1993

1993 A Political Economic Critque of the Site-Size Site- Population Relationship

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Essays in Honor of Richard B. Woodbury

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Research Report 28
Anthropology Department
University of Massachusetts
Amherst
1993

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A POLITICAL ECONOMIC CRITIQUE OF THE SITE-SIZE, SITE-POPULATION RELATIONSHIP

by Robert Paynter

It does not take profound insight to realize that there is some degree of correspondence between the number of people living at a given time and place and the number of objects used by a group or population. What is not all that clear, however, is the nature or structure of this relationship.
[Ammerman et al. 1976:31]

That a systematic relation between populations and site size should obtain is intuitively obvious. Furthermore, interest in reconstructing past demographies, and settlement hierarchies, as well as the general search for ethnologic regularities, makes understanding this relation of interest. The rub, as pointed out in the epigraph, is specifying the nature of the relationship. Most studies search for consistent correlations and are not designed to investigate the complexities of this relationship. Those that have specified qualitative and quantitative models of the relation of site population to site size stay within the family of dependence modeling found in regression studies. As a result, they fall short of accounting for much of the variation in this relation.

In the following I argue that *some* of the variability in this relation is conditioned by socio-culturally defined production. This means we should examine site population and site size as key variables in models of production, rather than as dependent and independent variables in regression models. In particular, I point out how variation in production systems, specifically in stratified political economies, leads to variation between site population and site size.

I begin by setting previous studies of site population-site size in their problem context. Some of the problems and suggestions identified in these studies are used to consider the site population-site size relation in terms of production. Data from a number of different political economies are evaluated against expectations generated from more general models of production. The implications include studying the relation in its own right for the information it can yield on sociocultural variation, as well as keeping

interregional contexts in mind when using site size as an index of past site population.

PROBLEM CONTEXT

Anthropologists have studied the relation between site size and site population for a variety of reasons. These studies are based on contemporary, historic, or ethnohistoric sources which have independent estimates of site population and site area size. The results of these studies are used to (1) reconstruct past settlement hierarchies (e.g., Johnson 1977), (2) estimate prehistoric demographies (e.g., Ammerman et al. 1976; Swedlund and Armelagos 1976; Swedlund 1978; Schacht 1981), and (3) identify cross cultural regularities (e.g., Naroll 1962).

Not surprisingly, the definition of variables and tools of analysis vary in these studies depending upon whether the aim is to identify cross cultural regularities or to establish site size as an index of site population. For this reason, it is necessary to review the results of these studies within their problem contexts.

Before proceeding to these studies, there is the initial issue of defining terms. While defining site population is usually taken as unproblematic, site size is defined in a number of different ways. Cook and Heizer (1968:85) typologize measures of site size by scale: floor space, site space, and operational space. *Floor space* "is the space within which a family (or group of families) eats, sleeps and carries on intimate personal activities." This notion is similar to Naroll's (1962) dwelling area, Kramer's (1979) dwelling area, and Yellen's (1977:103) "Limit of Nuclear Area, Total"; and is in many cases less than the total roofed area of a site (Kramer 1979; LeBlanc 1971; though see Yellen [1977:100] for hunter-gatherers). *Site space* "covers the entire settlement but does not go beyond it. This includes space devoted to internal domestic affairs and adds space concerned with interfamily activities--all of the varied social economic, and ceremonial life of the community" (Cook and Heizer 1968:85). *Operating space* is "the entire area in which a human group carries on any activity whatever of a standard and methodical character" (Cook and Heizer 1968:85). While all three present operational boundary problems, the last--operating space--seems to be quite difficult to bound (e.g., Flannery 1976:91-95; Wobst 1976). As it has not received systematic attention in its relation to population size, I will give it no further consideration.

The first two--dwelling space and site space--have been studied in their respective relations to site population. Not surprisingly, these measures are more or less effective in solving different problems. In their empirical studies of aboriginal California, Cook and Heizer (1968:110-115) note marked differences in the relationship between population and dwelling (or floor) space versus population and site space. They conclude:

> An association between site space and population is seen most clearly in restricted regions where climate, living conditions, and social customs are relatively uniform. When we move to larger and larger areas, and diversity of all kinds begins to be accentuated, the association between village space and village population may weaken and may ultimately disappear. This trend should be contrasted with the relationship between house or total floor space and population, which evidently remains stable...over a wide spectrum of peoples and environments. This distinction between the two kinds of space must be referable to a qualitative difference between those factors responsible for floor space and those which operate with total village or site space [Cook and Heizer 1968:110].

Sumner (1979:167) suggests that one of these qualitative differences is a site's location within the regional settlement hierarchy; "we would expect to find less space in large villages and towns devoted to habitation and more space devoted to administrative, commercial, industrial, religious and other public functions." This logical argument is supported in his analysis of the settlement pattern of the Fars Province in Iran (but see Schacht 1981:129). Thus, *site space* would seem to be more useful for studying regional settlement hierarchies (the above citations plus Johnson 1977:494-495), and dwelling or floor space seems best suited for studying demography and cross-cultural regularities (e.g., Cook and Heizer 1968:110-115; Kramer 1979: LeBlanc 1971; Naroll 1962; Yellen 1977:124).

DEVELOPING REGIONAL HIERARCHIES

Only the roughest analytic tools are needed to group sites within a region into settlement hierarchies. The basis for such hierarchical groupings is the notion of functional size, arising from Central Place theory. *Functional size* is the number and range of economic activities conducted at a site (e.g., Haggett et al. 1977; Johnson 1977:494-495; Smith 1976). Geographers studying

functional size suggest that it is positively related to population size (e.g., Berry 1967; Webber 1972); simply put, the more people, the greater potential for economic activity (though see Crissman 1976 for a dissenting opinion). Thus, settlement hierarchies can be developed by grouping places of similar population in the same hierarchy level.

