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Source: *Bulletin of the American Schools of Oriental Research*, No. 295 (Aug., 1994), pp. 31-48

Published by: The University of Chicago Press on behalf of The American Schools of Oriental Research

Stable URL: <https://www.jstor.org/stable/1357103>

Accessed: 29-07-2019 13:52 UTC

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Estimating the Population Size of Ancient Settlements: Methods, Problems, Solutions, and a Case Study

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An important element in any attempt to reconstruct an ancient culture is the ability to estimate the size and distribution of that society's population. Efforts to estimate ancient populations focus on the population size of specific settlements (the micro level) and on entire regions (the macro level). This study evaluates the primary means used to make these estimates: those based on density of habitation coefficients and those based on the availability of natural resources. It then explores their strengths and weaknesses, offering suggestions on how these methods may be improved. The Iron Age site of Tell en-Nasbeh is used as a test case of the site-specific methods. The article shows how different methods may be used together to achieve a population estimate at a site where the architectural pattern for the settlement is reasonably clear. Tell en-Nasbeh probably had a population of 800 to 1000 in the Iron Age II period, and perhaps 400 to 500 in the following Babylonian period.

INTRODUCTION

Interest in calculating the size of ancient populations is itself very old.¹ The Old Testament contains several lists purporting to be enumerations of the fighting men of Israel or Judah or both (e.g., Num 1:20–43; I Sam 24:2–9). The biblical writers also were interested in the areas occupied by the different tribes and provided several lists of tribal boundaries and associated settlements (e.g., Josh 15:1–63). There was little interest in the specific populations of individual towns. It is only with the return from the Babylonian Exile that references to village populations appear (e.g., Ezra 2:26–27). However, the interest of the ancient writers was not that of the modern demographer; and the reliability of their figures is open to doubt.

This article will first review selected modern methods that have been used for estimating ancient Near Eastern populations,² and then will attempt to estimate the population of one site, Tell en-Nasbeh, as a case study.

ESTIMATING POPULATIONS

Reasons for Estimating Populations

There are two main reasons for attempting to estimate the size of ancient populations. The first is at the micro, or site-specific, level; the other is at the macro, or regional, level.

At the micro level interest is primarily to reconstruct the cultural and environmental history of the site. Typical questions would be: Were there significant increases or decreases in the site's population over time, and what light does this shed on the site's function in those periods? How many resources (farm land, grazing land, water, and so on) would be required to support the site's population in a given period? This latter query leads to questions on the size of the area the site would have to control to sustain itself; the size of that area may affect the settlement's relationships with neighboring sites.

At the macro level, interest is in reconstructing settlement patterns in a given region. The relative

populations of the settlements in an area provide information on the social and economic organization of that region in a single period. The study of a series of patterns in one region can show the changing relations (if any) among the settlements through time.

The data these two research goals require are slightly different. At the micro level the need is for a precise population measurement that takes account of observable changes in the site's character. The macro level, often based heavily on survey data, requires a method of estimating the population of sites with possibly differing roles, a method that does not lead to large distortions in the estimates achieved.

Methods of Estimating Populations

Two main methods are used to estimate populations. The first is based on a density-of-habitation coefficient, the other on the availability of natural resources around the site. Density coefficients are based either on a general number of inhabitants per square area, or on the density of dwellings at the site multiplied by an estimate of the number of inhabitants per household.³ We will now examine these methods in more detail, pointing out what each approach requires to provide an accurate estimate, and the general strengths and weaknesses of each procedure. Where possible, ways for improving these methods will be suggested.

Area Estimates

The first method employs a flat density coefficient per square area (hectare, dunam, or acre) and multiplies that coefficient by the area of the site(s). For example, a density of 250 persons per ha at a 2-ha site means a population of 500. This coefficient usually is derived on analogy with pre-modern Muslim settlements, where it is assumed that habitation patterns in the past did not change much until the 20th century (Broshi and Gophna 1984: 41–42; Stone 1987: 2–3; Adams 1981: 69, 143–46; Shiloh 1980: 29).

The major strength of the area estimate is that it allows for quick comparisons of many sites across a region, and so is best used on the macro level. Its weakness is a (usually) unstated assumption about the uniformity of settlement types. That is, it ignores the possibility that sites of different sizes or functions may have different densities of occupa-

tion. For example, a major center with many public buildings may have a lower population density than a fortified rural town. It apparently is assumed that these density inequalities “even out” over a large sample size; this assumption, however, remains to be proven. Another problem involves ascertaining the area of the settlement in different periods. Assuming that the site always occupied its maximum area may skew the results.

The second method relies on an assumed constant minimum amount of floor space required per person. Such estimates have been based on the roofed areas of dwellings (Naroll 1962: 587–89), on total roofed living space (LeBlanc 1971: 210–11), on the total roofed and unroofed area (Marfoe 1980: 318), and on the total area of the building, including walls (Holladay 1992: 308–18). For example, if the average total dwelling size at a site is 80 m², and the total space required per person is 20 m², then the average house will contain four persons, and this formula can be applied as an average across the site. Similarly, if the total roofed dwelling area is estimated to be 10,000 m², using a ratio of 10 m² roofed dwelling area per person yields 1000 inhabitants.

As in the estimate based on family size (below), this method also relies on ethnographic analogy. However, there is no real consensus on which measure provides the most reliable figures, or on what ratio to use for each measure. For example, Naroll (1962: 587–89) proposed a constant of 10 m² of roofed area per person; but Stone (1981: 32) has suggested that at Nippur the constant was 5.31 m² of roofed space per person. As with the estimate based on family size, the floor-area-based estimate also requires a good understanding of the settlement plan. Often the floor areas of buildings are not tabulated in excavation reports; and when such tabulations do exist, they often do not state if the figure is the total area of the building or only the actual floor areas.

Dwelling-Based Estimates

This method is based on estimates regarding the size of the average family inhabiting the individual dwellings. Assume, for example, that in a 2-ha site, ca. 0.2 ha have been excavated and found to contain 50 dwellings. If an average family size of five is assumed, the 50 houses contain 250 people; and since this is one-tenth of the entire site, the

site has a total of 2500 inhabitants (Shiloh 1980: 29; Broshi and Gophna 1984: 42).

This method has the potential to yield a fairly good estimate for a particular settlement, and is well suited to micro-level studies. However, it has several weaknesses. The first involves determining the size of the average family. Although figures cited for this average have ranged between 3.5 and 8 (Russel 1958: 53, Shiloh 1980: 29), a consensus, based on premodern Middle Eastern populations, seems to be emerging that the most reliable figure should lie between 4 and 5.5 (Watson 1979: 47; Kramer 1982: tables 5.1–5.3; Finkelstein 1990: 48–49). The second weakness is in determining the number of families that occupy a single dwelling; a very large dwelling could house several branches of an extended family. The third, and most serious, weakness is that this method requires an accurate appraisal of the settlement's plan. It is crucial to determine what percentage of the site is housing and what percentage is public buildings, roads, and other nonhabitable spaces. Sites with only small exposures cannot provide an accurate estimate using this method.

Natural Resources

Some scholars have attempted to use the natural resources around the site to estimate its population (Rosen 1986; Rosenan 1978; Vita-Finzi 1978: 23–29, 71–87). The number of people regularly inhabiting a stable site cannot exceed the carrying capacity of the land. Farming and grazing land and water are the two most important resources to a preindustrial society and thus have been the resources most used for estimating populations.

