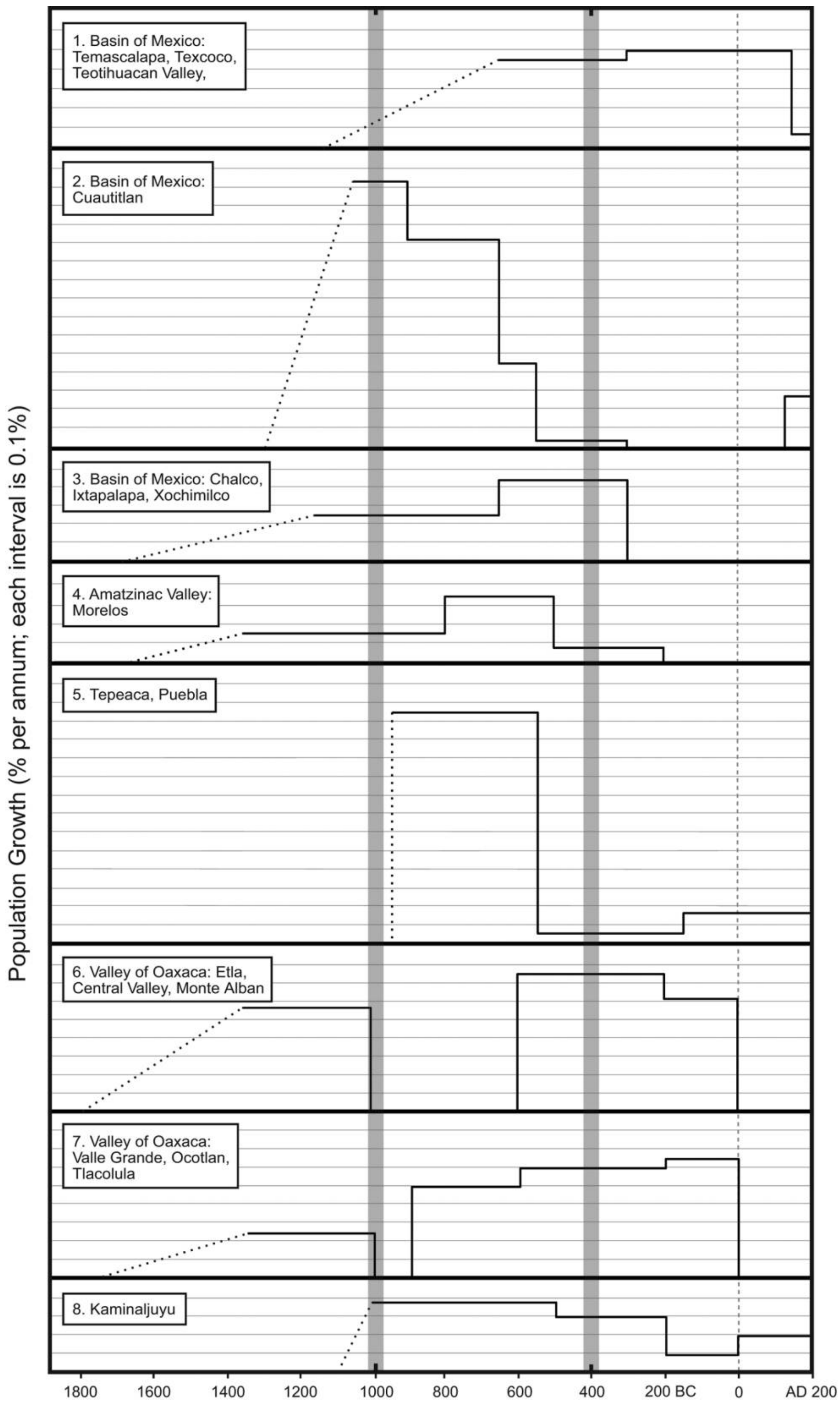

Figure 5. Eight cases of Formative-era population growth per year calculated from settlement data using a formula introduced by Bandy (2005). The era between 1000 and 400 BC is the Middle Formative. Data sources: Blanton (1972), Blanton et al. (1982), Gorenflo and Sanders (2007), Kowalewski et al. (1989), Michels (1979), Parsons (2008), Parsons, Kintigh, and Gregg (1983).

