CHAPTER 4

A HUMAN ECOSYSTEM FRAMEWORK FOR ARCHAEOLOGY

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Anthropological or Interdisciplinary Archaeology?

Archaeology is, by its nature, ultimately empirical. But archaeologists strive to go beyond the elucidation of material culture by attempting to identify social aggregates and to generate evidence of, and explanations for, change. Considering the difficulty of understanding group ecological behavior in a contemporary setting, or of identifying cause and effect relationships in the historical record, this seems an ambitious and challenging goal. But like many other social scientists, archaeologists have proposed to achieve such ends by borrowing theoretical concepts from the natural sciences, so as to develop and ostensibly to test hypotheses, based on a particular set of assumptions. Such assumptions are justified by disciplinary "mapping" of familiar, empirical configurations which, in the case of archaeology, are generally grounded in cross-cultural, ethnographic experience.

During the last 30 years, archaeology has moved from an essentially empiricist stance to an explicitly theoretical paradigm, with a strong, positivist and quantitative bias, only to be followed in recent years by the post-modernists' anti-positivistic reaction. These philosophical shifts parallel those in other social sciences. Apart from their direct significance for the formulation and execution of archaeological research, they affect the interdisciplinary relationships of archaeology. In the case of American archaeology, its academic context has been within the field of anthropology, with archaeology representing a subdiscipline,

explicitly or implicitly charged with the temporal elaboration of anthropology. This has the advantage of exposing archaeology to the intellectual cross-currents of anthropology. But it has also been disadvantageous, exposing archaeology to disciplinary fads and limiting effective contacts with other sciences.

An example of this is the long preoccupation of archaeologists with site-specific excavations, reflected in a closed-system approach, similar to that adopted by decades of ethnographic case studies and even early examples of energetics research (see Rappaport 1968). Archaeological survey of larger areas was considered a revolutionary innovation, and still is seen by some as a deviation from a "purer" form of research. The open-system perspective can dramatically change macro-scale interpretation, as Netting (this volume) and Adams and Kasakoff (1984) show. The traditional, disciplinary penchant for closed systems not only contrasts the perspectives of anthropology and human geography, but also helps explain why these disciplines communicate today so poorly.

In regard to ecology, the approaches of anthropologists and geographers complement each other. Anthropologists tend to be interested in the processes and structures whereby human groups match resources with their needs, and incorporate them into cultural behavior (Steward 1955; Barth 1956; Geertz 1963; Rappaport 1968; Orlove 1980; Ellen 1982; Adams 1988; Moran, 1982 and in this volume). Geographers, on the other hand, focus on a broad sphere of interaction with respect to resources, emphasizing the spatial matrix of the socioeconomic and biophysical environment (Brookfield 1964; Stoddart 1965; Clarkson 1970; Chorley 1973; Butzer 1976, 1982, 1989, n.d.; Denevan 1983). Evidently, anthropology and geography share many basic interests, at least at the macro-scale, and they have much to learn from each other. This is particularly so for archaeology, where macro-scale implies resource interdigitation, spatial dynamics, and long-term transformation of cultural systems.

Archaeologists generally accept that geography provides useful data and techniques, but rarely learn how to incorporate them effectively. One reason for this is that their intellectual priorities leave them insufficient time to acquire the requisite experience and technical skills. These factors may account for the frequently simplistic treatment of environmental variables in archaeology. The empiricists of the 1950s used environmental reconstruction or biological identifications with genuine interest but little sophistication. Their positivistic counterparts of the

1960s and 1970s actively explored concepts from biology and human geography (see Clarke 1968), but most eventually failed to assimilate them as more than mechanical constructs or peripheral variables, ultimately to be held constant (e.g., Gould 1978; Renfrew et al. 1982; Watson 1986; Schiffer 1987). The post-processualists simplified their search by abdicating interdisciplinary perspectives and downplaying the significance of socioeconomic change, in favor of social context and the symbolic meaning of data (e.g., Hall 1977; Hodder 1982; Miller and Tilley 1984; Leone 1986).

The argument of this paper is that archaeology cannot hope to achieve the degree of cultural resolution demanded by sociocultural anthropology. Firstly, a more productive eco-systemic focus is proposed for archaeology. Secondly, the limitations of archaeological inference are illustrated by historical cross-checking at the general and the detailed level. This is followed by a critique of how different levels of archaeological inference are constructed. Finally, a selection of fundamental questions is identified, and formulated in systemic terms, that demonstrate the vital importance of archaeological research for the social sciences.