For this method to be helpful certain conditions have to be met. In the case of water it is important to be able to estimate all sources of water, along with seasonal variations, available to the community. Such estimates must include, for example, the amount of rainfall that probably fell in the area in the past, and the times of the year during which it fell. The number of springs in the immediate vicinity and the amount of water they produce in different parts of the year must also be determined. One must also gauge the ability of the inhabitants to store water for long periods. Did their settlement have cisterns? If so, how many, and what was the cistern storage capacity? In some periods the use of aqueducts must also be considered. Finally, the

amount of water used by people, and possibly their animals, on a yearly basis must be estimated.

In the case of food there are also many questions. These include: What types of food were consumed by the people and animals, and how much? What is the yield rate for the different soils around the site for different crops? How much land was likely under the control of the settlement? Was there enough land to allow for fallow years? Most of these variables have a range of values, and an optimistic view of the availability of resources could yield a much higher population estimate than a more cautious approach.

All the methods for estimating ancient populations described above rely to some extent on ethnographic analogy. Results based on such analogy are only as good as the degree of similarity between the relevant ancient and modern situations. Some of the densities recently put forward for area coefficients have been based on unwalled, premodern villages (Finkelstein 1990; Watson 1979; Kramer 1982; Van Beek 1982; but not Jacobs 1979; note also Gremliza 1962). How similar is such a village to a walled Bronze or Iron Age town or city? Although this is not a case of comparing apples and oranges (more like oranges and grapefruit), it seems probable that the economic constraints of building a defensive system put a permanent physical limit on the settlement area. The settlement's inhabitants would try to squeeze as many dwellings into as small an area as practicable and culturally acceptable to lower the costs of building, maintaining, and defending the fortifications. Extensive habitation beyond the settlement's fortifications would generally occur only during times of relative security, or if potential economic gain outweighed security concerns.

Such constraints do not apply to unwalled premodern Middle Eastern settlements. There the only real constraint is to avoid encroaching on the settlement's fields. Thus, one might expect, in general, to find a higher population density within walled settlements than in the unwalled settlements used in most modern studies.

Note that all the above methods fail in their ability to estimate the number of people regarded as members of a settlement, but who live outside its walls. This number includes those living permanently outside the walls in scattered dwellings, and those pastoralists who are tied by kinship or employment bonds to the town but who reside away from it with their flocks.

TABLE 1. Population Estimates

<i>Reference</i>	<i>Persons/ha</i>	<i>Other measurements</i>
Garstang 1931: 167	625	
Frankfort and Delougaz 1950: 103–4	300–500	
Braidwood and Reed 1957: 26–27	500	
Naroll 1962: 587–89		1/10 m ² roofed
Avi-Yonah 1964: 114–24	1000	
Adams 1965: 41	200	
Jeremias 1969: 83, n. 24	330–400	135–60 persons/acre
LeBlanc 1971: 211		1/10 m ² roofed living area
Stager 1975: 242–45	150–200	
Watson 1979: 47		4–5 persons/household (mean 4.6)
Broshi 1980: 2, n. 6		5–6 persons/household
Marfoe 1980: 315–22	200–250	1/10 m ² total house space; 1/6 m ² total roofed space
Shiloh 1980: 29	400–500	8 persons/household
Adams 1981: 69 and n. 6	100–125	
Kramer 1982: 123–24		5.1–6.3 persons/household
Van Beek 1982: 61–67	290–300	5 persons/household
Broshi and Gophna 1984: 74	250	
Stager 1985: 18		4.1–4.3 persons/household
Finkelstein 1988: 331–32	250	
Finkelstein 1990: 198–99	170–250	4–5 person/household
Holladay 1992: 315		1/21 m ² of roofed space, including wall space
Rosenan 1978: 14		2–3 L water/day/person
Rosen 1986: 173		200 kg wheat/person/year

Table 1 summarizes the methods used in some of the more important studies on ancient populations. Note that over time the density coefficients have tended to decline.

CONVERGING METHODOLOGIES

The previous section showed the variety of ways used for estimating the populations of ancient settlements. Each method has individual strengths and weaknesses. By using several of the methods together, however, it may be possible to arrive at a more satisfactory estimate. I shall now outline a program to investigate the macro level more satisfactorily, and then focus on ways to determine more accurately the population of specific sites.

Several things can be done to improve regional estimates. The first is to define a site typology, i.e., a list of settlement types based on function. A few examples will suffice: major administrative centers, unwallled villages, border fortresses, cult sites, and so on.⁴ Of course some sites may have had multiple roles, and other sites will prove to have been exceptions to the entire typology. The important point is to create a system that allows us to broadly classify the major role of each settlement.

Second, several regions of the premodern Middle East, containing the settlement types we have already defined, must be analyzed to establish the density coefficients for several examples of each type. This will allow the creation of an index of site types with an average density for each settlement type, and a range within which the values of other sites of the same type should fall.

Lastly, all the ancient sites in the study region must be classified, where possible, according to type. The area of each site in the period(s) of interest must also be determined, either by excavation or—if excavation is not possible but a surface survey is practicable—by studying the distribution of surface pottery for that period on the site and roughly determining its boundaries (Portugali 1982: 170–88). For some sites, only the maximum area of the site will be clear, and will have to form the basis for the estimate.

The Micro Level

First, enough of the area of a site has to be excavated to the period of interest to establish the functional zones and habitation patterns of the site. It is vital to be able to estimate the amount of area devoted to domestic housing, monumental housing (palaces, barracks, and perhaps temples), nonhousing monu-

mental buildings (storage facilities, stables, fortifications), and public spaces (roads, plazas). Without these basic data an accurate estimate is not possible. When it is not possible, or desirable, to clear an entire site down to one stratum, a reasonable sample is required.

Second, the housing density for the site must be determined based on a sample of the site's domestic area. This sample serves as a basis for extrapolating a similar density across the rest of the residential part of the site, which yields the total number of expected dwellings. This figure is then multiplied by the best available ethnographically derived estimate for ancient family sizes to provide a base estimate for the site's population.

If the site has a substantial number of public buildings used as residences, some effort must be made to account for the expected population. At present, it is not possible to do this. However, it may be possible to determine the size of palace, barracks, and temple populations from later, better documented, periods and to use these data to extrapolate populations for similar ancient and less well-documented periods and regions. This means, for example, looking at the size of known palace households of several sizes (from imperial capitals to backwater outposts) and periods to determine averages for administrative centers of different ranks.

Combining these two estimates for private and monumental housing yields an initial population approximation. This estimate should be checked by dividing the total population by the ratio of space required for each individual. If the resulting figure is absurdly high or low, there is something wrong in either the ratio used or the average family size used, possibly both. If, for example, our initial estimate of a town's population is 1000, and the total space available is 2500 m², then each person had only 2.5 m², an absurdly low figure. Either the space estimate or family size must be off.

The feedback between these two estimating methods will remain somewhat subjective. What one researcher considers a viable amount of floor space, another may not; but it should be possible to eliminate extremes.

Once these two methods have been used to narrow the possible population range, it is worthwhile to look at the natural resources around the site to see if they can, by any reasonable measure, sustain the estimated population. If not, the lack of resources forces the researcher either to reexamine the estimate or to look for alternative resources that could have sustained the site. For example, if the estimated population of a desert settlement is 1000,

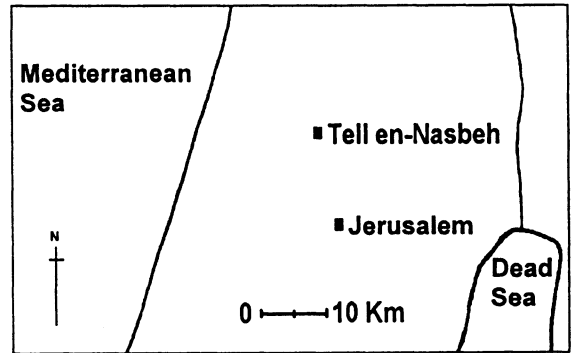


Fig. 1. Location of Tell en-Nasbeh.

but there are no springs in the area at present, and the measured and assumed capacity of the site's water storage facilities does not seem capable of supporting the population, a number of possibilities must be examined. Were there springs or water courses (including aqueducts) in antiquity, which were not discerned? Is there evidence in the site's topography for the existence of a major reservoir? Is the estimate of the per-capita water usage based on the best possible estimates?

