POPULATION DENSITY IN THE CLASSIC MAYA LOWLANDS: NEW EVIDENCE FOR OLD APPROACHES*

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> I told Morley that in my then several years of experience in the chicle business I had supervised the felling and burning of many hundreds—I might say thousands—of acres of forest land, both in southern Campeche and at present in Petén. . . . Without exception in this vast area—one hundred leagues in length—these clearings, upon being burnt, showed every evidence that practically all the land had been occupied by small house-sites and land under cultivation. Morley violently disagreed with me on this point. He told me that he would not dare to return to Cambridge with any such theory.[1]

POPULATION density is one of the most important and controversial issues surrounding the Lowland Maya Classic civilization, which occupied the Yucatán peninsular area between approximately A.D. 200 and A.D. 900 to 1000 (Fig. 1). Scholars have devoted considerable attention to this topic in order to gain insight into Maya sociopolitical organization and ecological problems and into the development and demise of the civilization. Two approaches have been used to calculate the density of peak populations in the lowlands: estimates based on the prevalence of relic house sites; and estimates based on agricultural carrying capacity.

The house site approach attempts to establish the maximum density of population for a specific locale. It has been applied to several civic-temple centers and adjacent areas in the lowlands, where large numbers of relic house sites suggest that Classic populations were large and that settlement was dense. For instance, Haviland concludes that central Tikal, a major civic-temple center, maintained peak population densities of 600 to 700 people per square kilometer.[2] Likewise, Puleston calculates a population density of 300 persons per square kilometer for the intersite area between Tikal and its neighbor, Uaxactún.[3]

The agricultural approach (carrying capacity) has been used to establish maximum potential population densities for the entire Maya lowlands and for specific regions within the lowlands. These estimates are generally based on contemporary

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* Revised from a paper presented at the fifth annual meeting of the Conference of Latin Americanist Geographers, Boca Raton, Florida, December, 1974. I thank W. M. Denevan and R. E. W. Adams for comments and Joseph Ball for ceramic analysis. Also acknowledged for assistance are the National Geographic Society and the Instituto Nacional de Antropología e Historia, Mexico. Financial aid was provided by the National Science Foundation and the Ibero-American Studies Program of the University of Wisconsin—Madison.

[1] P. W. Schufeldt: Reminiscences of a Chiclero, *in* Morleyana (School of Amer. Research and the Museum of New Mexico, Santa Fe, 1950), pp. 224–229, reference on pp. 225–226. Sylvanus G. Morley was one of the most noted Maya archaeologists of his time (see "The Ancient Maya" [Stanford Univ. Press, Stanford, Calif., 1946]).

[2] William A. Haviland: Tikal, Guatemala and Mesoamerican Urbanism, *World Archaeol.*, Vol. 2, 1970, pp. 186–198, reference on p. 193.

[3] Dennis E. Puleston: Intersite Areas in the Vicinity of Tikal and Uaxactun, *in* Mesoamerican Archaeology—New Approaches (edited by Norman Hammond; Univ. of Texas Press, London, 1974), pp. 303–311, reference on p. 309. The distance between Tikal and Uaxactún is approximately eighteen kilometers.

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swidden (slash-and-burn) production in the lowlands and are then applied to the Classic Maya. It is assumed that the Classic lowland civilization was supported by a short fallow swidden system of cultivation with maize as the principal crop. Cowgill calculates that the swidden carrying capacity of northern Petén ranges from 38 to 77 inhabitants per square kilometer.[4] Similarly, Vogeler suggests that swidden cultivation could support 28 to 85 persons per square kilometer in the Río Bec region.[5]

Thus considerable discrepancies exist in the maximum population estimates derived from the two approaches. The discord has provoked a series of arguments over the validity of both approaches and over the accuracy of the resulting estimates. Thompson suggests that the large house site estimates are inflated, owing to the erroneous assumption of the contemporaneity of the occupancy of the house sites.[6] Haviland and Willey and others counter with evidence that most of the house sites at Tikal and Barton Ramie were occupied simultaneously during the Late Classic Period.[7] Likewise, Reina questions the accuracy of the high carrying capacity estimates obtained by Cowgill in Petén.[8]

The population controversy stems largely from the traditional view that the subsistence economy of the Classic Maya was dominated by swidden agriculture. Therefore, it has been assumed that large populations and dense settlements could not have been supported over an extended lowland area.[9] Indeed, traditional estimates of maximum population densities in the lowlands are low, usually falling below about 30 people per square kilometer.[10] Many of the estimates from the more recent house site studies suggest densities of population that appear much too large to have been supported solely by swidden cultivation. This latter assessment is further enhanced by the fact that the maximum density figures obtained from house site surveys are often reduced, apparently in order to produce an estimate more in line with the traditional view.[11] Even after such reductions, estimates from the house site

[4] Ursula M. Cowgill: Soil Fertility and the Ancient Maya, *Trans. Connecticut Acad. of Arts and Sci.*, Vol. 42, 1961, pp. 1–56, reference on p. 39.