For the archeologist seeking to group prehistoric sites into settlement hierarchies, all that remains is to establish that site size is an index of population size (see Adams 1974 and Johnson 1977:494-495 for problems in this procedure). Since the groupings are relative, there is no need to actually estimate the past populations of the sites and no estimate of density need be developed. Methodological studies demonstrating the empirical relevance of linking site size to site population are all that is needed to justify the reconstruction procedure. The analytic tool used to demonstrate this relation is Pearson's product-moment correlation coefficient (Steel and Torrie 1960:183-190).

Table 1 presents Pearson's r values from a number of different studies, ranging from hunter gatherers to stratified societies (see also Kramer 1982: 160-162). While the appropriateness of Pearson's r is questionable, a point addressed below, the overwhelming impression is of a positive relation between total site size and site population. The low correlations arise from the aggregate grouping problems identified by Cook and Heizer (1968:110-115). Thus, it does seem reasonable to use total site space as a basis for reconstructing settlement hierarchies within culturally homogenous regions.

ESTIMATING POPULATIONS

Greater specificity of analytic tool is required to deal with the second problem, the reconstruction of past population sizes. Here the consistency of the relation between a measure of site size and site population needs to be established.

Furthermore, some estimator of density, usually a constant, is also needed to reconstruct the population size. This is usually a density value, people per dwelling space, measured as people per room (e.g., Ammerman et al. 1976; Millon 1973:44-45), or people per unit of floor or roof space (e.g., Jacobs 1979; Kramer 1979; LeBlanc 1971; Naroll 1962). The density estimators are usually justified with a direct historical methodology (e.g., Kramer 1979; Kramer 1982; Sumner 1979) or by using values derived from cross cultural analyses (e.g., Naroll 1962).

Table 2 presents Pearson's r values of site population and dwelling space from a variety of

Table 1. Consistency measures for site population by total site size: Pearson's r.

Source	r	n
Kur River Valley, Iran (Sumner 1979:165)	.76*	(110)
Khuzestan, Iran (Johnston 1989)	.855**	(53)
Oaxaca, Mexico (Johnson 1980)	.888**	(45)
16 San Camps, Botswana (Wiessner 1974:349)	.91 NR	(16)log-log
17 Yoruk villages, California (Cook and Heizer 1968:100)	.905 NR .956 NR	(17) (17)log-log
3 Yagahn settlement groups, Tierra del Fuego (Cook and Heizer 1968:100)		
Group A	.794*	(50)log-log
Group B	.652	(10) "
Group C	.755	(5) "
8 Chumash villages, California (Cook and Heizer 1968:102-103)	.721 .762	(8) (8)log-log
11 Northern California geographic regions (Cook and Heizer 1968:104)		
Region 1	.515**	(74)log-log
Region 2	.611**	(170) "
Region 3	.658**	(21) "
Region 4	.883**	(15) "
Region 5	.658**	(35) "
Region 6	.813**	(15) "
Region 7	.304	(30) "
Region 8	.565**	(72) "
Region 9	.709**	(29) "
Region 10	.736**	(26) "
Region 11	.752**	(11) "
26 Cultural regions, California (Cook and Heizer 1968:107)	.524 .372	(26) (26)log-log
3 Ecological subgroups of the 26 California cultural regions (Cook and Heizer 1968:107)		
Group I	.783** .656**	(17) (17)log-log
Group II	.392 .220	(5) (5)log-log
Group III	.877** .982**	(4) (4)log-log

* p<.05; ** p<.01; NR, no reported significance test; "log-log", transformation of variable to logarithms)

cultures (see also Kramer 1982:160-161). Again, while the applicability of Pearson's r may be questioned, the overwhelming impression is of a positive relation between dwelling space and population size. The consistency of this relationship is much stronger than that noted by Cook and Heizer (1968:110-115) for the relation

Table 2. Consistency measures for site population by site dwelling size: Pearson's r.

Source	r	n
Shahabad, Iran (Kramer 1979:153)		
Compound Area	.58**	(67)
Roofed area within compound	.70**	(67)
Dwelling area	.61**	(67)
18 Societies (Naroll 1962:588)	.88 NR	(18)
27 California cultural regions (Cook and Heizer 1968:98)	.978 NR	(27)
16 San camps, Botswana (Yellen 1977:124)	.8986**	(16)

* p<.05; ** p<.01; NR, no reported significance test

between total site space and population size.

Tables 3 and 4 present density estimates based on total site space and dwelling space respectively. The most famous of these is Naroll's (1962) rule of thumb of 10 m^2 per person (.1 person per m^2) (see Wiessner 1974, for a critique of this value's derivation). Considerable intercultural variability can be seen in this compilation of means. Furthermore, when standard deviations are reported, they also suggest considerable intracultural variability in the density values (e.g., Kramer 1979:153; LeBlanc 1971). The consistency of the relationship suggests that dwelling space is an index for population size, while the variability in the density estimator suggests caution in developing population estimates. The observation by Ammerman et al. (1976:38) that "it may be easier, contradictory as this may sound, to estimate population growth in some cases than population size" certainly seems justified by these tables.

Table 3. Density (per m^2) using total site space.