A CASE STUDY: TELL EN-NASBEH IN THE IRON AGE

Tell en-Nasbeh, probably biblical Mizpah of Benjamin, a 3.2-ha site 12 km northwest of Jerusalem (fig. 1), provides almost ideal conditions for attempting a site-specific, microlevel, population estimate. Approximately 67% of the site was excavated by Badè between 1926 and 1935 (cited in Wampler 1947; McCown 1947). This large exposure provides a good basis for establishing the town plan and defining the structural patterns in different parts of the settlement.

Built-up remains for the earliest two strata (Stratum 5 of EB I, and Stratum 4 of Iron Age I) are virtually nonexistent, consisting almost entirely of rock-cut installations; and the structures of the latest stratum (Stratum 1) are too fragmentary to reconstruct convincingly (Zorn 1993a: 94–113, 186–99).*

* The original Tell en-Nasbeh report used roman numerals to define the site stratigraphy (McCown 1947: 179–86). To avoid confusion with this earlier schema the revised stratigraphy uses arabic numerals to distinguish the strata (Zorn 1993a: 88–93). See Zorn 1993b for a summary of the proposed new stratigraphy.

The best-preserved remains are those from Stratum 3C–3A, Iron Age II (Zorn 1993a: 114–62). About 0.4 ha of well-preserved, contiguous architectural remains were uncovered in the southwest corner of the tell, amounting to approximately 50 identifiable structures. This area is just under one-quarter of the total area occupied by buildings. Enough architectural remains from this stratum to the north and south were traced to suggest that the architectural pattern is common across the entire site. The buildings are virtually all typical three- and four-room structures, or variations on those forms, packed close together along narrow roads. No remains of large public structures were discerned in the entire excavated area. These surviving excavated buildings suggest that the settlement's primary role was residential.

The Iron II town was originally defended by a casemate-like wall consisting of the connected back rooms of the dwellings along the periphery of the mound (Stratum 3C). This defensive system was supplanted in Stratum 3B by the construction of a massive offset–inset wall and inner and outer gate system down slope from, and totally enclosing, the Stratum 3C town, including the casemate-like wall. This defense system of Stratum 3B probably was constructed under King Asa of Judah in the early ninth century B.C. (1 Kgs 15:22). Stratum 3A consists primarily of repairs, expansions, and remodelings of the earlier Stratum 3C dwellings, most of them following the construction of the Stratum 3B offset–inset wall of that stratum.⁵ The Stratum 3C (Iron IIA) phase at Tell en-Nasbeh/Mizpah, in the period of the United Monarchy, may be “typed” as a fortified rural settlement. Phases 3B–3A of Iron IIB–C, the Divided Monarchy when Mizpah was on the northern border of Judah, represents a fortified border town.

Stratum 2, which probably dates to the Babylonian and early Persian periods, is less well preserved than Stratum 3, but is clearly different in form, consisting of four-room buildings much larger than those of Stratum 3, and even larger structures which may be public buildings (Zorn 1993a: 163–85). These buildings seem more dispersed than those of Stratum 3 and do not follow the natural contours of the hill on which the site was built, as did the buildings of Stratum 3. This stratum may be categorized as a small administrative center.

Tell en-Nasbeh, as usually cited in the literature, is a 3.2-ha site (Shiloh 1980: 31). However, this is the total area measured from the outer face of the offset–inset wall on the north to the outer face on the south, and the same from east to west.

TABLE 2. Population Coefficient Comparison

<i>Coefficient</i>	<i>3.2 hectares</i>	<i>2.4 hectares</i>	<i>1.7 hectares</i>
1000/ha	3200	2400	1700
625/ha	2000	1500	1062
300–500/ha	960–1600	720–1200	510–850
250/ha	800	600	425
200/ha	640	480	340
170/ha	544	408	289
150/ha	480	360	255

The offset–inset wall was “dead space” in which no one lived. If the area occupied by this wall and the two gates is deleted, the area of Tell en-Nasbeh is ca. 2.44 ha. The intramural area, the space between the casemate-like wall of Stratum 3C and the offset–inset wall of Stratum 3B, was uninhabited storage and drainage space. If this area is discounted, the total habitable area of Tell en-Nasbeh in Stratum 3 is reduced to ca. 1.72 ha, slightly more than half the total 3.2 ha. Table 2 estimates the population for Tell en-Nasbeh Stratum 3 using each proposed area coefficient (from table 1) for the different surface areas.

The inhabitable area remained the same from Phase 3C through 3B–3A; only uninhabitable fortifications and storage/drainage area were added in Phase 3B–3A (amounting to 1.5 ha). However, the density of occupation changed radically. For example, if the Stratum 3 town population numbered 1000, the density in Stratum 3C was about 590 persons per hectare (1000 ÷ 1.7 ha). Using the maximum area defined by the Stratum 3B offset–inset wall provides a density of 312 persons per hectare (1000 ÷ 3.2 ha), or 53% of the density of the earlier phase. This is a warning that area coefficients cannot be applied uncritically, even to a broadly excavated settlement. The extent of Stratum 2 is unclear, but seems to be between 1.7 and 2.4 ha.⁶

POPULATION BASED ON FAMILY SIZE

After the nature and extent of the inhabited area of Stratum 3 has been defined, an estimate of the size of its population can be suggested. This will be based initially on the number of dwellings multiplied by average family size.

A sample of 23 contiguous buildings with plans sufficiently clear to determine both total area for each structure (including walls) and actual floor areas will be used for this study (figs. 2, 3). Re-

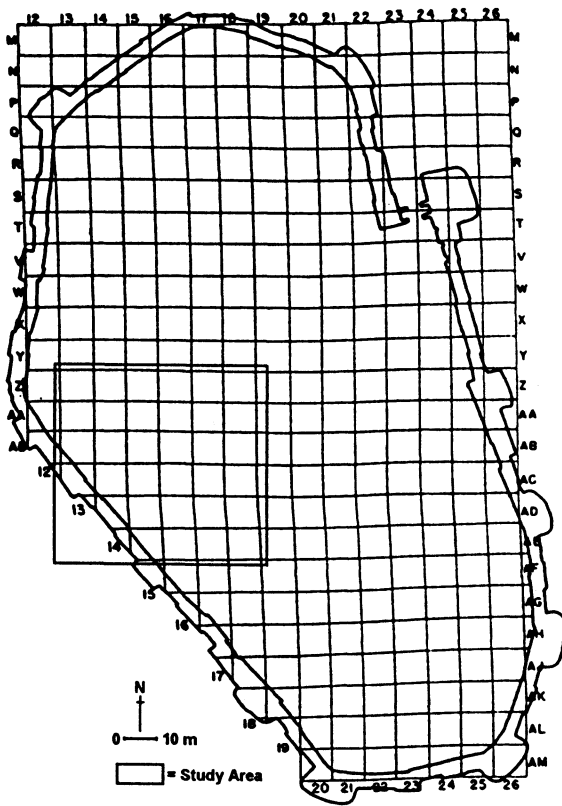


Fig. 2. Location of study area (adapted from McCown 1947: fig. 50:2).

mains to the north and south of this study area are more fragmentary but seem to reflect a similar density of construction. The data on the study area are summarized in table 3.