[5] Ingolf Vogeler: The Cultural Ecological Setting of Southeastern Campeche, *in* Preliminary Reports on the Archaeology of the Rio Bec Region (compiled by R. E. W. Adams; *Middle Amer. Research Inst., Tulane Univ., Publ. No. 31,* New Orleans, 1974), pp. 110–111, reference on p. 111. I have not been able to compute the same density figures using the same data and carrying capacity formula as Vogeler did. My calculations are 22 to 65 people per square kilometer.

[6] J. Eric S. Thompson: Estimates of Maya Population: Deranging Factors, *Amer. Antiquity,* Vol. 36, 1971, pp. 214–216.

[7] William A. Haviland: Estimates of Maya Population: Comments on Thompson's Comments, *Amer. Antiquity,* Vol. 37, 1972, pp. 261–262; and Gordon R. Willey, William R. Bullard, Jr., John B. Glass, and James C. Gifford: Prehistoric Maya Settlement in the Belize Valley, *Papers Peabody Mus. of Archaeol. and Ethnol., Harvard Univ.,* Peabody Museum, Cambridge, Mass., Vol. 54, 1965.

[8] Ruben E. Reina: Milpas and Milperos: Implications for Prehistoric Times, *Amer. Anthropol.,* Vol. 69, 1967, pp. 1–20.

[9] Sylvanus G. Morley: The Ancient Maya (revised by George W. Brainerd; 3rd edit.; Stanford Univ. Press, Stanford, Calif., 1956), p. 47.

[10] Several examples of traditional population estimates include: 6.6 people per square kilometer (Franz Termer: The Density of Population in the Southern and Northern Maya Empires as an Archaeological and Geographical Problem, *in* The Civilizations of Ancient America: Selected Papers of the 29th International Congress of Americanists [edited by Sol Tax; Cooper Square Publ., Inc., New York, 1967], pp. 101–107, reference on p. 106); 12 people per square kilometer (Morley, *op. cit.* [see footnote 9 above], p. 47); and 23 people per square kilometer (Joseph A. Hester: Natural and Cultural Bases of Ancient Maya Subsistence Economy [unpublished Ph.D. dissertation, Dept. of Anthropology, Univ. of California, Los Angeles, 1954], p. 129).

[11] Oliver G. Ricketson and Edith B. Ricketson: Uaxactun, Guatemala, Group E 1926–1937, *Carnegie Inst. of Washington Publ. No. 477,* Washington, D.C., 1937, p. 23; and William R. Bullard, Jr.: Maya Settlement Pattern in Northeastern Petén, Guatemala, *Amer. Antiquity,* Vol. 25, 1960, pp. 355–372, reference on p. 366.