The Human Ecosystem as a Focus for Archaeological Research

Both the advantages and difficulties of the ecosystem concept have been discussed by Moran (see introduction to this volume). As he defines it, the ecosystem refers to the structural and functional interrelationships among living organisms and their physical environment. Transfer of the concept to the social sciences requires several explicit restrictions. It is not a concrete unit of analysis but a dynamic perspective that facilitates the articulation of complex, interdependent relationships, characterized by positive and negative feedbacks, and variable equilibrium properties. It also provides insight into long-term changes, thresholds, "simplification," or "catastrophic" readjustment. But simulation or even quantification of entire ecosystems may be impossible. More fundamental is that human ecosystems differ from biological ecosystems in kind as well as degree (Butzer 1982:32). Information, technology, and social organization play inordinately greater roles in human ecosystems, and a primary "regulator" function must be introduced to accommodate the "steering" role of human cognition, value systems, and goal orientation (Bennett 1976: ch. 3). In doing so we are not creating a dichotomy between human beings and nature,

but rather singling out one human component--the mentalistic process--from the energetic processes of the system (Adams 1988:89).

Within these specific conditions, it is possible to accept the definition that *human ecosystems* represent the interlocking of social systems with ecosystems (Chorley and Kennedy 1971:4). For archaeology, a practicable general goal is to study and elucidate the archaeological data base, as derived from particular sites or site networks, as part of a human ecosystem. Such a focus serves to draw attention to the systemic interactions among cultural, biological, and physical factors or processes (Butzer 1982:7; see also Jochim, this volume).

The human ecosystem concept can be explicitly extended to include the roles of individual and aggregate human behavior, decision-making with respect to alternative possibilities, screening by the experience and deeper values encoded in culture, as well as the fundamental tension between individual goal-conflicts and human unpredictibility (see also Rappaport, this volume). These powerful variables for change vie with the community and institutional structures that favor stability, to maintain a fundamental tension that is incompatible with a homeostatic, ahistorical view, even in the absence of external perturbations (Butzer n.d. 1).

The human ecosystem, as more broadly defined above, has great heuristic value to examine socioeconomic behavior, but its applicability for strictly systemic goals is limited. Complex systems are almost impossible to simulate effectively, as exemplified by the failure of almost all economic prognoses. Prediction, whether of long-term evolutionary change or of rapid modification, is difficult, even in probabilistic terms. Retrodiction is almost as difficult, with historical processes remarkably intractable to generally accepted modes of explanation.

The value of the human ecosystem as a framework for archaeological research is explicitly conceptual. It is an interdisciplinary perspective that readily encompasses spatial variables, differences of scale, complexity and complex interactions, as well as equilibrium modes, including adaptive change and evolutionary transformation (Butzer 1982:7-11; 286-313). It is also flexible. In situations where the detail of sociocultural resolution is poor, it can be used in its narrow sense to deal primarily with socioeconomic inferences. And in cases where such resolution is good, it can be applied in its expanded form to incorporate a range of cognitive concerns.

Lessons from Historical Archaeology

Without contemporaneous, written records, and working with configurations well removed from the ethnographic "present," archaeologists can only postulate how economic structures functioned, and they have little prospect of grasping the values and goals of a society by whatever leap of ethnographically-based optimism. These assertions can be justified by two examples from historical archaeology.

Historical archaeology is a relatively little understood subfield, that receives only grudging National Science Foundation support. To North Americanist archaeologists it represents research in very late time ranges, usually Colonial or Industrial era sites. Many such historic sites are excavated in the course of salvage projects, and some involve only a single high-rise foundation in an inner-city area. Historical documentation here represents supplementary information, that rarely elucidates fundamental questions about cultural activities, since time and place are already well understood. There are no big surprises, as a rule, from either the historical or archaeological side, and relatively few, basic contradictions arise. Excavation discoveries mainly serve to enhance an already richly-textured historical appreciation. A different twist is provided by excavation of historic Indian sites, to ask new questions and discover new insights, independent of Euroamerican written records (Trigger 1980).