Source	Density
Kur River Valley Iran (Sumner 1979:166)	.0147
Tell-i Nun, Iran (Jacobs 1979:187)	
Old Village	.0116
New Village	.0053
Khuzestan, Iran (Johnson 1980)	.0202
Oaxaca, Mexico (Johnson 1980)	.0033
16 San camps, Botswana (Wiessner 1974:349) for camps of 10 to 25 on log-log model	.17 to .10

Table 4. Density (per m^2) using site dwelling space.

Source	Density
Shahabad, Iran (Kramer 1979:155)	.1
Tell-i Nun, Iran (Jacobs 1979:187)	
Old Village	.09
New Village	.03
Fasito'otai, Samoa (LeBlanc 1971:211)	.11
Leipua'i, Samoa (LeBlanc 1971:211	.09
Hasanabad, Iran (LeBlanc 1971:211)	.14
Wachipaeri, Peru (LeBlanc 1971:211)	.11
18 Societies (Naroll 1962:588)	.1

Cultural Regularities

The most sophisticated studies of the relation between site population and site size are those generally aimed at establishing cross cultural regularities. Since a consistent relationship between site population and site size is expected, correlation coefficients are usually reported. Furthermore, a specific model of this relationship is usually proposed. This is often based on an underlying behavioral idea relating site population to site size.

In a site where natural features of the landscape impose no constraints on the size or arrangement of a camp, it is obvious that in any correlation between group size and total camp area, the former is the independent variable and the latter the dependent one [Yellen 1977:99].

A similar dependence model of the relationship can be found in Cook and Heizer (1968:80): "We shall assume that the population is the independent variable and that the space occupied is dependent upon the number of occupants."

Frequently this behavioral relationship is presented as a linear mathematical model of the form:

$$y = a + bx \qquad (1)$$

where

y = site size
x = site population
a = Y-intercept
b = slope.

Both Yellen (1977) and Cook and Heizer (1968) use regression analysis to estimate parameters for the Y-intercept, the slope. Once these parameters have been estimated, rearranging the regression

equation allows one to retrodict site population from site area (Yellen 1977:99).

A number of studies (e.g.,Naroll 1962; Cook and Heizer 1968; Wiessner 1974) point out that the behavioral relationship of site size to site population is *no simple linear* relationship. The most common non-linear model is the exponential of the form:

$$y = ax^b \qquad (2)$$

which in its logarithmic form is:

$$\log y = \log a + b(\log x). \qquad (3)$$

The use of this non-linear relation is usually justified by appeal to the principle of allometric growth (e.g., Naroll and von Bertalanffy 1956; Cook and Heizer 1968:98; Yellen 1977:129). This principle, as presented by Naroll and von Bertalanffy states:

> that the specific growth rate (i.e., increase per unit size and unit time) of an element *y*, stands in a constant ratio to the specific growth rate of another element or the total system *x*....That is, the part *y* receives from the increase of the total system...a share which is proportional to its ratio to the total system...[1956:76-77].

Naroll and von Bertalanffy (1956) go on to demonstrate the widespread applicability of this relation for biological phenomena (e.g., head length to body length in *Homo sapiens*, pulse rate to body size in mammals) and sociological phenomena (e.g., city population and number of city manufacturing establishments, population of largest settlement and number of occupational specialties, and rural to urban population). Nordbeck (1971) also applies the allometric law to the relation between population and site size.

The development of exponential models of the relationship between site population and site size raises a number of issues. One is that non-linear models other than the exponential may provide better fits, however they have received little attention in the archaeological literature (Cook and Heizer 1968:80-81). Another, raised by Wiessner (1974) and discussed further below, is that the parameters of any of these models may themselves be variables.

Finally, the non-linear character of the relation between site population and site size has an implication for studies of the consistency of the relation. Pearson's r used in the settlement and demographic studies to demonstrate a consistent positive relation between site population and site size, is designed to study bivariate normal distributions (Steel and Torrie 1960:183). The acknowledged non-linearity of the relation creates difficulties for the interpretation and testing of Pearson's r (Speth and Johnson 1976:40-43; Steel and Torrie 1960:188-189). If one follows the allometric argument justifying the exponential non-linear model, it is reasonable to transform the data to their logarithms, and calculate r on the logarithms (e.g., Naroll 1962; Cook and Heizer 1968; Wiessner 1974).

A less restrictive approach to demonstrate consistent, positive covariation is to use non-parametric correlation coefficients, such as Spearman's Rho (Bradley 1968:91-96) or Kendall's Tau (Bradley 1968:284-287). These coefficients are based on rank data, assume that the scale of measurement is at most ordinal, make no assumption about the shape of variable distributions, and have tests of the hypothesis of no correlation. Given the robust nature of these assumptions and the crude nature of much of the data, these coefficients and their hypothesis tests are preferable to Pearson's r when a study is simply demonstrating a positive relationship between site population and site size.

In sum, studies of the relationship between site population and site size have been conducted to solve three related but distinct problems: (1) as indices of the functional size of sites for the relative grouping of a region's settlements into settlement hierarchies; (2) to estimate prehistoric site populations; and (3) to develop ethnological theory by discerning cross cultural regularities. Similar but distinct analytic procedures have been used in each: (1) measures of consistency, specifically Pearson's r, to define relative settlement groupings, (2) measures of consistency plus some estimate of density to reconstruct past populations; and, (3) mathematical models, along with correlation studies and density estimates, to identify cross cultural regularities. Measures of site size are best for estimating functional size, and dwelling space is better for estimating population size or identifying cross cultural regularities.