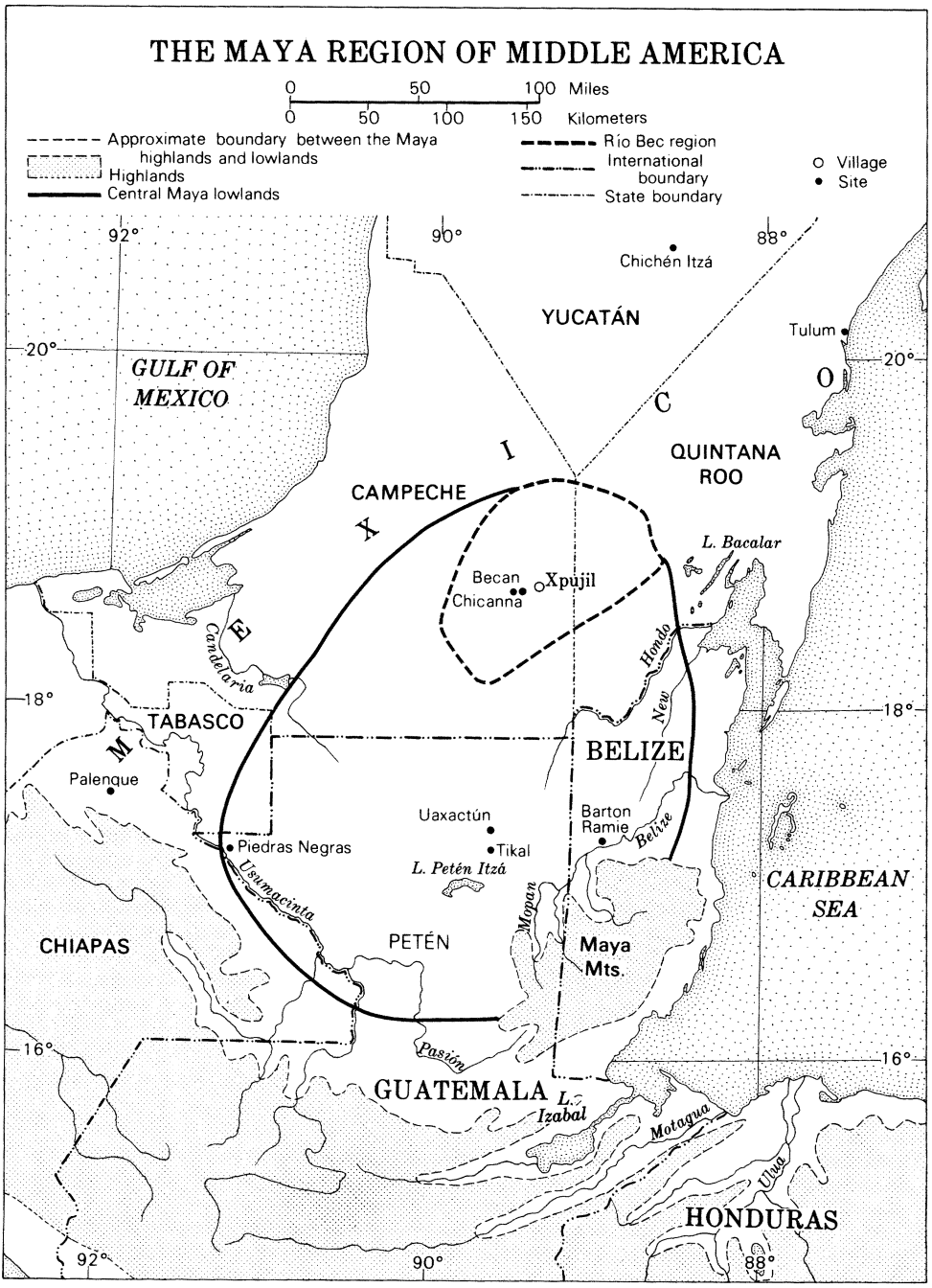
THE MAYA REGION OF MIDDLE AMERICA
0 50 100 Miles
0 50 100 150 Kilometers
Approximate boundary between the Maya highlands and lowlands
Highlands
Central Maya lowlands
Río Bec region
International boundary
State boundary
Village
Site
92°
90°
88°
20°
18°
16°
Chichén Itzá
YUCATÁN
Tulum
GULF OF MEXICO
CAMPECHE
QUINTANA ROO
L. Bacalar
Becan
Chicanna
Xpujil
Candelaria
Hondo
New
TABASCO
BELIZE
Palenque
Uaxactún
Barton Ramie
Tikal
Piedras Negras
Usumacinta
Belize
L. Petén Itzá
CARIBBEAN SEA
CHIAPAS
PETÉN
Mopan
Maya Mts.
Pasión
GUATEMALA
L. Izabal
Motagua
Ulua
HONDURAS

FIG. 1

studies exceed the carrying capacity of most swidden systems in the tropics. For example, a productive swidden system, such as that suggested by Cowgill, could have supported the estimated population of Tikal (45,000) if a large zone for swiddens had been available near the civic-temple center.[12] Coe estimates that this agricultural zone would have to have encompassed an area of about 500 square kilometers.[13] However, the area surrounding Tikal is dotted with relic house sites, temples, and other large civic-temple centers, testifying that it too was densely settled.[14]

Clarification of the population controversy may be forthcoming. Recent discoveries of relic terraces and raised fields throughout the central portion of the Maya lowlands indicate that the Classic civilization was supported by forms of cultivation much more intensive than swidden.[15] Particularly significant has been the identification of large-scale terracing over a 10,000-square-kilometer segment of the Río Bec region and of large complexes of raised fields along the Río Candelaria in Campeche, along the Río Hondo in Belize, and in numerous *bajos* (seasonally inundated depressions) in southern Quintana Roo.[16] This evidence suggests that population densities in the Maya lowlands may have been large.