These 23 buildings were found in an area of ca. 0.16 ha, yielding 144 buildings per hectare. This is over twice the density Shiloh quotes for his sites (Shiloh 1980: 29; Broshi and Gophna 1984: 42). Two, possibly three, of these structures were used for olive pressing; and a fourth, in which a human skull was found on the floor, may have had some nondwelling function.⁷ Probably buildings with specialized functions had few, if any, permanent occupants. Even after removing from consideration the estimated 24 nondwellings, there are still some 120 dwellings per hectare. The area examined was ca. one-eleventh of the total site. If the same ratio of dwellings to nondwellings holds across the Stratum 3 town, there would be ca. 244 buildings, of which about 200 would be dwellings.

The data available on premodern Middle Eastern families suggests an average family size of between four and five individuals (Finkelstein 1990:

47–49). Assuming, for the purposes of this study, a similar average family size, the estimated total of 200 dwellings for Stratum 3 Tell en-Nasbeh would house 800 to 1000 occupants, or roughly 900.

The mean, or average, family size is a useful statistic for generalizing about a population. However, not all families are the same size, and the number of family members residing at home varies over time. Children grow up and leave, or marry and bring their spouses to live with the family; a widowed mother may come to live with a son or daughter. It is also important to consider the standard deviation, which measures the average deviation from the mean. In a normal distribution, 67 percent of all values fall within one standard deviation of the mean. The smaller the standard deviation in relation to the mean, the more homogeneous the distribution is. For example, if the average is 10 and standard deviation is 0.5, the distribution is very homogeneous: 67 percent of all values will fall between 9.5 and 10.5. If the mean is 10 and the standard deviation is 5, the distribution is almost random; 67 percent of all values will fall between 5 and 15.

Five studies have determined the mean and standard deviation for family sizes in Middle Eastern villages. These are summarized in table 4.

Although several of the means derived from these data are above the values used in this study, the real significance of these studies is the size of the standard deviation in each example. For instance, in Watson's village, the mean family size is 4.5 and the standard deviation is 2.2. This means that 67% of all households should have between 2.3 and 6.7 members, and there will be some households, the remaining 33%, that will have either more or less than this range.

In Iron Age Tell en-Nasbeh a "typical" family size, assuming an average of 4.5 and a standard deviation of 2.5, would range between 2 and 7. Any population estimate based on average dwelling-floor area should thus fit a family size of 2 to 7. Of course sometimes houses had to accommodate more inhabitants than they were meant for, while others may have been more sparsely occupied. The poor tend to live in more crowded conditions than the more well-to-do, for example.

POPULATION ESTIMATE BASED ON FLOOR AREA RATIOS

The average total area (including walls) of the 23 buildings in table 3 was ca. 58.3 m², with a standard deviation of 19.0 m². The plans of 13 of

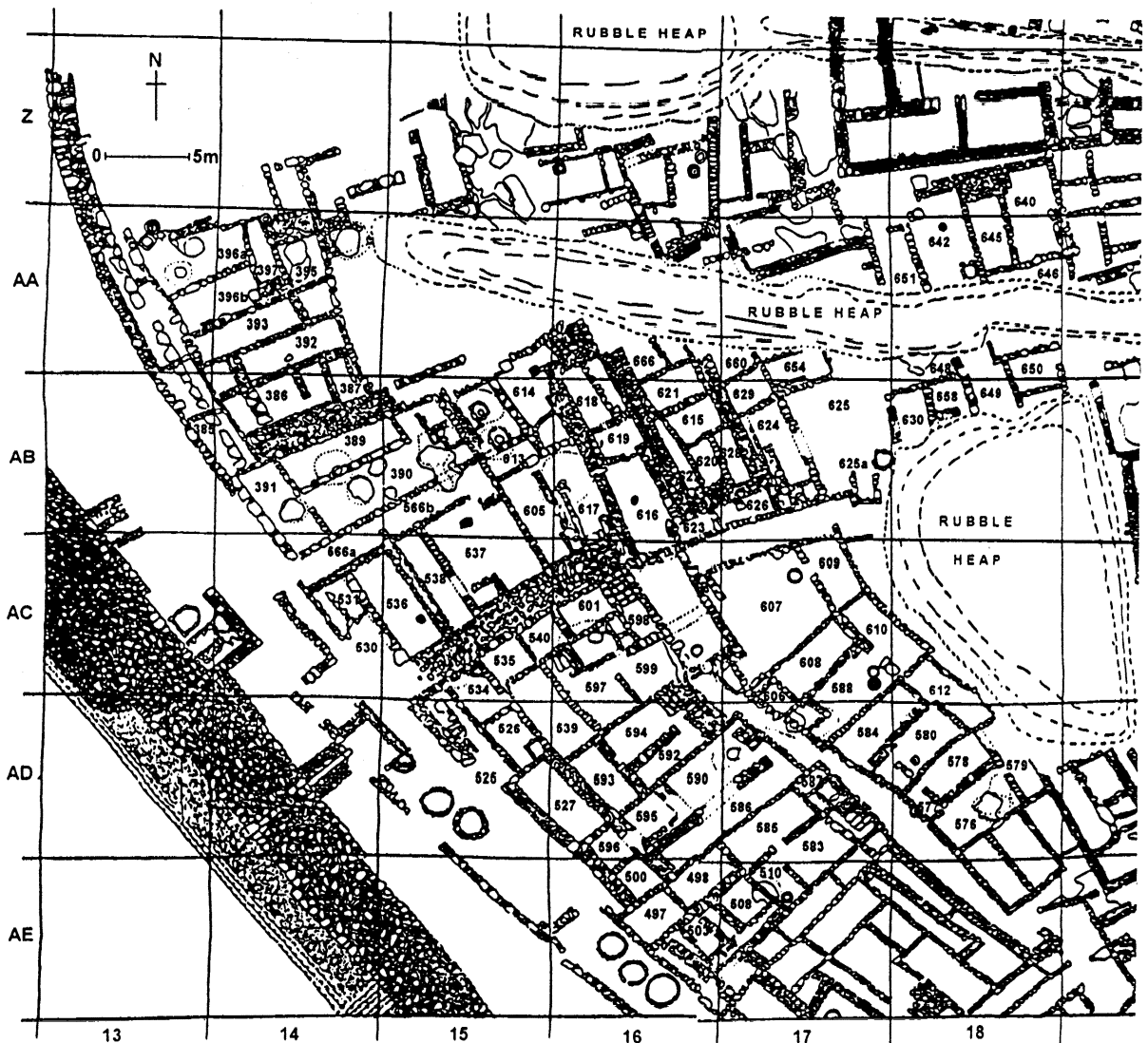


Fig. 3. Plan of study area (figs. 3 to 7 are adapted from McCown 1947, 1:400 Survey Map).

the buildings were clear enough to accurately measure their total floor area. In these buildings floor area occupied 62% of the space, and nonfloor area (walls) occupied 38%. Applying these percentages to the total estimated area of 1342 m² yields an estimated total floor area of ca. 832 m², an average of ca. 36.2 m² and a standard deviation of 11.7 m². After eliminating the four nonresidential buildings, the total estimated area is 1136 m² (average 59.8 m² and standard deviation 20.6 m²), and the total estimated floor area if 693 m² (average 36.5 m² and standard deviation of 12.7 m²).

Can these data be used with the various methods proposed for estimating populations based on ratios of inhabitants to the total roofed area, the

total living area, or the total area of the buildings? Unfortunately, two related, unresolved issues make it difficult to successfully apply any of the ratios of inhabitants to floor area. The first is whether Iron Age houses contained open courtyards (Holladay 1992: 315–16; Mazar 1990: 340–42, 485–86; Netzer 1992: 196–97; Stager 1985: 15). The second issue concerns how extensive second stories were; i.e., did they cover the whole area of the house, or only part of it (Holladay 1992: 315–16; Mazar 1990: 485–86; Netzer 1992: 198; Stager 1985: 15–16).