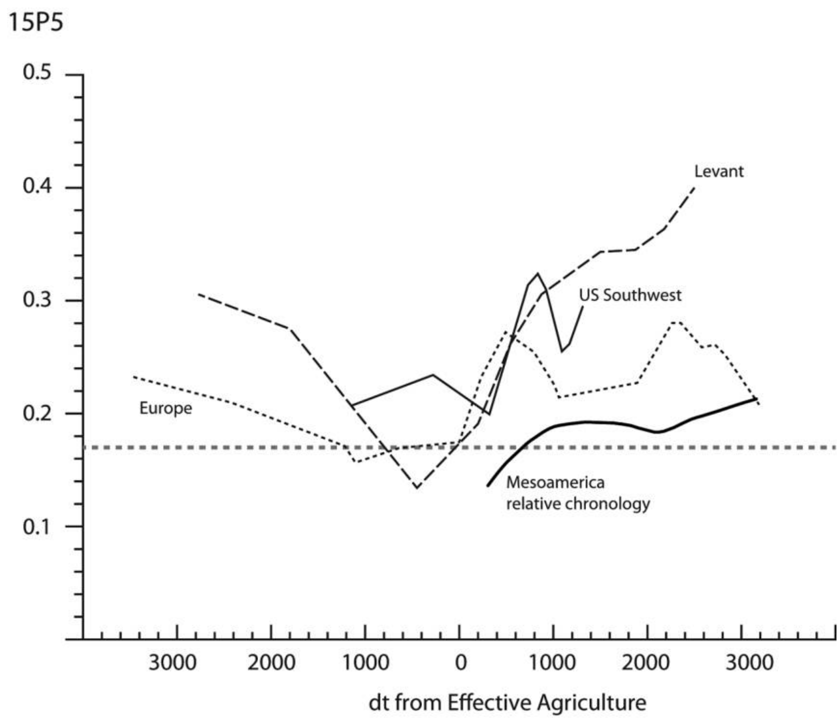

Figure 6. Loess fitted curve from figure 4 compared with curves previously published for Europe (α = .3; Bocquet-Appel 2002, fig. 4), the Levant (α = .5; Guerrero, Naji, and Bocquet-Appel 2008, fig. 2), and the U.S. Southwest (α = .56; Kohler et al. 2008, fig. 4).

and social mechanisms facilitating exchange (Kohler et al. 2008:662)—that the NDT arrived in the U.S. Southwest.

Aside from the gap in time between the two NDTs, the two other features that distinguish the NDT of the Southwest from that of Mesoamerica are its more sudden, explosive character and its higher associated birthrates. To some extent, these differences may be expected when a secondary region is compared with a primary region of agricultural origin (Bellwood and Oxenham 2008:30). The NDT of the Levant, however, though gradual, yielded birthrates similar to those in regions of the secondary spread of the Levantine agricultural complex (fig. 6). The higher birthrates achieved during the NDT in the Southwest (compared with Mesoamerica) may be related to the more productive agricultural package on which it was based. By the first millennium AD, Mesoamerica may have been essentially saturated as a result of over 2,000 years of more gradual population expansion. It is intriguing that toward the middle of the second millennium AD, just before the arrival of the Spanish, birthrates in the Southwest appear to have descended to values similar to contemporaneous rates in Postclassic Mesoamerica (fig. 7).

Conclusion

Our analysis of data from pre-Conquest Mesoamerican burials suggests that the demographic transition associated with the emergence of an agricultural economy extended throughout the two millennia of the Formative era. In comparison to other world regions, including the U.S. Southwest, Mesoamerican skeletal assemblages are characterized by lower proportions of young individuals 5–19 years of age throughout the NDT. We attribute this pattern to the initially low productivity of the Mesoamerican agricultural complex. The higher birthrates that characterize the NDT in the U.S. Southwest may be attributed to the different historical moment of the Southwestern NDT: the demographic transition in the Southwest, from AD 500, was based on a significantly more productive crop complex than that of the second millennium BC, when the Mesoamerican NDT began.