This study, based on fieldwork conducted in 1973 and 1974, is an evaluation of peak population densities in the Río Bec region, situated in the southeastern and southwestern sectors of Campeche and Quintana Roo, Mexico, respectively (Fig. 1). This segment of the central Maya lowlands is composed of well-drained ridges and hills (or uplands) and poorly drained depressions, either bajos or savannas. The Río Bec area contains a large number of ruins, including house sites, small buildings, and major civic-temple centers such as the fortified site of Becan.[17] These ruins are found primarily on well-drained land and are almost absent in depressions. Both the house site approach and the agricultural approach are used to show that the region probably maintained a large and densely settled populace during the latter stages of the Río Bec Classic Period (ca. A.D. 250–1000) and that the estimates derived from the two approaches are compatible. New evidence is presented concerning the prevalence of rural house sites in the region, and the relic terraces and raised fields are used to evaluate carrying capacities.

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[12] Ursula M. Cowgill: An Agricultural Study of the Southern Maya Lowlands, *Amer. Anthropol.*, Vol. 64, 1962, pp. 273–286.

[13] William R. Coe: Tikal: Ten Years of Study of a Maya Ruin in the Lowlands of Guatemala, *Expedition,* Vol. 8, No. 1, 1965, pp. 5–56, reference on p. 52.

[14] Puleston, *op. cit.* [see footnote 3 above].

[15] Raised-field cultivation has often been overlooked as a principal technique of land reclamation and as an indicator of intensive cultivation in the tropics (see W. M. Denevan and B. L. Turner II: Forms, Functions and Associations of Raised Fields in the Old World Tropics, *Journ. Tropical Geogr.*, Vol. 39, 1974, pp. 24–33.

[16] B. L. Turner II: Prehistoric Intensive Agriculture in the Mayan Lowlands, *Science,* Vol. 185, 1974, pp. 118–124. For a more detailed discussion, see B. L. Turner II: Prehistoric Intensive Agriculture in the Mayan Lowlands: New Evidence from the Río Bec Region (unpublished Ph.D. dissertation, Dept. of Geography, Univ. of Wisconsin—Madison, 1974). See also Alfred H. Siemens and Dennis E. Puleston: Ridged Fields and Associated Features in Southern Campeche: New Perspectives on the Lowland Maya, *Amer. Antiquity,* Vol. 37, 1972, pp. 228–239; Gerald W. Olson: Field Report on Soils Sampled Around San Antonio in Northern Belize, *Cornell Agronomy Mimeo 74–23,* 1974; and Peter D. Harrison: Archaeology in Southwestern Quintana Roo: Interim Report of the Uaymil Survey Project (paper presented at the XLI Congreso Internacional de Americanistas, Mexico City, 1974).

[17] Most of the archaeological research at Becan has been conducted by the Middle American Research Institute under the directorship of E. Wyllys Andrews IV (see Preliminary Reports [see footnote 5 above]).

House Site Approach

A total of 142 house sites have been identified on 106 hectares of terraced fields in various sectors of the Río Bec area, a frequency of one house site for every 0.74 hectare or 1.34 house sites per hectare.[18] To calculate a population density based on these data two variables must be considered: the average number of occupants per house site; and the number of house sites simultaneously inhabited. Because house site investigations in the Río Bec region are in their infancy specific data concerning the two variables are limited and comparable figures must be drawn from more thorough house site examinations in other sectors of the lowlands.

A common estimate of the number of occupants per house site is five, though Willey and others suggest an average house site occupancy of 7.5 at Barton Ramie.[19] Following Naroll's formula, Puleston calculates an average of 5.4 persons per house site for the Tikal-Uaxactún intersite area.[20] If the more conservative figure of 5 persons per house site is applied to the Río Bec data, the maximum (rural) population density for areas in which terraced fields have been discovered is 670 inhabitants per square kilometer.