The correlations in Tables 1 and 2 indicate one other common feature of these studies. None of these indicates a perfect correlation between site population and site size. Furthermore, none of the studies suggests that the only variable conditioning site size is site population, even though this is often considered the most important variable. In fact a number of studies identify other sources of variation, and it is to a consideration of these sources of variability that I next turn.

SOURCES OF VARIABILITY AND MODELS OF ASSOCIATION

The previous section presented a qualitative and formal model, prevalent in the archeological literature, relating site population and site size. The qualitative model has site population as an important factor conditioning site size (Cook and Heizer 1968:80; Yellen 1977:99). Formally, this is expressed as either a linear or an exponential relation with site size as the dependent variable and site population as the independent variable. Before considering an alternative relationship, it is useful to review some of the other factors generally thought to condition the site population-site size relation. These can be conveniently grouped under the variable names found in Equation 4: level of sociocultural integration, place in regional hierarchies, place in regional ecological mosaic, other sources of intercultural variability, construction and occupation history, and errors.

Site space = f(P, S, R, M, V, H, Error) (4)
where:
- P = population
- S = level of sociocultural integration
- R = place in regional functional, productive, and social hierarchies
- M = place in regional ecological mosaic
- V = other sources of intracultural variability
- H = construction and occupational history

Errors are of two types. The first arises from a poor fit between the data and the assumption of the analytic procedures. For instance, calculating Pearson's coefficients with non-randomly drawn samples from non-normal bivariate populations creates a situation in which distorted correlations are expectable. The other involves measurement errors that arise in the collection and processing of spatial data. Sumner (1979:165-167) discusses some of these, calling particular attention to the difficulty of determining site area for villages not circumscribed by walls. Cook and Heizer (1968: 101) experimented with different methods for determining site space and obtained Pearson's r values ranging from .812 to .956 for the same maps with different bounding principles. Paynter (1980:414-426) discusses a procedure for controlling for machine and human inaccuracies when taking areas from maps with digitizers (also appropriate for using polar planimeters). These sources of error can never be eliminated, a fact of life that lends weight to the plea for careful explication of procedures and assumptions.

A number of other, more behavioral, sources of variability have been proposed. Ammerman and co-workers (1976:32-33) mention the general problem of *intracultural variability* (V), particularly regarding different "modes of household occupation". Other sources of intracultural variability (all identified as R in equation 4) include place in the *functional hierarchy* (Sumner 1979), place in a regional *productive hierarchy* (e.g., industrial versus commercial sites) and place in the *social hierarchy* (e.g., Kramer 1979, 1982). Cook and Heizer (1968: 110-114) note the effect of the *ecological mosaic* (M) on total site area. These caveats, while quite general, are well worth keeping in mind, particularly when universal relations are proposed (see Kramer 1982: 84-199 for a careful and detailed consideration of intra and intersite sources of variability).

More specific socioeconomic functions have been studied. For instance, Kramer (1979) has investigated the relation between household wealth and various measures of house size, finding that the area of a residential compound correlates strongly with wealth. Cook and Heizer found that total site size varied with the economic specialization of the site (1968:114). Residency rules have an arguable effect on house size. As presented by Ember (1973) and Divale (1977) matrilocal households should reside in larger houses than patrilocal households. As already noted, functional size, or place in the regional functional hierarchy also effects total site space (Sumner 1979).

The construction and occupation history (H) of sites also affects the relation between site population and site size. For instance, one hundred percent of a site may not be occupied 100% of the time, a factor particularly relevant for religious or political centers or periodic marketplaces. Walled villages are reported to go through a period of increasing density until settlement breaches the walls, at which point the density drops (Jacobs 1979; Sumner 1979: 167). Kramer reports that the earliest compounds at Shahabad were the largest (1979:154).

Intrasite settlement characteristics, such as clustered versus dispersed patterns, can obviously affect site size. Sumner attributes such differences to cultural preference in noting nomad's penchant for living in dispersed villages (1979:168). Wiessner (1974) presents an interesting geometric argument associating settlement pattern and site population-site size variability with *level of sociocultural integration* (S). Working with the exponential model of the site size-site population relation, she argues for systematic variation in the exponent (b) as a

function of the shape of the settlement. Thus, the one-dimensional shape of hunter-gatherer camps leads to an expectation of b=2; agricultural villages of two dimensions have a b=1; and urban agglomerations have b=1/2.

These suggestions represent some of the ideas in the literature on site population-site size relations, and suggest a different qualitative model of the relation (Kramer 1982; Schacht 1981). Such a model of association builds on the simple qualitative dependence model. Recall, the usual dependence presentation casts site size as a dependent variable and site population as *the* independent variable. It is clear that a number of other variables should be included in models accounting for site size. The above model is but one way of grouping some of the additional factors.

What do we learn by explicating the discussions of site population and site size in the form of Equation 4? Most obviously, the formal model points out that an adequate account of the relation between site population and site size need consider many variables. In effect, it extends the bivariate model to a multivariate relation. Additionally, formalizing the potential variables helps remind us that few if any of these variables are unrelated. So, in addition to the variables identified, there should be interaction terms expressing the effect of the variables on each other. For instance, terms are needed for the effect of certain levels in regional hierarchies found in certain parts of the ecological mosaic on site size, or of population found in different social hierarchies in relatively young sites. All this should become quite intricate and specifying the nature of the relations between variables would result in quite complex models. And, such a formalization helps us better see that the relation between site population and site size is surely not simply linear in form.