In the Old World, the perspective is very different, because a potential time range of 5000 years is involved in some areas, and because the cultural record prior to the 16th century is incompletely and imperfectly understood. The history of study of ancient Near Eastern civilizations, or of the Greek and Roman worlds, reveals a genuine complementarity between excavation results, on the one hand, and inscriptions, historical texts, or archival documents on the other. "Classical" archaeologists and philologist-historians, long ago converged their attention on problems of common interest. Since each field worked with a different set of assumptions, neither of them foolproof, the net effect was to mutually correct flaws in interpretation.

A question that has never been raised is whether "anthropological" archaeology by itself could have done (1) a credible job in reconstructing the broad outlines of cultural

configurations in the Mediterranean Basin and Europe prior to A.D. 1500, and (2) offered reasonably correct interpretations for observed changes? My reply to the first part of the question would be a qualified yes, to the second, a definite no. This opinion is based on a long-term, macro-study of ancient Egypt and an equally protracted micro-study of a small ecosystem across a thousand years in a mountain cluster of eastern Spain.

Limitations of the Archaeological Record for Ancient Egypt

The historical record of Egypt has, since classical times, been divided into three eras, eventually known as the Old, Middle, and New Kingdoms. They were followed by 2500 years of foreign domination, interrupted by only one episode of independence. This cyclicity of the Egyptian historical record poses particularly interesting questions in regard to what I would call system growth and periodic discontinuity, superimposed on a trajectory otherwise characterized by socioeconomic continuity. Over some 30 years I have been periodically engaged in archaeological survey or excavation in Egypt, complementing this experience by in-depth examination of the textual evidence, in translation. From this I have developed a series of theoretical, regional, or thematic publications addressing subsistence-settlement change, socioeconomic developments, recurrent ecological crises, and systemic response (see Butzer 1960, 1976, 1980b, 1984a, 1984b). The following conclusions are drawn from this background.

In regard to basic configurations, even without the ability to decipher inscriptions, the shifts of royal residence from the Old to Middle Kingdom would have alerted archaeologists to a major dynastic change, and the progressive impoverishment of elite tombs during the late Old Kingdom would have signalled economic problems. The Middle Kingdom breakdown, resulting from the Hyksos invasion, would not have been recognized, although Asiatic settlement sites in the eastern Delta might have raised postulates about a temporary loss of that region. The Ethiopian, Assyrian, and Persian conquests or occupations would have remained unknown, since there is no evidence other than texts or inscriptions in Egyptian. The New Kingdom control of Syria-Palestine would have been interpreted as nothing more than trade contacts, with Egyptian commercial outlets at two Lebanese ports.

At a more cognitive level, the appreciation that the same elite families controlled and deliberately held Egypt together as a nation from the Old to the New Kingdoms, despite dynastic replacement and changes of the official deities, would have been lost, leading to gross misconstructions. The multitude of factors responsible for cyclic discontinuity–dynastic fragility, bureaucratic inadequacy or corruption, administrative dysfunction, social change, foreign invasion, Nile failure--would not have been grasped. Instead, simplistic interpretations would have been touted every few years, without an appreciation for how the system really worked or why it periodically faltered or recovered.

On the other hand, historical study alone would have been sterile indeed without the unusually informative legacy of architecture and artistic expression, or the record for progressive social and technological change evident in the archaeological record. Equally fundamental is that the Old Kingdom capital had at most 15,000 inhabitants, with less than 50,000 people nationwide living in towns of 1,000 or more; during the New Kingdom there were two capitals, with 150,000 people each, and a half-million urban residents overall. The historical evidence by itself did not suggest substantial differences in urbanization or socioeconomic complexity.

These examples from Egypt, deliberately chosen at a macro-scale, illustrate the severe limitations of both archaeology and history if they were theoretically isolated.

Limitations of the Archaeological Record in a Spanish Micro-Study

These problems carry right down to the detailed level of standard archaeological interpretation. How fundamental the problems are became evident during the course of a project in the Sierra de Espadán, 50 km north of Valencia, Spain. Settled by Muslims around A.D. 1100, this area was reconquered by Christian Aragón A.D. 1238, but the Muslims were allowed to remain until their expulsion and replacement by Christian settlers A.D. 1609-10.