This Río Bec estimate is based on the assumption that all 142 house sites were simultaneously occupied during specific cultural phases of the Late Classic Period. Maximum figures have been lowered by some Maya scholars by as much as 75 percent in order to compensate for any errors that may result from the contemporaneity of the house sites in question.[21] The 75 percent correction factor is quite large, and despite the arguments of Thompson and of Sanders, there is no substantial evidence which would suggest that such large reductions are warranted for periods of peak population.[22] To the contrary, investigations at Tikal and Barton Ramie demonstrate the opposite. At both sites, 95 percent or more of the house sites examined are believed to have been occupied during the Late Classic Period.[23]

Initial Río Bec data conform to the Tikal and Barton Ramie pattern of occupation. Ceramic evidence suggests that the house sites excavated in conjunction with this study (four in terraced fields) were inhabited during the Río Bec Late Classic Period (A.D. 730–830).[24] If subsequent research indicates that these sites were continuously occupied throughout the entire period, then a large reduction in the Río Bec house

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[18] Most rural house sites in the Río Bec region appear as rectangular rubble platforms with sides of ten meters or less. In this study, each platform is considered to represent one house site. Larger ruins, with sides exceeding ten meters, occur at a frequency of one per 2.35 hectares of terraced land in the Río Bec area.

[19] Bullard, *op. cit.* [see footnote 11 above], p. 366; and Willey and others, *op. cit.* [see footnote 7 above], p. 576.

[20] Raoul Naroll: Floor Area and Settlement Population, *Amer. Antiquity,* Vol. 27, 1962, pp. 587–589; and Puleston, *op. cit.* [see footnote 3 above], p. 309.

[21] Ricketson and Ricketson, *op. cit.* [see footnote 11 above], p. 23; and Bullard, *op. cit.* [see footnote 11 above], p. 366.

[22] Thompson, *op. cit.* [see footnote 6 above]; and William T. Sanders: The Cultural Ecology of the Lowland Maya: A Reevaluation, *in* The Classic Maya Collapse (edited by T. Patrick Culbert; Univ. of New Mexico Press, Albuquerque, 1973), pp. 325–365, reference on pp. 329–332.

[23] William A. Haviland: A New Population Estimate for Tikal, Guatemala, *Amer. Antiquity,* Vol. 34, 1969, pp. 429–433; *idem,* Tikal [see footnote 2 above]; T. Patrick Culbert: The Lost Civilization: The Story of the Classic Maya (Harper and Row, Publishers, New York, 1974), pp. 44–55; and Willey and others, *op. cit.* [see footnote 7 above]. These conclusions are based primarily on ceramic studies of house sites.

[24] House sites were excavated by Jack Eaton and Jennifer Tascheck Ball, and ceramic dating was conducted by Joseph Ball, all members of the 1973 National Geographic Society—University of Texas at San Antonio and University of Wisconsin—Madison Río Bec Project.

site population estimate may not be necessary. Even if the estimate of 670 persons per square kilometer of terraced fields is lowered by 75 percent, the resulting density is 168 persons per square kilometer of terraced fields. This lower figure considerably exceeds Cowgill's and Vogeler's potential population densities (77 and 85 people per square kilometer, respectively) under swidden cultivation and is in accord with Sanders's latest assessment of population densities of 100 to 200 inhabitants per square kilometer in the more densely settled zones of the Maya lowlands.[25]

Río Bec house sites are not limited to terraced slopes. Ruins, including house sites, are more frequent on level, noninundated terrain. Also located in more level areas are such civic-temple centers as Becan and Chicanna, which undoubtedly contained large numbers of people. Thomas offers evidence that a 2.5-square-kilometer area adjacent to Becan may have once maintained a dense population.[26] Including only rectangular platforms, vaulted structures, and undifferentiated mounds with a diameter larger than six meters, 404 residential structures are identified in the zone inspected. Assuming 5.6 people per house site, Thomas calculates an "extremely conservative estimate" of about 900 people per square kilometer.

Considering the minimum population estimate (about 170 people per square kilometer) associated with the terraced fields, the high densities of population surrounding civic-temple centers (such as the 900 inhabitants per square kilometer suggested for the periphery of Becan), and the biotic zones that generally lack ruins (about 35 percent of the area),[27] the Río Bec region may have maintained an average minimum density of population of 150 to 160 persons per square kilometer, or a total of 1,500,000 to 1,600,000 people in the Late Classic Period.[28] This estimate is probably conservative, for it assumes that only 25 percent of the house sites located on terraced land were occupied simultaneously. Furthermore, it does not consider the population of central Becan, Chicanna, and other civic-temple centers in the region. If further investigations establish that the central sectors of these centers were densely settled and that most of the house sites were inhabited contemporaneously, then the maximum average population density for the Río Bec region during the Late Classic Period may have been as high as, or higher than, 500 people per square kilometer.