The formalization of the relationship between site population and site size, as in Formula 4, calls attention to the complexity of any rigorous statement of cross cultural regularity between these variables. Advancing such a model would call for sophisticated mathematical modeling and the collection of finally controlled data not commonly encountered in the literature of ethnology. Given the size of the task to advance this model, one must ask: is it worth elaborating such a model?

This can best be considered in terms of the three problem contexts presented earlier. For the first two--reconstructing past settlement systems and reconstructing past demographies--this seems a rather unrewarding exercise. The estimates for all of the independent variables are sufficiently crude to make any such model tenuous in the prehistoric setting. The coefficient estimates derived from ethnohistorical and ethnographic contexts would probably not be correct for specific prehistoric situations. To use site area to study population growth (Ammerman et al. 1976) or settlement hierarchy (Johnson 1977) simply does not require this level of precision. The quality of the reconstructed data and the nature of the questions are sufficiently rough to recommend against such elaborate nonlinear multivariable modelling.

That leaves the problem of establishing ethnologic regularities. For such a task, a high level of precision is desirable. But, that only raises the question of the significance of learning that there is a highly specifiable model of predicting site size from a number of variables. What problems in ethnology would such a model help explain? Ethnology should be interested in elucidating the similarities and differences of human relations, not simply in searching for any possible regularities. High speed computers and complex fitting procedures guarantee finding regularities; they in no way guarantee the regularities will be interesting.

What is called for is a model of sociocultural variability which includes variables that can be approximated with site size and site population. With such a model it would be possible to understand how site size-site population relations vary along dimensions of general anthropological interest, rather than simply along dimensions of operational convenience. This involves considering the relation of site population-site size in a more useful form than one of dependence (even multivariable dependence).

POLITICAL ECONOMIC VARIABILITY

Different approaches can be used to connect site population-site size variability to socio-cultural variability. In the following, I use a political economic perspective. Site size and site population are considered in terms used in political economic analysis. Furthermore, numerous theories of sociocultural variability arise from this perspective that could usefully be evaluated with archeological data. While the full range of sociocultural variation falls within this perspective, I will restrict myself to considering how variation in stratified political economies affects the site population-site size relation.

The political economic perspective seeks to elucidate the institutions and material conditions relevant for provisioning society (e.g., Harris 1979; Sahlins 1972; Wolf 1966). Social production of goods and services necessary for provisioning soc-

iety is embedded within a matrix of social and ecological relations (e.g., Polanyi 1977). Obviously change in these relations leads to change in the quality and quantity of social production, which in turn can reinforce or alter the nature of the social and ecological relations. However, for stratified societies the limiting condition for this change is maintaining unequal access to strategic relations and resources (Fried 1967).

Site population and site size fit within this perspective in fairly obvious ways. Site population is labor supply mobilized in various institutionalized settings for the purpose of social production and it is one source of demand for this social production. Site size is in part a reflection of the fixed technology used in social production. Retail and wholesale shops, factories and workshops, clerk's offices, and even housing, all play roles in activities which result in the provisioning of society.

In this perspective, the nature of the site population-site size relation is of a different sort from that presented above. Site size and site population, as measures of fixed technology and labor, interact with each other in the transformation of raw material into goods and services. Sites are built environments (Harvey 1973c:195-284), built as part of the general reproduction of society, not simply the dependent fallout from population occupation. And as the production of socially useful goods and services varies, so too should the mix of the elements of this production, including site size and site population.

Situating site population and site size within a political economic perspective suggests a number of sources of variation between these two variables. Generally, as the political economy varies, the mix of labor to fixed technology might also vary. For instance, consider the effects of industrialization. Since under industrialization more people work with large, fixed technology--at factories, on highways, in office buildings--the densities of people per site should increase. Furthermore, with industrialization, there is a shift in employment form agricultural activities to activities associated with industry. This also is reflected in larger ratios of people per unit fixed technology. Since fixed technology is being considered in its spatial dimension as a site, then increasing industrialization leads to increasing numbers of people per site.

A little less obviously, industrialization entails an intricate division of labor with differing ratios of labor to fixed technology for different enterprises. The presence of a mix of these different productive practices in a region would result in variation in the relations between site population and site size within a region. For instance, in an early industrial region in which water-powered textile factories have recently arrived in a region still populated by many less industrialized craft producers, the mix of people to fixed technology would vary greatly throughout the region.

A further source of inconsistency in market allocation systems is the imperfect character of markets. Assumptions underlying models of market allocation such as an isotropic plain, spatially uniform and identical incomes, demand schedules, propensities to consume, perfect knowledge of the market, and profit maximizing behavior (Lloyd and Dicken 1972:9) rarely hold in reality. Deviation from these assumptions results in mismatches between the distribution of fixed technology and labor, experienced in some regions as overcrowding while others go through abandonment and decay. These mismatches are likely to induce imperfect regional correlations between site population and site size.

Administered economies represent an alternative to market economies. Administrative allocation institutions--the state bureaucracies of socialist societies and religious bureaucracies of theocracies--also affect the consistency of the site population-site size relation. All such administered economies have the potential for very consistent mixes, through central planning and allocation. However, all administered economies do not exhibit equal degrees of centralization and allocation control (Amin 1980; C. Smith 1978). Strongly centralized bureaucracies, such as Old Kingdom Egypt, presumably Middle Horizon Mesoamerica, the Inca Empire, and socialist state countries, would expectably exhibit quite consistent mixes. Weakly organized administered economies, such as in Egypt's Intermediate Periods, in Medieval Europe, and in Postclassic Yucatan, would show less consistency in the mix of labor and technology.