The Espadán Project was focused on one municipality, Aín, but was extended to exploration of a dozen others, with discovery and recording of 15 "lost" but historically-known Medieval villages. One such satellite village, called Beniali, and belonging to Aín, was occupied 1342-1526. It was partially excavated during two seasons. Another excavation was devoted to the adjacent castle of Aín, occupied during the 12th and 13th centuries, as was a second castle,

used as a Bronze Age and then as a Muslim settlement site, and converted into a Christian fortress during the 14th century. The project included detailed archival documentation of local Medieval life, ethnographic research, and delineation of social and land-use history from the 12th century to the present (Butzer et al. 1985, 1986, 1989; Butzer and Butzer 1989; Butzer n.d.1; Butzer and Ferrer 1987).

The objective of the Espadán Project was not simply to "understand" continuity and change in a unique setting, but to consider the micro-region as a laboratory to explain the interplay of culture-ecological variables involved in the social maintenance of resilient minority communities and their succeeding Christian counterparts, in terms of socio-cultural dynamics and adaptive strategies. The discussion that follows relates to a by-product of this project--the unexpectedly valuable complementarity of archaeological and archival research.

Given two good, parallel records, from excavation and from the archives, it was for the first time possible to compare such records to examine whether and how archaeological, hypothethico-deductive procedures of the 1970s would have succeeded or failed. Several examples can be singled out. Some are relatively trivial but instructive; others are fundamental.

The castle of Aín was abandoned in the 13th century, according to the pottery and geoarchaeological evidence, only to be soon but briefly reoccupied by common villagers, then besieged and destroyed. Given the general historical context, one would have "predicted" that the nearby people of Aín sought refuge in and defended the castle during the great Muslim revolt against Aragón 1276. *Instead, documents demonstrate that Aín was one of the villages that did not participate in this revolt: the rebels besieged here came from other places.*

The founding of the satellite village of Benialí, deep within Aín's municipal lands and directly above its major water source, logically suggests a daughter colony, set up in greater proximity to relatively distant fields. *But instead, a document indicates that another town, across the mountains, had received a royal charter to colonize the site.* Further, the surnames of the 15th century inhabitants verify that the settlers did not come from Aín, but from several other Sierra villages, and considerable rivalry between Aín and Benialí is witnessed by litigation records.

Excavation showed that Benialí consisted of about two dozen thatched, but mortared, stone houses with average interior dimensions of only 11.2m^2. So small, and located in the mountainous hinterland of a rural village with less than 100 families, one would "expect" a high degree of isolation from the outside world and a homogeneous farming economy. *Yet 13 tax-exemptions (franquicias), essentially licenses for commerce, were granted to residents of Benialí in the early 1400s, and one of them was a Jew.* In the case of Aín, we know that some of its residents actually did craftwork on contract in the distant city of Valencia. That Benialí was neither isolated in an economic or social sense, nor socioeconomically homogeneous, is supported by other lines of evidence.

The abundance of luxury pottery, imported from ceramic centers 80-120 km away, would normally be explained by indirect trade, via middlemen and local market centers. *However, in one case a resident of Aín posted bail for a potter in an 80 km-distant pottery center, indicating much more intimate contacts, once again arguing against social isolation.* The distribution of luxury wares among the structures of Benialí shows that the number of decorated sherds is proportional to pottery abundance, and does not allow the inference of a concentration of wealth in any particular house or zone. *Yet the archives show that eight families received commercial licenses while two or three others, at various dates, were indigent.* The material record failed to demonstrate this differentiation of status and wealth.

Parish registers after 1624 show a mean radius of 2.7 km for exogamous marriages in the case of Christian Aín, concentrated in two other villages, suggesting a logical ethnographic premise. *However, comprehensive study of hundreds of patronyms in 14 local villages between 1380 and 1563 suggest that the Muslims of Ain shared mates with five villages, at an average distance of 8.9 km.* In effect, Muslim family networks were much larger and involved a radius three times as large. By extension, *the Muslim villages maintained wider and tighter interconnections than did Christian ones.* This could not have been anticipated by normal archaeological procedures.