These estimated densities are not exorbitant in light of the Río Bec house site data and of the mounting evidence from other lowland locales that such sites tended to be inhabited contemporaneously,[29] for "the principal of least effort makes it seem unlikely that the Maya would have been prone to abandon perfectly good platforms [house sites] and invest the considerable amount of time necessary to build new ones, just because the houses on top of the platforms were getting rickety."[30] Furthermore,

[25] Sanders, *op. cit.* [see footnote 22 above], p. 332.

[26] Prentice M. Thomas, Jr.: Prehistoric Settlement at Becan: A Preliminary Report, *in* Preliminary Reports [see footnote 5 above], pp. 139–146.

[27] The biotic zones that exhibit few, if any, ruins of inhabited structures include bajos and savannas. A high number of ruins, including house sites, ring bajos that contain relics of raised fields (see Harrison, *op. cit.* [see footnote 16 above], pp. 1–3).

[28] These figures are based on the minimum population estimates for terraced land, on the estimate by Thomas (*op. cit.* [see footnote 26 above]) of the density of population surrounding Becan, and on the assumption that the two estimates are applicable to 60 percent and 5 percent of the Río Bec region (about 10,000 square kilometers), respectively.

[29] Willey and others, *op. cit.* [see footnote 7 above], p. 576; Haviland, Tikal [see footnote 2 above]; *idem,* Estimates of Maya Population [see footnote 7 above]; *idem,* New Population Estimate [see footnote 23 above]; *idem,* Family Size, Prehistoric Population Estimates, and the Ancient Maya, *Amer. Antiquity,* Vol. 37, 1972, pp. 135–139.

[30] Culbert, Lost Civilization [see footnote 23 above], p. 45.

it seems unlikely that Maya farmers would waste agricultural land by the needless construction of a new house platform when an old platform could be rebuilt.

I suggest, therefore, that the density of population in the Río Bec area during peak periods (probably the Late Classic) ranged from an average minimum of 150–160 to a maximum of 500 persons or more per square kilometer. Specific population densities obviously varied from one locale to another. Larger civic-temple centers, such as Becan, maintained densities greater than 500 people per square kilometer, and some rural areas may have been unoccupied.

Agricultural Approach

Agriculturally based estimates of potential population size or density in the Maya lowlands must be viewed with caution, for they are contingent on numerous assumptions and interpretations. Such estimates (carrying capacity) rely on formulas that purport to measure, given the habitat and a particular mode of cultivation, the maximum population size or density beyond which the process of land degradation will begin. Specific data required to compute the maximum potential population size or density usually include the intensity and productivity of the agricultural system in question and the amount of cultivable land available to the system. Since specific information pertaining to Classic Maya agriculture has been limited, modern assessments of agriculture have often been used as a measure of carrying capacities during ancient times.[31] As such, carrying capacity estimates of the lowlands can become a mental exercise wherein any number of potential population figures may be established by manipulating the variables.[32]

Despite the shortcomings, the agricultural approach is one of the few methods that allows the computation of crude, but possible, population densities for the Classic Maya. Carrying capacity assessments have been used in support of various theories concerning actual and potential densities in the lowlands during past times and often are used to justify the reductions of large population estimates obtained from house site studies.[33] Because the carrying capacity estimates of the lowlands are usually based on swidden agriculture and on the limited cultivation techniques associated with this mode of cropping, it is enlightening to demonstrate potential Maya population densities based on nonswidden systems of cultivation. To this end, the relic terraces and raised fields in the Río Bec region are particularly significant, for they represent the pursuit of large-scale intensive agriculture.

Relic agricultural features yield considerable insight into the cropping patterns of the Río Bec Maya. The remnants of stone terraces and raised fields indicate that past agricultural activities differ considerably from modern swidden cultivation in the lowlands. In particular, such relics suggest an annual or almost annual cropping pattern and the potential to crop almost any type of terrain, including uplands, bajos, and savannas.

I have computed several potential population sizes and densities for the Río Bec region, based on the cultivation of maize under various levels of agricultural intensity and corresponding cropping techniques (Table I). As the intensity increases from

[31] Willey and others, *op. cit.* [see footnote 7 above], p. 577; and William A. Haviland: Prehistoric Settlement at Tikal, *Expedition,* Vol. 7, No. 3, 1965, pp. 14–23, reference on p. 23.