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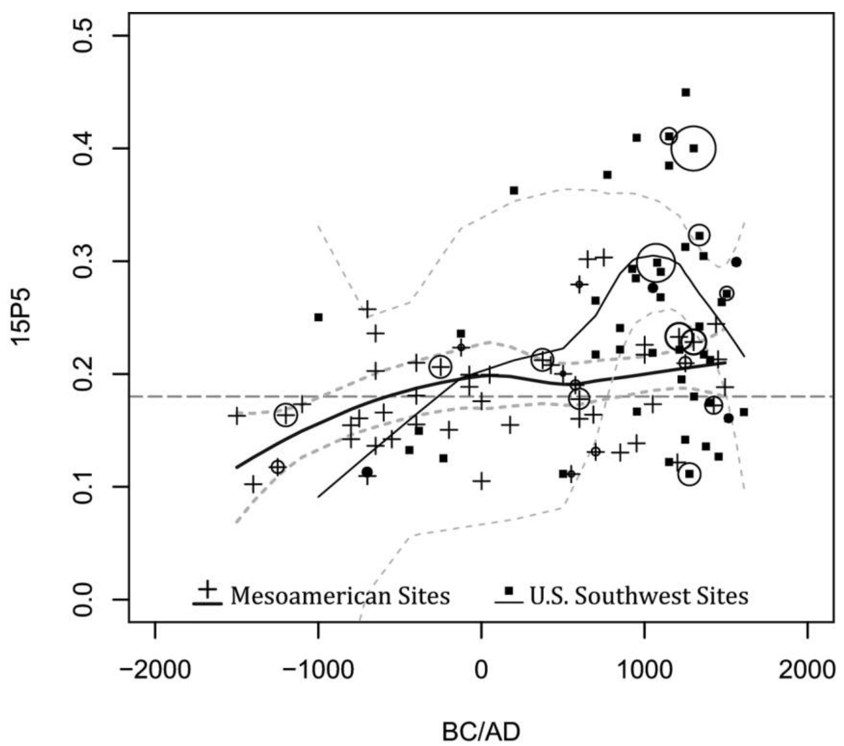

Figure 7. Comparison of separately observed profiles of ${}_{15}p_5$ from Mesoamerica and the U.S. Southwest on an absolute chronology (BC/AD; α = .5; *n* observations = 52, 46). A color version of this figure is available online.

References Cited

Arnold, Philip J., III. 2009. Settlement and subsistence among the Early Formative Gulf Olmec. *Journal of Anthropological Archaeology* 28:397–411.

Bandy, Matthew S. 2005. New World settlement evidence for a two-stage Neolithic demographic transition. *Current Anthropology* 46(suppl.):S109–S115.

Bellwood, Peter. 2005. *First farmers: the origins of agricultural societies.* Malden: Blackwell.

Bellwood, Peter, and Marc Oxenham. 2008. The expansions of farming societies and the role of the Neolithic demographic transition. In *The Neolithic demographic transition and its consequences.* J.-P. Bocquet-Appel and O. Bar-Yosef, eds. Pp. 13–34. New York: Springer.

Benz, Bruce F., Li Cheng, Steven W. Leavitt, and Chris Eastoe. 2009. El Riego and early maize agricultural evolution. In *Histories of maize: multidisciplinary approaches to the prehistory, linguistics, biogeography, domestication, and evolution of maize.* J. Staller, R. Tykot, and B. Benz, eds. Pp. 73–82. Walnut Creek, CA: Left Coast Press.

Benz, Bruce F., and Austin Long. 2000. Prehistoric maize evolution in the Tehuacán Valley. *Current Anthropology* 41:460–465.

Blanton, Richard E. 1972. *Prehispanic settlement patterns of the Ixtapalapa peninsula region, Mexico.* Occasional Papers in Anthropology, no. 6. University Park: Department of Anthropology, Pennsylvania State University.

Blanton, Richard E., Stephen A. Kowalewski, Gary M. Feinman, and Jill Appel. 1982. *Monte Albán's hinterland, part I: the prehispanic settlement patterns of the central and southern parts of the Valley of Oaxaca, Mexico.* Memoir, no. 15. Ann Arbor: Museum of Anthropology, University of Michigan.

Bocquet-Appel, Jean-Pierre. 2002. Paleoanthropological traces of a Neolithic demographic transition. *Current Anthropology* 43:637–650.

———. 2008. Explaining the Neolithic demographic transition. In *The Neolithic demographic transition and its consequences.* J.-P. Bocquet-Appel and O. Bar-Yosef, eds. Pp. 35–55. New York: Springer.

———. 2011. The agricultural demographic transition during and after the agriculture inventions. *Current Anthropology* 52(suppl. 4):S497–S510.