Abundant ethnobotanical materials from the Benialí excavations include "hard" and bread wheat, sorghum, oil seeds, green beans, olives, almonds, and various orchard fruits. Against the "predictable" inference, that the residents of Benialí were

self-sufficient, Mediterranean-style farmers, stand *numerous documents from the 15 km-distant market center of Onda, verifying that residents of Aín and other nearby villages frequently purchased large quantities of grain there on credit, and sometimes even oil or beans.* This startling fact reveals that the Sierra was not self-sufficient in staples, possibly selling only orchard products and flax (not present at Benialí, but verified by its commensal, weedy oil plant, Camelina). Further light is provided by private economic records of the early 1800s, showing that grain was purchased at the market centers in some years, sold there in others. Hypothetico-deductive procedures from an exclusively archaeological data base would have offered an erroneous, or at least inadequate, interpretation.

A rich archaeozoological inventory indicates that goats represented the main livestock, but that female goats were slaughtered at a somewhat earlier age than would be ideal for optimal herd reproduction, a trait symptomatic of people living near the hunger mark. *Archival resources shed a great deal more light on this phenomenon. The annual tithe income from flour mills and from the butchery in a larger, adjacent village show that more animals were slaughtered in those years when less grain was ground: goats were mainly eaten during poor harvest years.* This is indeed consonant with ethnographic experience, but the dietary implications could not have been specifically inferred from the excavation data. The convergent lines of evidence underscore the marginal character of the resource base deduced from site catchment analysis: only 24 ha of cultivable land (10% of that potentially irrigated) for 20 to 25 families.

Finally, the archaeological record provided minimal evidence for differences between Muslim villagers and Christian castellans of the 14th century. Both used the same pottery, with luxury classes produced in a Valencian center where Muslim potters crafted wares steeped in Islamic tradition, but symbolically modified to incorporate popular, Gothic themes. Such pottery was used in the region by both ethnic groups, but also exported to both Christian France and Muslim Egypt. The only hint of a difference in preference was the presence of a Gothic "rose" in a Christian castle level--a specifically Christian symbol--and a highly stylicized mano de Fátima, (a hand to ward off the evil eye), in a Muslim village level. *This suggests that stylistically-informative pottery is not necessarily as specific to identity conscious groups as it is sometimes claimed to be.*

These discordances between, or lacunae of the archaeological and archival records were only resolved when the two sources of information were combined. In isolation, both the economic and social inferences that would normally be drawn from the archaeology would, in several significant ways, be either wrong or misleading. These caveats go well beyond the so-called cautionary tales about interpreting micro-activities from artifactual distributions (see Gould 1978). They raise serious questions about the reliability of seemingly logical conclusions drawn from deductive socioeconomic principles that have been taken for granted. Post-processual archaeologists have begun to appreciate the difficulties of generalization from universal categories, but primarily for theoretical reasons. These case studies also show that matters of cognition are almost hopelessly elusive to archaeological investigation alone.

This is not to suggest that the archaeology of the Espadán project was in any way inconsequential. It was essential, in that it elucidated living arrangements and subsistence patterns only vaguely hinted at in the written documents, thus illuminating the material culture, the way of life, the basic social structure, relative values placed on material goods, and the overall poverty of the Benialí community. The archival documents, however, revealed the people as individual actors in the dynamics of local and regional processes or events. The archival sources also demonstrated direct contacts with the world outside of the Sierra, implying a vision of and an active participation in a larger, regional arena.

An Interim Assessment: The Emperor Has No Clothes

The lesson to be drawn from these Egyptian and Spanish examples is that archaeology can never be a direct analog to ethnography, to be achieved by excavation, regional survey, and sophisticated deductive models. Archaeology simply cannot provide the range of sociocultural information possible in an anthropology of contemporary populations. Socioeconomic theories, as well as ethnographic inferences from living peoples, must be treated with much greater caution than has usually been the case.

In further suggesting that it is counterproductive to place social context and, especially, meaning and symbolism at the center of archaeological aspirations, I risk being compared with Hawkes (1954). But having recently been labelled as both a logical

positivist and a hyperparticularist, by different archaeologists, I have little to lose to reductionism. While the "real past" is not inaccessible (to apply the terms of Watson 1986), substantial and consequential parts of that past are. The primary value of "structural archaeology" is that it serves to draw attention to prehistoric ideological or cognitive systems. These are legitimate concerns for archaeology, in as far as the possibility of at least sketching their outlines as potential variables in broader interpretation must be explored. Individual contributions to this genre of research also demonstrate that attention to culturally-sensitive phenomena allows valuable insights (e.g., Hodder 1984; Pearson 1984; Young 1988; Hastorf, this volume). But the limitations of prehistoric archaeology are such that cognitive dimensions can never represent primary concerns, and it is improbable that they could be "reconstructed" as more than component parts of larger, mainly hypothetical structures.