On the basis of ethnographic analyses, scholars have proposed the following ratios for the number of square meters required per person. Naroll

TABLE 3. Building Sample from Tell en-Nasbeh

<i>Building No.</i> ^a	<i>Rooms</i>	<i>Type</i> ^b	<i>Total Area (m²)</i> ^c	<i>Floor Area (m²)</i> ^d
125.02: fig. 6	640, 645, 646	three-room	60	29.2+
141.01: fig. 4	393, 395, 396a,b, 397	four-room	90+	45.8+
141.02: fig. 4	385–87, 392	three-room	57	41.7
141.03: fig. 4	389–91	three-room	70	48.2
141.04: fig. 4	537, 538, 566b	four-room	60	43.2
141.05: fig. 4	530, 531, 536, 566a	three-room	44	18.7
141.06: fig. 5	605, 617	two-room	30	24.2
142.01: fig. 7	525, 526, 534, 535, 539, 540, 597–99, 601, 604	multi-room	120	75.5+
142.02: Press: fig. 8	607, 609	two-room	50	37.1
142.03: Press: fig. 8	588, 606, 608, 610	three-room	52	36.3
142.04: Skull: fig. 5	616, 619, 622, 623	three-room	47	26.1+
142.05: fig. 5	615, 620, 624, 626, 628, 629	four-room	55	27.7+
142.06: Press?: fig. 5	625, 625a, 654	two-room	57+	40.0+
142.07: fig. 6	630, 648, 658	three-room	43	11.1+
142.08: fig. 6	649, 650	three-room	47	10.5+
142.09: fig. 6	642, 651	three-room	54	23.6+
142.10: fig. 5	621, 660, 666	four-room	49	14.2+
142.11: fig. 5	613, 614, 618	multi-room	63	23.8
159.01: fig. 7	527, 592, 593, 594	three-room ⁺ e	56	32.1
159.02: fig. 7	500, 586, 590, 595, 596	three-room ⁺	65	39.7
159.03: fig. 7	497, 498, 503, 508, 510, 583, 585, 587	three-room ⁺	90	44.0
159.04: fig. 8	580, 584, 612	three-room	42	31.2
159.05: fig. 8	576–79	three-room	41	25.9
Total		23 buildings	1342	749.8
Mean			58.3	
Stand. dev.			19.0	
Expected				
Total				831.7
Mean				36.2
Stand. dev.				11.7
Less special buildings		19 buildings		
Total			1136	693.9
Mean			59.8	36.5
Stand. dev.			20.6	12.7

^a Building no.: As defined in Zorn 1993a: 620–76, 723–63.

^b Type: Basic form, irrespective of actual number of rooms.

^c Total area: Total estimated area, including walls in m².

^d Floor area: Total measurable floor area in m².

^e A “+” indicates that the building plan is incomplete and that the actual area is somewhat greater.

TABLE 4: Mean Family Size and Standard Deviation for Five Villages

Reference	Mean	Standard Deviation	Country
Kramer 1982: 72-75	6.2	2.9	Iran
Watson 1979: 42-46	4.5	2.2	Iran
Antoun 1979: 51	6.5	2.4	Jordan
Jacobs 1979: 182	8.4	4.9	Iran
Sweet 1960: 241-47	5.6	2.9	Syria

(1962: 588) suggested 1:10, i.e., one person for every 10 m² of total roofed area. LeBlanc preferred to apply the 1:10 ratio only to the total roofed dwelling area, excluding storage areas, animal pens, and the like (LeBlanc 1971: 210-11). Marfoe suggested that 1:10 applies, at least in Syria-Palestine, to the total roofed and unroofed living area; if the total roofed area alone were to be used Marfoe (1980: 318) would drop the ratio to 1:6. Casselbery (1974: 118-22) suggested that a ratio of 1:6 be applied to the total floor area in multi-family dwellings. Holladay (1992: 312) has suggested using an area of 21 m² per person for the entire area of the dwelling, including walls.⁸

Unfortunately, the studies of Naroll, LeBlanc, and Marfoe do not specify whether or not the area involved includes the building's walls. For example, if we assume that the entire 1136 m² of dwelling space at Tell en-Nasbeh (including walls) was completely roofed over and lacked second stories, and if we applied Naroll's constant, the population of the study area would be ca. 114, and the site population would be ca. 1254, or almost 6.3 inhabitants per dwelling. A complete second story would double this estimate. If only the floor area of ca. 694 m² is used, the study-area population would be ca. 69, and the total site population will be ca. 763, or ca. 3.8 inhabitants per dwelling. A complete second story will again double this value. If the 21 m² advocated by Holladay is used for the total 1136 m², the area population is ca. 54, and the site population is 594, not quite three inhabitants per dwelling. If a complete second story is assumed, there will be about six inhabitants per dwelling. If it is assumed that approximately one-third of all dwelling space

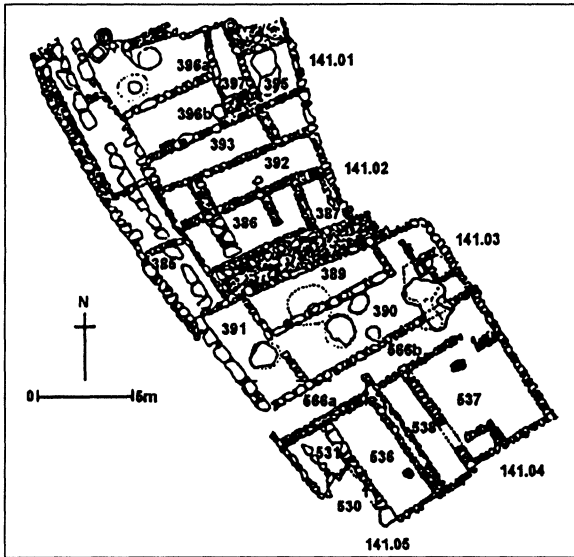


Fig. 4. Buildings 141.01 to 141.05.

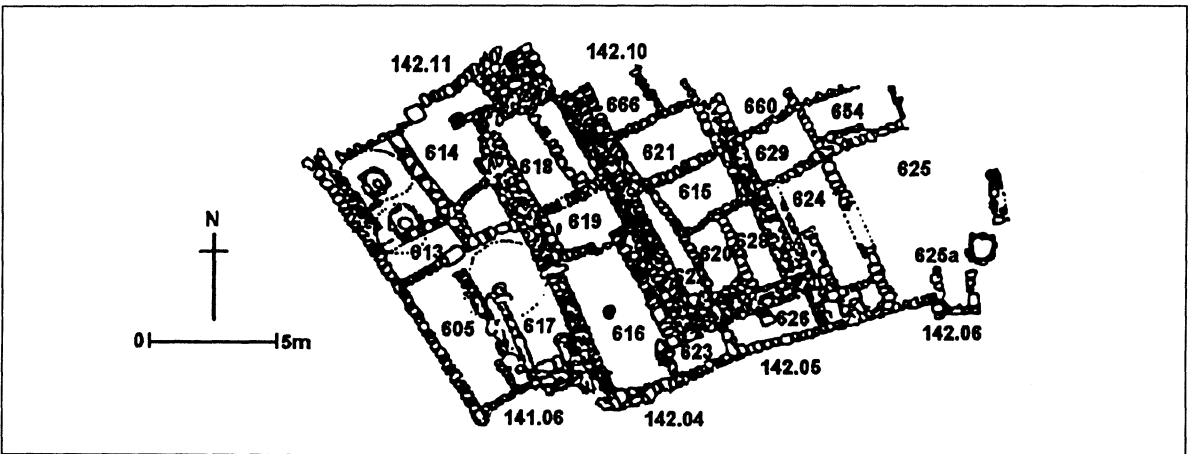


Fig. 5. Buildings 141.06, 142.04, 142.05, 142.06, 142.10, 142.11.