A third factor affecting the site population-site size relation in stratified societies is the spatial organization of cores and peripheries. Core areas are engaged in the concentration of surplus while peripheries have productive systems and social-political organizations promoting the export of surplus (Wallerstein 1974, 1979; Harvey 1975). The surplus brought to the core areas can be consumed in a number of different ways. One of these is in building construction: ornate monuments to the powerful, structures for the institutions of social power, living and recreation accommodations, baseball stadiums, transport facilities, etc. The effect of plowing social surplus into the built

environment is to depress the site population-site size ratio. Thus cores should be less densely occupied than peripheral sites.

The surplus from peripheries can also be directed in another manner that affects the site population-site size ratio. Amin (1980) points out that core areas, by investing in social control, seem to be more organized in their economies than are peripheral areas. In this regard he points to the mix between capitalist and precapitalist production systems found in contemporary Latin America and Africa (131-181) and to the incomplete centralization of the peripheral Medieval Europe (60-70). The relative uniformity found in core areas should contrast with the mix of political economic institutions found in peripheries leading to less consistency in the allocation of production factors. Thus, measures of consistency should be greater in core areas and less in peripheries.

At least these three dimensions of political economic variability expectably affect the relation between labor and fixed technology, and through this, between site population and site size.

1. Industrialization should increase the number of people who work with fixed technology, thusly increasing the ratio of site population to site size over that found in preindustrial setting.

2. Strongly administered economies have a greater potential for consistently mixing labor and fixed technology than that found in either market economies or in weakly administered economies.

3. Differences between cores and peripheries have two expectable affects:
   (a) surplus importing cores should have more fixed technology per capita than surplus exporting peripheries, thus lower site population-site size ratings; and
   (b) more consistent mixes between labor and fixed technology should appear in economically uniform cores than in the loosely organized economies of peripheries.

The utility of a political economic perspective for studying the site population site size problem hinges on (a) locally connecting the perspective to the problem, (b) demonstrating the empirical relevance of these theoretical propositions, and (c) providing a source of interesting problems. This section has discussed how to restructure the relation between site population and site size to be sensitive to political economic variability. The next section considers the relevance of this restructuring to empirical studies of this relation.

ANALYSES AND INTERPRETATIONS

Government documents, gazetteers, atlases, area handbooks, etc. would seem to be likely sources of data useful for evaluating hypotheses about site population-site size. However, estimates of site size, similar to those used by archaeologists in the previous studies are *not* frequently encountered. One source that does publish site size statistics for contemporary settlements is the International Statistical Institute and their comments on compiling this information are informative:

> The towns seem to have had considerable difficulties in answering the questionnaire [regarding site size]. Even many large European towns have given incomplete answers only [International Statistical Institute 1972:xi].

There are a great number of "no reports" for their questionnaire. When data are reported, a number of difficulties arise, such as the sub-totals for specific land uses not adding up to the total area reported. While frustrating for this study, the underreporting of area is also interesting and would seem worth pursuing in another inquiry.

Data were obtained on four study areas--Late Medieval Europe, twentieth century U.S., mid-twentieth century Czechoslovakia and Poland, and mid-twentieth century India. With the exception of India, the measure of site size is a measure of the area covered by structures at the site. The U.S. sample is based on "urbanized areas" rather than the politically bounded Standard Metropolitan Statistical Area (Dept. of Commerce 1977:xx); the East European samples are based on the "built up area" (International Statistical Institute 1972: Table 12). Russell (1958:60-63) calculated area estimates from a number of sources, many of which are taken from Late Medieval maps. The India sample is most likely based on political boundaries (Ahmad 1965:126). Its inclusion was deemed useful to include contemporary peripheries.

This sample is so small and the measurement procedures so uncontrolled that rigorous comparisons seem a rather senseless exercise in number crunching. This means it is not possible to ascertain whether the variability between measures of density and consistency from these samples is due to political economic factors or to some of the other factors outlined in the previous sections.

Such a definitive study is not possible with the kinds of data that are readily available.

However, this does not preclude some rough analysis of the expected political economic affects. Specific relative trends are expected. If they do not show up, then it would seem unwise to invest the time and effort necessary to collect the data to conduct the more rigorous study. To study these tendencies requires typing the cases along each of the expected dimensions of variation.

It is not possible to pigeon hole empirical entities of the scale and complexity of these samples neatly into the political economic categories presented in the previous section. All of these study areas exhibit varying degrees of industrialization, mixes of market and administrative allocation institutions and varying degrees of accumulation and export of surplus. The four areas can be categorized in terms of their degree of industrialization, form of allocation institution, and position in the World System. Thus, the tendencies suggested in the previous section might appear in comparisons between these study areas, rather than by comparison to some theoretically derived standard of density or consistency.

The twentieth century data areas are obviously more industrialized than is the late Medieval European data. While U.S. settlements are built with resources allocated by both the market and administrative bureaucracies (e.g., Harvey 1973c: 153-194) the market is clearly more important in the U.S. than it is in socialist countries (French and Hamilton 1979), in India (Ahmad 1965:116), or in late Medieval Europe (Pirenne 1952; Stephenson 1933; Tigar and Levy 1977:117-180; Vance 1977:75-199). The socialist cities are the only strong central bureaucracies. Finally, since the core periphery ideas have been best worked out for capitalist systems (e.g., Brookfield 1975; Wallerstein 1974, 1979), only those places involved in this system are analyzed along this dimension. The twentieth century U.S. sample is obviously from a core area, and the recent colonial status of India points to its more peripheral position. The expectations can be summarized as follows:

1. Industrialization: The U.S., India, East Europe all should be populated more densely than Late Medieval Europe.

2. Administered Economy vs. Market Allocation: East Europe should have higher correlation values reflecting a more consistent mix of labor and fixed technology than the U.S., India or Late Medieval Europe.