A Critique of Positivist Theory and Inference in Archaeology

Since about 1960, archaeologists have engaged in, or been subjected to, a barrage of epistemological discussions as to how to transform archaeology into a science with a body of "laws." The wearisome monologues on what is a science, whether the social sciences qualify as sciences, and whether archaeology can be made into a science, became more tempered as disillusionment set in during the mid-1970s. Although this initiation to positivism exacted a high cost on civility, archaeology has indeed evolved into a more pluralistic discipline, with broader horizons, a firmer grasp of how analysis is linked to inference, and developed a more explicit problem formulation.

Unlike the philosophers of science and social theorists that some try to imitate, archaeologists have a substantial body of data at their disposal. Their primary concern remains the elucidation of those data, and deliberate reflection on the premises upon which interpretation is offered. Such premises involve assumptions and working models ("theory"), that facilitate (rather than constitute) "explanation." Some models form testable hypotheses and may be converted into generalizable statements or "laws." Other models have intuitive appeal but cannot be verified to general satisfaction, a common problem in the social sciences. Eventually a body of laws and models, based on "behavioral correlates" derived from observed,

contemporary contexts, is applied to reconstruct the nature and functioning of past societies.

Since the laws and working models in use commonly relate to lower levels of inference, mainly built directly upon empirical data (the "middle range theory" of Binford, 1989 and earlier works), legitimate questions can be raised whether archaeology has assembled a sufficiently comprehensive body of "theory" to allow high-level reconstruction. To illustrate the nature of this problem, it is essential to examine the several levels of inference integral to such a process.

Low-Level Inference

At the *micro-level*, archaeologists deal with artifacts (*sensu lato*), artifact-patterning, and matters of basic intrasite or intrastructural activity-patterning. Perhaps 95% of the empirical and analytical work of archaeology is expended at this level, and this is what archaeologists do best. From an era of unrealistic confidence in the 1960s that the reconstruction of activity-patterning could be realized within reasonable limits of confidence, archaeologists have learned that such limits must be defined in more elastic terms. Although they refuse to consider that site formation is firstly a geoarchaeological phenomenon (Butzer 1982:chaps.6-7; Rosen 1986), there is increasing acceptance of the disturbing reality that site residues hardly ever record a freeze-frame of representative behavioral activity. That record is normally distorted by natural or cultural processes or both, leading to efforts to filter out that distortion to recover valid behavioral information (e.g., Schiffer 1987).

The problem is not insurmountable if we are prepared to scale back expectations, and emphasize less specific goals: even a disturbed context can be highly informative. Ethnoarchaeological observation and experimental work have similarly shown that artifacts and non-artifactual residues of cultural activities do not allow foolproof inferences as to specific activities or more generalized economic behavior (Gould 1980,1985). Most archaeologists no longer are dogmatic at this level. This has not minimized their research, merely cast their low-level inferences in a more appropriate framework. Others of the social sciences have hesitantly reached the same conclusions: verification in the social sciences is fundamentally different than in the physical or natural sciences,

where the number of variables can be controlled and experiments can be replicated at will. For that reason, "laws" in the social sciences rarely are absolute or universal.

Mid-Level Inference

At the *meso-level*, archaeologists attempt to move from the particular to the general, employing site-specific data and related, basic inferences to reconstruct socioeconomic patterns. Here archaeology is on less stable ground and there is need for a healthy level of skepticism. The Espadan examples illustrate that least-effort and other "rational" inferences may be misleading or absolutely wrong. This should not be surprising, since contemporary research in the social sciences contains numerous examples that "satisficing" solutions are more common that "optimal" ones, and that people choose between alternatives and that their strategies vary over time. As anticipated by Clarke (1968:79), the principle of Occam's razor is unacceptable in sorting out inferences: the most parsimonious explanation was seldom right in the Espadan, and "reality" was always more complex.