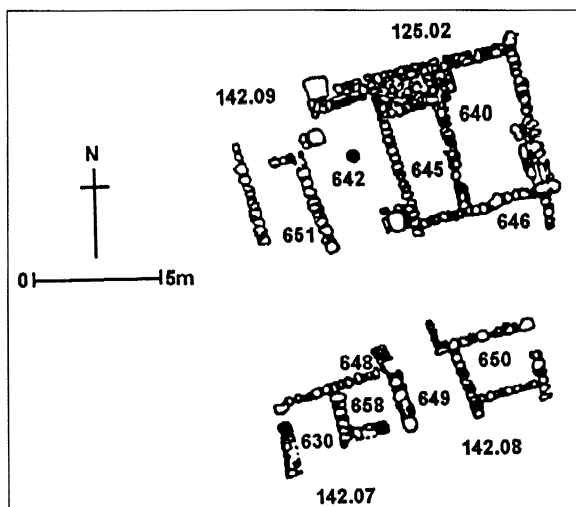


Fig. 6. Buildings 125.02, 142.07, 142.08, 142.09.

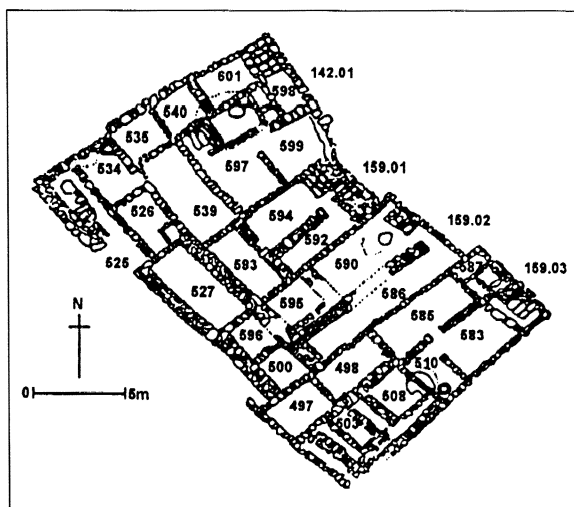


Fig. 7. Buildings 142.01, 159.01, 159.02, 159.03.

was used for courtyards, and that the rest of the area included a second story, the total roofed space (including walls) is ca. 1500 m²; excluding walls the value is ca. 916 m². If Marfoe's ratio of 1:6 for roofed areas is used, the estimates will be 250 or 153 for the area, and 2750 or 1683 for the site.

The above examples demonstrate how in many cases an assumed single floor leads to values below the ethnographically derived average of 4.5, while complete second stories tend to lead to values above the average. These widely different results are a product of insufficiently precise definitions of the area to be used in the ratio (total area, including walls, or floor space only; covered or noncovered), and a lack of certitude concerning the existence of courtyards and the extent of second stories. To resolve this dilemma we need a broad study of walled, premodern Middle Eastern towns and cities where the total number of houses and population are known, and the percentage of houses that contained courtyards and second stories can be determined.

Constructing a fortification system was a costly endeavor. An effort would be made to accommodate as many people as possible in the least amount of space. It might be expected that houses in walled settlements would be smaller than those in unwalled sites where the main constraint would be to avoid encroaching on the fields. Also, once a major defensive system was in place, it effectively curtailed all horizontal expansion within the settlement. If a family wanted to expand its home, the only available space, which did not involve purchasing parts of adjacent houses, was upward. The presence of court-

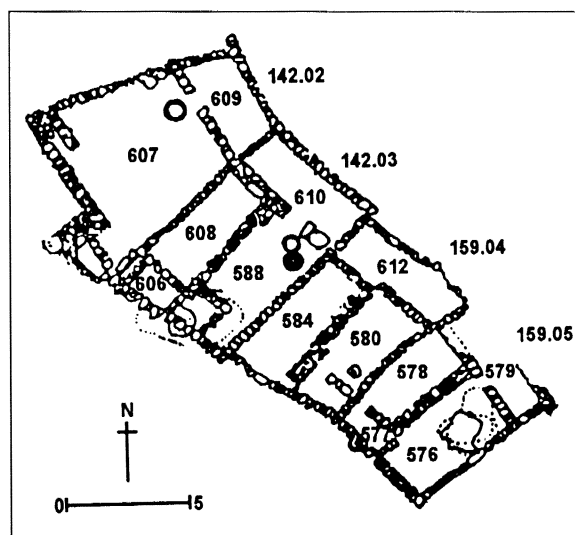


Fig. 8. Buildings 142.02, 142.03, 159.04, 159.05.

yards in such crowded premodern settlements would be more analogous to the situation in walled ancient sites than to studies based on unwalled premodern sites.⁹

Our estimate derived from assumed average family size (4.5) multiplied by the estimated number of buildings at Tell en-Nasbeh (200) was ca. 900. The average total floor area per dwelling is 36.5 m², which yields ca. 7300 m² of total estimated floor area for the estimated 200 dwellings. This allows ca. 8.1 m² per person. If all buildings had complete second stories the space available per person would

be 16.2 m². These floor areas are neither absurdly high nor low, suggesting that a site population of ca. 900 is a reasonable estimate. Compare these values with those derived from the highest and lowest values in the third column of table 2. If the site's population were 1700 (1000 per ha) each individual would have only ca. 4.3 m², or a maximum of 8.6 m² if all buildings had complete second stories. If the site population were 340 (200 per ha), each person would have ca. 21.5 m² of floor area; that is above even Holladay's estimate, which is based on total dwelling area, including walls. However, excluding these extreme values still leaves a possible population range between 340 and 1700. We can probably exclude any site population estimate below 600 as well, as this would lead to an average family size of less than three per family for the estimated 200 dwellings.

NATURAL RESOURCES

The availability of natural resources may help bracket reasonable upper and lower limits for the population of Tell en-Nasbeh. Let us next examine the site's water-storage capacity, and the agricultural potential of the surrounding land.

An average adult requires 1 ml of water for every kilocalorie of energy expended. A sedentary adult of 70 kg requires about 2.5 L water per day; someone engaged in moderate activity requires 3.0 L, and a very active person needs 3.5 L (Briggs and Callaway 1984: 120, figs. 6–8; 321–22). This is in an environment where the temperature varies between 65 and 75 degrees Fahrenheit. Someone engaged in moderate to strenuous activity in the summer around Tell en-Nasbeh no doubt required somewhat more water, but these are good minimum figures from which to work. However, this figure includes only drinking water. It does not include water required for cooking, cleaning, bathing, and other miscellaneous uses. A study of rural townships in the Ciskei area of South Africa showed that impoverished families used about 9 L per day per person (Wilson and Ramphela 1989: fig. 51, 2.05). This agrees with an estimate of 10 L per day used by Broshi (1979: 2) and Callaway (1985: 40). Wilkinson (1974: 49) notes that Jerusalem in 1918 used about 16 L per day per person, relying only on cisterns.