3. Core vs. Periphery: (a) the U.S. should be less densely populated than India, and (b) the U.S. should have a more consistent mix of labor and technology than India.

The measures are reported in Table 5.

There are a number of points to be made about this Table. First, all the correlation coefficients indicate a positive relation between site population and site size, thus supporting previous studies and the basic intuition concerning this relation. Second, the densities vary considerably from the rule of thumb value of .1 person per m^2. In part this is to be expected since the measure of size is total site area rather than dwelling area. However, since the variation is greater than three orders of magnitude, these results tend to support Wiessner's critique (1974) of .1 person per m^2 as a cultural universal.

A third point concerns the formal nature of the relation. As was noted above, there is good a priori reason to expect the site population-site size relation to be non-linear. Scattergrams of the variables (not reproduced here) support the very skewed character of site size and site population for each case. This tends to make the Pearson's r unreliable as a measure of the strength of correlation, a point borne out by the non-parametric Spearman's and Kendall's correlation coefficients. All three statistics support the notion that site size is positively correlated with site population, though the strength of the relation seems to be overestimated by Pearson's r. Future studies should make use of the non-parametric coefficients, given the likelihood that the Pearson's r will distort the strength of the relation.

To test the notion that site population is related to site size by the allometric model, logarithmic transformations were performed and the correlation coefficients recalculated (Table 6). This improved the strength of the correlation in only the late medieval Europe sample: it weakened the correlation in the other three cases. The result does not give strong support for the allometric model, though it does not necessarily reject it.

Finally, it does seem worthwhile to pursue the effect of political economic variability. The expectations for variation along the industrialization and the core-periphery dimensions are met. The one unexpected result is that the strong central bureaucracy of the East European samples are not revealed as the most consistent. They are clearly stronger than the relations for India by any measure. However, they are only slightly stronger than the twentieth century U.S. And, when one uses

Table 5. Consistency and density of site population to total size for political economic samples.

	Pre-Industrial	Industrial		
	Administered Economy (Weak) Medieval Europe (91)	Administered Economy (Strong) Socialist Europe (24)	Market Economy Core U.S. 1970s (30)	Mixed Economy Periphery Indian 1960s (85)
Density ($1m^2$)	.0111	.1650	1.0531	7.8598
S.D. ($1m^2$)	.0053	.0640	0.4120	5.5059
r	.77**	.97**	.96**	.72**
r^2	.60	.93	.93	.52
Spearman's Rho	.88**	.88**	.89**	.58**
Kendall's Tau	.70**	.75**	.76**	.42**

* $p < .05$ ** $p < .01$

Table 6. Consistency measures on logarithmic transformation of site population by total site size for political economic samples.

Measure	Medieval Europe (24)	Socialist Europe (24)	United States 1970s (30)	India 1960s (85)
r	.87**	.92**	.94**	.71**
r^2	.75	.85	.88	.50
Spearman's Rho	.88**	.88**	.89**	.58**
Kendall's Tau	.70**	.75**	.76**	.42**

** $p < .01$

non-parametric coefficients, the late Medieval sample is also about as strong.

There is one final characteristic of these samples that deserves further attention. Unlike the studies from Iran and Mexico noted above, none of these samples are from a contiguous settlement system. They are only the tops--the largest places in their national settlement patterns. This might affect the observed trends. For instance, these large sites might be swamped by housing and not truly sensitive to differences in the mix of production factors. However, the consistency measures from these peripheral areas are lower than the values from the core areas (though not as low as the value from India), which suggests that the difference between cores and peripheries regarding consistency measures may be useful at both scales. The density patterns are not as expected, probably reflecting the non-industrial character of the Iran and Mexico samples.

The effects of analyzing contiguous settlement patterns can be exemplified with data from the Connecticut River Valley in Massachusetts between 1830 and 1850. Data is available on all towns within a 5,000 km^2 study area. During these three decades the area was changing from an agricultural periphery of the British world system and adopting more core-like industrial attributes (Paynter 1982). Consistency measures should increase as the area becomes more core-like.

Population data was obtained from the U.S. census for 1830, 1840, 1850. Site size was estimated by calculating the number of structures in each town (all structures worth more than $20 were recorded for tax purposes). Population and structure densities were calculated to control for the different areas included inside town boundaries (Massachusetts towns being analogous to townships in the rest of the U.S.). Correlations between population density and structure density follow the expectable patterning of increasing consistency (see Table 7).

In summary, trends in the relation of site population to site size expectable from variation in political economy can be theoretically identified, and do receive qualified support in this series of

Table 7. Consistency measures on site population density by number of structures density on Middle Connecticut River Valley samples.

Year	r	Spearman's Rho
1830	.7998*	.8919*
1840	.8668*	.8129*
1850	.8865*	.9137*

* $p < .05$

empirical analyses. The qualification is due to the small number of cases from which data on site size is available. The most noticeable trends involve increasing densities with increasing industrialization and decreasing densities and increasing consistencies with movement from peripheries to core areas.

CONCLUSIONS

The initial problem was to consider the nature of the relationship between site population and site size. It is easiest to discuss the results in light of the three problem contexts within which this relation has been studied.