For many authors, applications of the scattered and inhomogeneous body of what is sometimes called "middle range" theory can be extended upward to include synchronic, socioeconomic reconstructions at the meso-level. A particularly poor assumption in such chains of argumentation is invocation of the principle of uniformitarianism. This geological tool applies only to physical and chemical processes, not to human behavior. The assumptions according to which contemporary examples are chosen may also be wrong (Denbow and Wilmsen 1986). Going beyond the level of linking artifacts and artifact-patterning with direct human activity also underestimates the critical matter of cognitive behavior, alternative choices, and multiple means to achieve a particular goal. From probabilities this moves inference into the realm of possibilities. Despite the disclaimer that even in its heyday, positivistic reconstruction strove only to reduce uncertainty (Watson 1986), occasional qualifiers went largely unnoticed amid the overbearing rhetoric. While the potential margin of error in Palaeolithic archaeology may be acceptably small to some, that is certainly not the case in younger time ranges. Here the Egyptian and Espadan examples show that probabilities of distortion or gross error are a more appropriate frame of reference than "levels" of uncertainty.

At the meso-level we are ultimately left with little but models or hypotheses, that do not appear to be testable in prehistoric contexts, at least not without affirming the consequent. There is a deep chasm between a reasonable interpretation of micro-archaeological activity patterns, on the one hand, and socioeconomic reconstruction, on the other, one that is not bridged by any "robust" laws. Inferring degrees of social differentiation from archaeological data is one thing. Identifying a particular kind of social hierarchy is quite another.

The basic difficulty that archaeology has with verifiability at the meso-level is that complex, synchronic "structures" cannot be reliably inferred from a limited number of simpler components. (Re)constructing the whole requires a new set of laws that must in turn be verified. In the synchronic social sciences this may well be practicable, since the difference is primarily one of integration and scale. In a diachronic context, the interrelationships of a much larger number of variables are not covered by the original, micro-level laws.

The grounds for skepticism increase exponentially when, at the same meso-level, some archaeologists move even beyond socioeconomic reconstruction into the sociocultural or sociopolitical realm. This may be warranted in situations just beyond the ethnographic "present," or in protohistorical contexts. At greater distance in the past, anthropological preconceptions as well as Western biases must be circumvented before even the premises for an explicit model are decided upon.

There are also inherent difficulties as to how culture traits, cultures, and ethnic (self-)identification are linked. Archaeologists commonly assert that material culture is not equivalent to culture, but in practice they do not necessarily adhere to that maxim. In Africa, Hodder (1981) discovered that ethnic boundaries do not coincide with those of material culture or particular spatial macro-patterns. Indeed, even in modern Europe neither ethnic nor linguistic boundaries are tied to readily discernible differences in material culture, and correlations of specific economic strategies or sociocultural (e.g., kinship or inheritance) patterns with ethnic identity only apply in local areas, and cannot be generalized to other segments of such boundaries. In this perspective, the interpretation of large-scale archaeological "components" becomes especially problematical, in default of primary attention to multiple criteria sensitive to identity consciousness.

Protestations to the contrary, too many archaeologists are still willing to ascribe particular social hierarchies and inferred political structures to such "components," e.g. to the Hopewellian or the Mississippian. This is an implicit expression of belief that an area with shared material culture has sociocultural meaning. In general, the problems of cultural or political reconstruction have not yet been adequately addressed or resolved.

Macro-Interpretation

At the *macro-level*, in the leap from "reconstruction" to the interpretation of process and change, all the inherent problems of hierarchical inference are compounded. This can indeed be minimized by selecting partial problems and limiting the number of variables. Process and change can then be attacked with some success, particularly in arenas with a strong empirical base. Examples include Paleolithic subsistence change (Klein 1978,1988), agricultural transitions (Ford 1985) or intensification (Sherratt 1983; Barker 1985), and cycles of settlement expansion and contraction (Adams 1981; Van Andel and Runnels 1987).

Cultural evolution and the origin of complex societies represent the greatest and most difficult challenge for archaeology. Evolutionary concepts are indispensable to the historically oriented social sciences, and underlie most medium- and long-range adaptive processes (Kirch 1980a) in, for example, cultural ecology. The problem in applying archaeology to cultural evolution begins with the premise of evolutionary classification. A group of attributes is directly, or by seriation of sociocultural adaptations, applied to delineate a succession of stages (e.g., the "big-man" collectivity, simple or complex chiefdom, archaic state) to arbitrarily subdivide what is a complex, systemic continuum. Such a directional and ahistorical scheme is evidently based on the normative concepts of ecological succession. It is inappropriate because it assumes, incorrectly, that cultural and social phenomena always vary in tandem, and that socioeconomic functions are linear and hierarchical (see also Richerson and Boyd 1978).