Tell en-Nasbeh is in an area that receives an average of ca. 500 mm of rain per year (Zorn 1993a: 209–10). Most of the rain comes between November and April; the cisterns would be continually

replenished during this period. However, whatever was in the cisterns at the end of April would have had to suffice until the beginning of the next rains, without trips to the springs. The total volume of water falling within the Stratum 3C town is 8575 m³. This amounts to 8,575,000 L. This is the maximum available to the inhabitants without going outside the walls to use springs more than half a kilometer from the Stratum 3B outer gate. The inhabitants, however, could not achieve total conservation of this rainfall. It is impossible to determine how much was lost.¹⁰ It is possible, however, to measure the capacity of the cisterns in the excavated areas.

It was possible to estimate the storage capacity of 61 cisterns found scattered across the length of the tell. These had a combined capacity of 1062 m³, or an average of 18 m³. The actual capacity of these cisterns varied from a little less than 1 m³ to 90.6 m³. Not all of the 61 cisterns belong to Stratum 3; 13 (20 percent) were cut by walls of that stratum, indicating that they were earlier features that did not continue in use. The average capacity of cisterns not cut by later walls was 20 m³.

The 48 cisterns belonging to Stratum 3, if full at the end of the April rains, would contain enough water for 585 people, using 9 L per day, for six months. An additional 43 cisterns were found at Tell en-Nasbeh for which no volumes could be determined. If it is assumed that 20% of these were not used in Stratum 3 (leaving 35) and the remainder also averaged 20 m³, they would support another 425 inhabitants, for a total of 1010.

These 83 Stratum 3 cisterns were found in the 67% of the site that was excavated. If the same proportion of cisterns exists in the unexcavated area there would be 27 additional cisterns, which at an assumed 20 m³ capacity each, could support another 329 people. The total site population that could then be supported would be around 1340 people, assuming full cisterns in April, and water lasting for six months. If these 110 estimated cisterns were only at 70% capacity at the end of April, this would be enough to support 938 people. The estimate arrived at above for ca. 110 total cisterns for Stratum 3 suggests that not every dwelling had a cistern. If extended families lived in adjoining dwellings, one cistern could have sufficed for two households. It cannot be determined how many animals were kept within the walls. If they were watered at all from the cisterns this put an additional strain on the water supply.¹¹ Table 5 summarizes the data presented above.

TABLE 5. Water Storage Capacity

<i>Number of 20 m³ Cisterns</i>	<i>100% Capacity Supports for Six Months</i>	<i>70% Capacity Supports for Six Months</i>	<i>50% Capacity Supports for Six Months</i>
48	585	410	293
83	1010	707	505
110	1340	938	670

The data suggest a maximum population of ca. 1300 assuming 110 cisterns; in drought conditions, when rainfall was only half the norm, ca. 700 could be supported. If the drought were more severe, e.g., even less rainfall (perhaps 25%) or the drought continued for more than a single year, the site's population would likely begin to shrink. The population estimate of 800 to 1000 inhabitants based on average family size falls within the estimated normal supportive capacity of the cisterns.

Does the land around Tell en-Nasbeh have the capacity to support a population of around 900? During Iron Age II there were no other major sites within 5 to 6 km of Tell en-Nasbeh.¹² The site's catchment area can reasonably be set at 3 km. Within this area are a variety of good soil types suitable for growing grains, olives, and grapes, and also for grazing flocks (Hillman 1973: 223–40; Webley 1972: 169–80; Zorn 1993a: 201–8).

The average person whose diet consists mostly of grain requires 150 to 240 kg of grain per year. Broshi cites figures of 185 to 195 kg of grain per year in antiquity and early modern times (Broshi 1979: 6). A more recent study of eight villages in the province of Aleppo, Syria, showed that grain consumption was around 140 kg per year per person. Grain constituted ca. 88 percent of the local diet, but actual consumption varied widely by household (Mokbel and Pellett 1988: 203, table 4). In Anatolia 80% of the calorie intake in a study village was from grain (Hillman 1973: 228–29). The average amount of grain consumed by Iranian villagers in Kramer's study was ca. 168 kg per person, and this grain amounted to ca. 87 percent of the villagers' total diet (Kramer 1982: 181, table 2.2). In Neolithic and Bronze Age Greece the diet was more mixed, ca. 200 kg of cereal and pulses per year per person (Halstead 1981: 317). An assumed average of 200 kg of grain per person per year is not unreasonable.

In the 16th century A.D. Levant, approximately two-thirds of the grain sown was wheat and the

remaining one-third was barley (Rosen 1986: 171; Hütteroth and Abdulfattah 1977: 83). The barley was used primarily for fodder. A typical modern yield for wheat is about 650 kg per ha, while the barley yield is 800 kg (Rosen 1986: 172; Kramer 1982: table 2.3). A population of 900 would require 180,000 kg of wheat, which would require an area of 277 ha. If 90,000 kg of barley were harvested the additional area would be 112 ha. This is a total of about 390 ha. This total should be doubled to 780 ha to account for a one year on, one year off fallow system. Probably other crops, making up no more than 15 to 20 percent of the total diet, added only again that much land, ca. 68 ha (848 ha total), since most of it was not fallowed.

Additional land would be required for the town's herds and flocks. About 4.5 ha per year can be plowed by an average ox or ox-equivalent (Rosen 1986: 169).¹³ Thus, to plow the fields around Tell en-Nasbeh required a minimum of ca. 87 oxen-equivalents. Kramer's (1982: table 3.7) and Watson's (1979: table 4.1) data suggest that a family owns one to two bovines (oxen and cows). An approximate total for 200 households at Tell en-Nasbeh would be 300 bovines. Ancient tribute lists and examples of typical premodern Middle Eastern communities suggest that in a settled agricultural system bovines make up about 20%, or somewhat more, of the total ruminants, with caprovines making up most of the rest (Rosen 1986: 160–65). An estimate of ca. 1500 caprovines for Tell en-Nasbeh would be acceptable. Cattle consume about five times more than caprovines do; thus 300 bovines are equal to ca. 1500 caprovines (Rosen 1986: 168–70). The area around Tell en-Nasbeh would have to support the equivalent of 3000 caprovines. A caprovine requires about 0.8 ha of grazing land, meaning that 2400 ha would be required. However, the fallow land, half the total arable land, would be available for grazing, as would the area of the harvested fields for about a month. Finally, there are the areas sown specifically for fodder, which were

already added into the 390 ha required each year. The formula is: total grazing land minus (arable land/2 + arable land/12 + fodder land) = required extra grazing land $2400 - (390 + 32 + 112) = 1866$ ha (Rosen 1986: 170).

Thus an additional 1866 ha are required for Tell en-Nasbeh's animals, making 2714 ha total (790 for grain, 68 for other crops, and 1866 for the animals). Within a 3-km radius of the town there are 2800 ha (28 km²) of land well-suited for growing crops and grazing (Zorn 1993a: 201–14). This leaves 86 ha for the town (3.2 ha plus any buildings and installations outside the walls), and any land too poor or rocky to be farmed. The agricultural/grazing capacity of the land around Tell en-Nasbeh seems capable of supporting a population of 800 to 1000 in normal conditions. A population above this is unlikely unless the animal population was lower or the exploitable area available to Tell en-Nasbeh was greater than that used here.¹⁴

CONCLUSION

We should look again at some of the area coefficients presented in table 1. If we assume a density of 200 per ha for the core Stratum 3C town of 1.7 ha, the total population is 343. However, this means each of the 200 estimated dwellings would have 1.7 occupants. Even at a density of 250 ha, and 429 inhabitants, the average number of occupants is only 2.1. If, as we have suggested, the population of Tell en-Nasbeh was between 800 and 1000, the density coefficient will be between 470 and 590 in the Stratum 3C town.¹⁵ This is significantly higher than

the most recent figures cited in table 1, and provides a caution against using such general estimates when the habitation pattern and settlement type of a site are not known.¹⁶

This discussion has shown that in a site like Tell en-Nasbeh, where there is good evidence for the structural and functional layout of the settlement, it is possible to give a reasonable population estimate based on the number of known dwellings and an average family size. This estimate can be checked by estimating the ability of the local water and land resources to support the assumed population. In the future it may also be possible to use ratios of floor area per person as a more precise cross-check on these other results than is currently practicable. This degree of precision is not possible at sites where only the monumental buildings and defenses have been excavated. Archaeologists need to excavate enough parts of a mound to provide some idea of its total plan. Sites from which only survey data are available will yield less satisfactory results, but the results can be improved if the surveyor can determine the site's functional type.