The first was the problem of reconstructing settlement hierarchies. Nothing in the present study contradicts the basic idea that there is a positive relation between site population and site size, the basic relation necessary for settlement reconstruction. However, the non-parametric correlation coefficients are lower than the parametric coefficients, suggesting that the relationship is more variable than previously reported. Given the greater applicability of non-parametric measure to site population-site size data, this finding suggests that settlement hierarchies should be constructed using other site attributes in addition to site size (Johnson 1975). This is particularly the case when working in peripheral areas.

The second problem was reconstructing past demographies. This study does not measure site size in terms of dwelling space, so direct comment on proposed constants is not possible. However, the variability of density among different types of political economies supports Wiessner's (1974) suspicion that no such cultural universal (of dwelling space to population size) will be found. Attention might be better directed towards identifying systematic cross cultural variability rather than constants.

The third problem has been Anthropology's concern with identifying cross-cultural regularities. This study supports the consensus that the relationship of site population to site size is regular and non-linear. However, the proposed allometric model is not well-supported. Something more complex than allometric growth seems to be operating.

A number of sources of variability in the relationship of site size to site population have been proposed. This study proposes yet another--political economic variability--and undoubtedly more can be described and evaluated. I have argued that further study should not proceed by simply identifying more and more variables to increase the precision of the index of past site population or site functional size. I have also argued that these variables can be set in a theoretical context of more general interest. In the long run, keeping the theoretical context in mind should help us avoid misleading cultural constants, address issues of general ethnologic interest, and keep cultural variability prominent.

ACKNOWLEDGEMENTS

Carol Kramer, Greg Johnson, Martin Wobst, John Cole, Brooke Thomas and Dorothy Krass read, contributed leads and commented on earlier versions of this paper. Many thanks to them all.

I met Dick Woodbury on my first day of graduate school at the University of Massachusetts, Amherst. There was a morning of orientation for the largest class yet admitted to the graduate program. I knew none of my classmates. Somehow I ended up with Dick and one or two other people for lunch (at Chequers). He was the chair of the Department and cordial; I was almost hopelessly wet behind the ears and anxious.

My class included Stan Green, Sheryl Horowitz, Libbet Cranshaw, Alan McArdle, and Lydia Black. Pete Thomas, Dave Carlson, Jerry Rose and Steve Perlman were already here; Anne Early was about to graduate; and Jim Moore, Joan Gero, Dolores Root, and Pete Thorbahn were to arrive soon. The next two years saw much heated debate about the graduate program--debate that split both the faculty and graduate students into factions. Dick had to run the Department during this tumult. In doing so, he had firm opinions about what the program should be--opinions often at odds with mine. He also had firm opinions about administration, namely, that all voices should be given their due in an orderly process, and that the Department should be run on the basis of majority rule. These latter opinions were much respected by the Department and are a lasting legacy of his to this day. The graduate students recognized that we had much to learn about the craft of college administration from Woodbury. Indeed, Thorbahn and I served on Departmental committees with the goal of seeing how Dick chaired them.

I took a reading course on Civilizations, sat in on a small seminar on the Southwest, and benefitted from Dick's participation on my dissertation committee. The New Archeology was all the rage: it was exciting, provocative, polemical and self-righteous. Above all it was disdainful of anything that came before. Dick encouraged reading the New Archeology as well as selected pieces of earlier work, always helping us see the intellectual and social history of the discipline within which contemporary debates were enmeshed. In his classroom observations and his written comments, he gave us an alternative model for scholarship to the bombast that was the style of the time. It was quite similar to his notions about administration: listen to and read others, provide space in articles, journals and meetings for alternative voices, and come to your own firm positions.

I started this paper shortly after completing my dissertation, one of those leads that the editor Woodbury helped identify and wisely counselled taking up at a later time. The mathematical modelling and the political economic theory reflect more my (still ongoing) conversations with professors, friends and colleagues, Wobst and Cole. However, my attempt to give all sides their due and then come to my own position--the style and tone--is attributable to Dick. He continues to be one of my guides for crafting a life in the academy. Thanks.

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PALEOPATHOLOGIST AS DETECTIVE: DISEASE AND DEATH IN PREHISTORY

by George J. Armelagos and Dennis P. Van Gerven

The work of the paleopathologist is similar to that of a detective. Just as the detective must reconstruct a crime by sifting through the evidence for clues that reveal a pattern, the paleopathologist (scientist who studies disease in ancient populations) must analyze the bones and artifacts of populations long dead in order to understand their patterns of disease and death. For the detective, the major objective is to determine that a crime has been committed and to uncover the perpetrators; for the paleopathologist, it is to analyze prehistoric skeletal remains to understand how a population lived and died.

In the past two hundred years, paleopathologists have discovered a variety of human ailments in ancient populations. Trauma, amputation, infectious conditions such as syphilis and tuberculosis, congenital defects, rickets (vitamin D deficiency), arthritis, malignant tumors, and even poisoning from toxic substances have been found in prehistoric populations (for a review of paleopathology see Brothwell and Sandison 1967; Ortner and Putschar; Steinbock 1976; Wells 1964). These discoveries have helped us trace the evolution of those diseases to modern times, through the examination of their history and geography. But the contribution of paleopathology goes beyond space and time and single diseases; it can help to reconstruct the lifeway of a society and its adjustment to its environment.

Disease and death are not random events; they form discernible patterns. As Calvin Wells notes:

> The pattern of disease or injuries that affect any group of people is never a matter of chance. It is invariably the expression of stresses and strains to which they were exposed, a response to everything in their environment and behavior. It reflects their genetic inheritance (which is their internal environment), the climate in which they lived, the soil that gave them sustenance and the animals or plants that shared their homeland. It is influenced by their daily occupation, their habits of diet, their