[32] For an example of carrying capacity manipulation see Sanders, *op. cit.* [see footnote 22 above], pp. 342–343.

[33] Willey and others, *op. cit.* [see footnote 7 above], p. 577.

level 1, forest fallow, to level 6, multicropping, a parallel increase in potential population sizes and densities occurs. The population potential applicable to the Río Bec Maya depends on the particular level of cultivation pursued. The relics of terraces and raised fields found throughout the Río Bec zone indicate that this level most likely ranged from semipermanent grass fallow (level 4) to intensive multicropping cultiva-

TABLE I—POTENTIAL RÍO BEC POPULATION DENSITIES, BASED ON LEVELS OF AGRICULTURAL INTENSITY*

LEVEL OF AGRICULTURAL INTENSITY	MAXIMUM CULTIVABLE LAND AVAILABLE (L) (*in square kilometers*)	MINIMUM AVERAGE UNITS OF CROPPED LAND REQUIRED PER INDIVIDUAL PER YEAR (A) (*in hectares*)	MINIMUM AVERAGE DURATION OF THE FULL AGRICULTURAL CYCLE (T) (*in years*)	CRITICAL POPULATION SIZE, OR CARRYING CAPACITY (C_s)	POTENTIAL POPULATION DENSITY (*per square kilometer*)
Swidden agriculture:					
1. Forest fallow	1,696	0.50	21.0	16,152	6
2. Bush fallow	1,696	0.50	11.0	30,836	11
3. Bush fallow	1,696	0.50	5.0	67,840	24
Semipermanent agriculture:					
4. Grass fallow	2,121	0.50	2.0	212,100	75
Intensive agriculture:					
5. Annual	2,543	0.50	1.0	508,600	180
6. Multicropping	2,543	0.50	0.5	1,017,200	360
7. Annual	2,543	0.28	1.0	908,214	321
8. Multicropping	2,543	0.28	0.5	1,816,428	643

* The computations use the formula developed by Conklin (*op. cit.* [see text footnote 34], p. 63), $C_s = L/AT$. The area under consideration includes 2,826 square kilometers around Xpujil, Campeche, Mexico.

tion (level 6). The corresponding potential population densities range from about 75 to 640 people per square kilometer.

These carrying capacity estimates are derived by applying figures obtained from other studies of contemporary maize-swidden cultivation in the Maya lowlands to Conklin's measure of critical population size or carrying capacity $C_s = L/AT$.[34] The maximum cultivable land available, L, will vary in accordance with the cropping techniques used. Swidden cultivation is largely restricted to the uplands, which comprise about 60 percent of the Río Bec area.[35] Semipermanent cultivation, given the use of semiterracing and minor drainage techniques, can be pursued on about 75 percent of the land. Intensive terracing and raised field cultivation, however, is probably adaptable to at least 90 percent of the Río Bec terrain.

The minimum average unit of cropped land per individual per year, A, is estimated by Vogeler to be 0.5 hectare (0.005 square kilometer) for swidden techniques of cultivation.[36] This figure is based on swidden techniques now used in the Río Bec region and is in accord with other estimates of A in the central lowlands. For instance,

[34] Harold C. Conklin: Population–Land Balance Under Systems of Tropical Forest Agriculture, *Proc. Ninth Pacific Sci. Congr., Pacific Sci. Assn.*, 1957, Vol. 7, 1959, p. 63.

[35] Turner, Prehistoric Intensive Agriculture in the Mayan Lowlands: New Evidence [see footnote 16 above].

[36] Ingolf Vogeler: Frontier Settlements in South-Eastern Campeche: A Report for the 1970 National Geographic Society—Tulane University Archaeological Project at Becan, Campeche, Mexico (unpublished manuscript).

Cowgill notes that only 0.4 hectare is necessary for subsistence for one person near Lake Petén Itzá, and Reina argues that approximately 0.8 hectare per individual per year is a minimal subsistence requirement for the same area.[37] Vogeler's figure of 0.5 hectare is used for variable *A*, for intensity levels 1 through 6.[38]

If, however, the relic terraces and raised fields were cropped with the use of mulches, fertilizers, mounds, and other soil-enhancing measures, agricultural yields undoubtedly increased. Experiments from the central lowlands confirm this assessment. Urrutia finds that agricultural plots which are weeded, mounded, and/or fertilized produce significantly higher yields than typical swidden-cropped plots.[39] Indeed, the average mean increase in production for the "improved plots" is about 90 percent over the swidden plots. Converting this yield increase to the variable *A*, the minimum average units of cropped land per individual per year is lowered to 0.28 hectare. This figure is applied to intensity levels 7 and 8.