Bocquet-Appel, Jean-Pierre, and Stephan Naji. 2006. Testing the hypothesis of a worldwide Neolithic demographic transition: corroboration from American cemeteries. *Current Anthropology* 47:341–365.

Castanzo, Ronald A. 2002. The development of socio-economic complexity in the Formative period: central Puebla-Tlaxcala Basin, Mexico. PhD dissertation, Pennsylvania State University, University Park.

Clark, John E., and David Cheetham. 2002. Mesoamerica's tribal foundations. In *The archaeology of tribal societies.* W. A. Parkinson, ed. Pp. 278–339. Archaeological Series, no. 15. Ann Arbor, MI: International Monographs in Prehistory.

Gorenflo, Larry J., and William T. Sanders. 2007. *Archaeological settlement pattern data from the Guautitlan, Temascalapa, and Teotihuacan regions, Mexico.* Occasional Papers in Anthropology, no. 30. University Park: Department of Anthropology, Pennsylvania State University.

Guerrero, Emma, Stephan Naji, and Jean-Pierre Bocquet-Appel. 2008. The signal of the Neolithic demographic transition in the Levant. In *The Neolithic demographic transition and its consequences.* J.-P. Bocquet-Appel, O. Bar-Yosef, eds. Pp. 57–80. New York: Springer.

Killion, Thomas W. 2013. Nonagricultural cultivation and social complexity: the Olmec, their ancestors, and Mexico's southern Gulf Coast lowlands. *Current Anthropology* 54:569–606.

Kirkby, Anne V. T. 1973. *The use of land and water resources in the past and present Valley of Oaxaca, Mexico*, vol. 1. Memoir, no. 5. Ann Arbor: Museum of Anthropology, University of Michigan.

Kohler, Timothy A., Matt P. Glaude, Jean-Pierre Bocquet-Appel, and Brian M. Kemp. 2008. The Neolithic demographic transition in the U.S. Southwest. *American Antiquity* 73:645–669.

Kohler, Timothy A., and Mark D. Varien. 2010. A scale model of seven hundred years of farming settlements in southwestern Colorado. In: *Becoming villagers: comparing early village societies.* M. S. Bandy and J. R. Fox, eds. Pp. 37–61. Tucson: University of Arizona Press.

Kowalewski, Stephen A., Gary M. Feinman, Laura Finsten, Richard E. Blanton, and Linda M. Nicholas. 1989. *Monte Albán's hinterland, part II: prehispanic settlement patterns in Tlacolula, Etla, and Ocotlan, the Valley of Oaxaca, Mexico.* Memoir, no. 23. Ann Arbor: Museum of Anthropology, University of Michigan.

Lesure, Richard G. 2008. The Neolithic demographic transition in Mesoamerica? larger implications of the strategy of relative chronology. In *The Neolithic demographic transition and its consequences*. J.-P. Bocquet-Appel and O. Bar-Yosef, eds. Pp. 107–138. New York: Springer.

Michels, Joseph A. 1979. "A history of settlement at Kaminaljuyu." In *Settlement pattern excavations at Kaminaljuyu, Guatemala*. Joseph W. Michels and William T. Sanders, eds. Pp. 277–306. University Park: Pennsylvania State University Press.

Parsons, Jeffrey R. 2008. *Prehispanic settlement patterns in the northwestern Valley of Mexico: the Zumpango region*. Memoir, no. 45. Ann Arbor: Museum of Anthropology, University of Michigan.

Parsons, Jeffrey R., Keith W. Kintigh, and S. A. Gregg. 1983. *Archaeological settlement pattern data from the Chalco, Xochimilco, Iztapalapa, Texcoco, and Zumpango regions, Mexico*. Technical Report, no. 14. Ann Arbor: Museum of Anthropology, University of Michigan.

Smalley, John, and Michael Blake. 2003. Sweet beginnings: stalk sugar and the domestication of maize. *Current Anthropology* 44:675–703.

VanDerwarker, Amber M. 2006. *Farming, hunting, and fishing in the Olmec world*. Austin: University of Texas Press.

Watson, James T. 2005. *Cavities on the cob: dental health and the agricultural transition in Sonora, Mexico*. PhD dissertation, University of Nevada, Las Vegas.

Webster, David L. 2011. Backward bottlenecks. *Current Anthropology* 52:77–104.