In the case of the 1.7-ha fortified town of Stratum 3 Tell en-Nasbeh the population was probably 800 to 1000, with a density coefficient of ca. 450 inhabitants per ha. Stratum 2, possibly an administrative center, occupies more area, approximately 2.4 ha, but seems to contain fewer dwellings, and possibly monumental housing and nonhousing public structures, which are not present in Stratum 3. Probably the area density coefficient should be closer to 200 to 250 ha, with a total population of 400 to 500.

NOTES

¹I thank John Hayes and Carol Redmount for reading earlier versions of this paper and offering useful comments. Any errors or inaccuracies are mine.

²The literature on estimating the size of ancient populations is vast and it is beyond the scope of this article to provide more than a sample of these methods. The methods vary widely, from estimates based on the number of Hoplites in a Greek city-state's army, to those based on the depth of midden deposits. For Greece see Gomme (1933), Hansen (1985; 1988); Osborne (1987) and Sandars (1984) explore the use of natural resources to assess population limits. For the New World see Ascher (1959), Dobyns (1966), Glassow (1967), Haviland (1972). Hassan (1978) surveys a variety of methods.

³Hopkins (1985: 153–57) and Frick (1985: 141–59) offer critiques of these methods. Both seem unduly pessimistic about estimates based on household size, and perhaps too optimistic about the use of estimates derived from floor areas alone or in conjunction with estimates based on local resources.

⁴Van Beek (1982: 65–66) correctly notes that towns or cities could have population densities as high as 500 per ha, while densities of small unwalled villages could be as low as 125 per ha. Finkelstein (1990: 49–50) notes that density coefficients can vary widely based on the settlement's environment (villages dependent on herding might have a lower density than those relying more heavily on agriculture) and the size of the settlement itself. London (1992: *74) notes that separate estimates

are likely required for urban centers and rural communities. On settlement hierarchies, see also Herzog 1992.

⁵Stratum 3 thus covers a period of ca. 400 years, or ca. Iron Age II. It is remarkable that the Survey Map and photographs published with McCown's 1947 report show very little evidence for change in most of the house plans, suggesting that mudbrick and stone houses, if properly maintained, may have longer life spans than is commonly expected (Battle 1983: 39). Finkelstein (1988: 61–63) has also noted the "uniformity" in the plan of Tell en-Nasbeh and suggested that it underwent almost no change from its founding, as early as the 12th century B.C., until its abandonment, which he does not specify, but is presumably no later than the end of Iron II; this is a span of ca. 500+ years. Mazar (1990: 437) also suggests that the domestic architecture of the "Judean Country Towns" could be in use for "hundreds of years." In the Wadi Hadramawt in Yemen there are mudbrick houses, usually more than two stories high, often five to seven stories high, whose lower walls are slightly under 1 m thick, the oldest of which is ca. 300 years old (Lewcock 1986: 56, 65–67, 74). It is also possible that when the Tell en-Nasbeh houses fell into disrepair they were rebuilt along exactly the same lines and such rebuilds may be archaeologically "invisible." For an approximately comparable breakdown of the Tell en-Nasbeh stratigraphy see McClellan 1984: 54.

⁶Buildings of Stratum 2 were constructed over the inner (four-chamber) gate, over the passage that connected the inner and outer (two-chamber) gate, and sometimes in the space between the casemate-like wall and the offset-inset wall of Strata 3B–3A, as well as over the original dwellings of Stratum 3C (Zorn 1993a: 176–81). The remains of Stratum 2 are more fragmentary than those of Stratum 3, so it is impossible to determine the total area of Stratum 2 with the same degree of accuracy as for the earlier stratum.

⁷The olive press structures are Building 142.02 and Building 142.03; the possible press is Building 142.06. The building in which the skull was found is Building 142.04.

⁸At Kramer's site of "Aliabad" the average total non-courtyard space per person was 24 m². This value was derived by subtracting the total courtyard area from the total compound area in Kramer's table 4.1, 9947 m², and dividing this by the total number of inhabitants, 418, in Kramer's table 3.7. However, it is not clear from her table 4.1 if the total compound area includes its walls (Kramer 1982).

⁹Probably we should envision a situation where some (many?) dwellings possessed open courtyards and some (many?) dwellings had partial or full second stories. 2 Sam 17:18 and Neh 8:16 indicate that private houses could have courts (חצר). Courts also existed in ancient Mesopotamia, as attested textually and archaeologically.

Note Akkadian *kisallu* = court (CAD vol. K: 416–417). Herodotus (*Persian Wars* 1.180) states that Babylonian houses had three or four stories. Archaeological examples for courts include Ur (Woolley and Mallowan 1976: 23–24) and Tell Asmar (Delougaz 1967: 275, 277). Depictions of contemporary houses in the Assyrian reliefs are rare, but they do occur. They show single-story dwellings and dwellings with partial second stories (Russell 1991: figs. 17, 56, esp. 65).

¹⁰Water that could not be stored was channeled along roads and alleys to reach drains that led out through the town wall and gate (Zorn 1993a: 259–75).

¹¹Possibly the animals were customarily watered from springs, wells, or cisterns outside the town as in Gen 21:25–31, 24:11–22, 26:18–22.

¹²In catchment analyses of this type a 5-km radius is often used (Vita-Finzi 1979: 165). However, this is a maximal approach that ignores sites in the immediate vicinity, which might also have a claim to the land in the catchment area. For example, el-Jib/Gibeon is only 5 to 6 km southwest. By employing a 3-km radius, the effects of such overlapping areas of exploitation should be reduced.

¹³A donkey consumes about half of what an ox does and a cow consumes about 80% of an ox's intake. The plowing capacity of the donkey is close to half that of an ox, and the cow about 75% (Rosen 1986: 169; table 10.7). The consumption-to-plowing ratios are roughly comparable for oxen, cows, and donkeys; camels used for plowing probably were fairly rare in a settled agricultural environment (Rosen 1986: tables 10.2, 10.6). For ease of calculation it is thus permissible to speak in terms of oxen-equivalents.

¹⁴Hillman (1973: 239) estimated that in the Anatolian village of Aşvan the average family (5.5 members) required 12.2 ha of farmland, which works out to 2.2 ha per person. This same ratio applied to a population of 900 at Tell en-Nasbeh would result in ca. 2000 ha of farmland; this is below the estimate derived here. However, Aşvan's farmers used river-based irrigation for much of their land; presumably in a region of dry farming, such as Tell en-Nasbeh, the land requirement would be higher.

¹⁵The figure is close to Shiloh's 400 to 500 per ha, but this is misleading (Shiloh 1980: 28–30). His study sites have about half the building density of those at Tell en-Nasbeh; but he assumes a family size of eight, about twice that used here. For example, he estimates 164 dwellings at Tell Beit Mirsim and a total population of 1312. If he used a family size of 4.5 the population would be 738.

¹⁶Marfoe (1980: 318–19) also recognized this in his review of the *Early Arad* report. He argues for a population density of 320 to 400 per hectare in the domestic area, but a lower value for the settlement as a whole, 160 to 240 or 200 to 300, with a median value of 200 to 250.

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