It is important to contrast intensive cropping cycles (levels 5 through 8), which are usually predicated on the use of soil-enhancing techniques, with bush fallow cultivation, which is associated with minimal soil care. Urrutia's study indicates that with the use of slash-and-burn techniques of cultivation in the lowlands, an agricultural cycle of six years (1 : 5, or 1 year cultivation and 5 years fallow) is necessary if soil fertility is to be maintained and if the system of cultivation is to have some measure of permanence.[40] However, Urrutia's study only includes the cultivation of maize and does not consider the soil-enhancing qualities of legumes (in this case, beans [*Phaseolus vulgaris* L.]), which were probably an important crop for the Classic Maya. With the cultivation of various legumes, a stable swidden cycle for the central lowlands may well be five years (1 : 4), as Cowgill suggests.[41] This cycle is used for intensity level 3.

Contemporary analogies denote that stone-embanked terraces and raised fields are cropped on an annual or almost annual basis. At a minimum, then, the relic agricultural features of the Río Bec zone indicate semipermanent agriculture: a grass fallow cultivation (1 : 1). More intensive cultivation may have reached the multicropping stage (+2/1 : 0; two or more crops per year, with no appreciable fallow period).

The figures applied to variables *A*, *L*, and *T* for swidden levels of agricultural intensity (1, 2, and 3) are liberal assessments. Despite this generosity, the highest computed population density for swidden cultivation is a mere 24 persons per square kilometer for the Río Bec region. Semipermanent cropping (level 4) can support about 75 people per square kilometer, a figure in line with Vogeler's assessment of a 3:4 swidden cycle in the Río Bec zone.[42] Applying the same production figures (*A*) to intensive cultivation (in which case the figures become conservative rather than generous) raises the potential population densities to 180–360 inhabitants per square kilometer (levels 5 and 6). If *A* is adjusted to account for increased yields under intensive cultivation, the carrying capacity range is enlarged to 321–643 people per square kilometer. The latter figure is larger than the upper house site density figure of 500 inhabitants per square kilometer that I offered for the Río Bec region. In other words, it is

[37] Cowgill, Soil Fertility [see footnote 4 above], p. 15; and Reina, *op. cit.* [see footnote 8 above], p. 15.
[38] Vogeler, Frontier Settlements [see footnote 36 above].
[39] Victor M. Urrutia R.: Corn Production and Soil Fertility Changes under Shifting Cultivation in Uaxactun, Guatemala (unpublished M.S. thesis, Dept. of Agriculture, Univ. of Florida, Gainesville, 1967), p. 85.
[40] *Ibid.*, p. 81.
[41] Cowgill, Soil Fertility [see footnote 4 above], pp. 38–39.
[42] Vogeler, Cultural Ecological Setting [see footnote 5 above].

theoretically possible, given known agricultural techniques, for the Río Bec Maya to have supported the maximum populations associated with the house site estimates.

Obviously, carrying capacity estimates are not precise and should be thought of only as relative measures of "possible" densities of population. Both Cowgill and Vogeler calculated larger carrying capacities for swidden cultivation in the central Maya lowlands by adopting values for A and T that differ from those used here.[43] Furthermore, if crops other than maize are considered—root crops or tree crops, for example—all of the estimates of population density would be raised somewhat.[44] In this instance, the carrying capacity approach is used to demonstrate that large potential population densities can be established for the central Maya lowlands based on evidence of intensive agriculture.

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[43] *Ibid.;* and Cowgill, Agricultural Study [see footnote 12 above], p. 277.

[44] Ethnohistorical evidence indicates that root crops may have been important to the lowland Maya (Bennet Bronson: Roots and the Subsistence of the Ancient Maya, *Southwestern Journ. Anthropol.*, Vol. 22, 1966, pp. 251–279). Also, tree crops, particularly the *ramón (Brosimum alicastrum)* may have been cultivated by the Classic Maya (Dennis E. Puleston: *Brosimum alicastrum* as a Subsistence Alternative for the Classic Maya of the Central Southern Lowlands [unpublished M.A. thesis, Dept. of Anthropology, Univ. of Pennsylvania, Philadelphia, 1968]). Both root crops and ramón have been used to establish carrying capacities for the Maya lowlands (Sanders, *op. cit.* [see footnote 22 above], pp. 342–343).