The problem is, then, compounded when "evolutionist" archaeologists accept these preconceptions as reality, and then coerce their data to fit them, regardless of whether models derived from ethnographic case studies on obscure Pacific islands are foisted on peoples with very different cultural traditions. Given the

"loaded" assumptions that evolutionary stages are "real" and that they serve as an explanatory tool (rather than as a deductive typology), hypotheses can become self-fulfilling (e.g., Johnson and Earle 1987). Tautological arguments of this kind do archaeology a disservice.

Cultural evolution is not only a valid, but a central concern of archaeology. However, the specific problems and selected methods for investigation must be directly based on the nature and capabilities of the archaeological record, with its objective reality but its less-than-lucid meaning. Archaeology identifies particular sequences in a particular time and place, providing a wealth of empirical data. Cumulatively such studies contribute a wealth of detail that suggests the broad outline of processes, for which one or more explanatory models can be offered. Sometimes such models can be verified reasonably well, particularly if estimation is substituted for prediction, using internal and ratio levels for data sets, so as to examine proportional relationships. The general validity of models may also be corroborated or contradicted by evidence from parallel studies elsewhere. Archaeology can therefore contribute substantially to macro-problems of process and change. But the questions it raises must be formulated and testable within the context and constraints of its data and methods.

Accepting such limitations with good grace would not cripple archaeology, but instead open it up to a more active interchange with a wider intellectual arena. The problems that archaeology has in dealing with high-level inference are not unique, but shared by the other social sciences (or the field of ecology). All are constrained by the vast differences of scale between the basic units of analysis and the complexities of society or societal behavior. None of the social sciences is equipped to tackle macro-problems singlehandedly, but each can contribute a particular kind of insight to what should be envisaged as a cross-disciplinary forum for productive discussion.

Process and Change in the Archaeological Record

The purpose of the preceding analysis and critique of archaeological interpretative methodology was to identify epistemological limits rather than question the contributions and effectiveness of archaeology as a social science. It is disappointing that the historical elucidation of process in cognitive terms cannot be effectively realized in archaeology at this time.

But if a broader, interdisciplinary perspective is accepted, it may well be possible to study process in certain, specific terms. If data are organized and properly manipulated at the nominal, ordinal, interval, and ratio levels, it may be possible to identify or delineate critical factors and variables at different levels of analysis or inference, and to examine and test potential relationships in terms of historical, adaptive, or evolutionary change. The human ecosystem framework, as defined earlier, provides an ideal context in which to both identify and formulate significant questions. That approach also invites the subsequent incorporation of comparative, cognitive data sets.

During the last 30 years the cumulative result of much painstaking archaeological work has revolutionized our appreciation of process and change in the prehistoric past. It is appropriate to briefly outline a selection of macro-level examples that illustrate some of the contributions of archaeology to the formulation and resolution of broader, interdisciplinary questions. Each example is first presented as a "proposition," based on empirical data or verifiable inference, and is followed by discussion or speculation that elucidates the potential implications of the proposition. The organizational framework is eco-systemic and evolutionary.

Stasis and Change in the Paleolithic Record

Three basic themes can be singled out for the later stages of the Paleolithic: the accelerating change of material culture, demographic growth, and diversification of subsistence activities.

Proposition One. During the course of the West European Mousterian, about 115,000-40,000 B.P., there is minimal evidence of synchronic stylistic variability in lithic artifacts and little diachronic, stylistic or technological change; instead, the basic pattern is one of repetitive interchange of several associations of lithic types (facies) over a phenomenal time span of 75,000 years. With the subsequent Upper Paleolithic, more distinctive assemblages appear, that include diagnostic tools, that vary as to both style and inferred function. Such assemblages are regularly replaced after about 2500 years, with lag times of 800 to 1300 years from place to place (Laville et al. 1980; Butzer 1986). By 20,000 B.P. stylistic variation is pronounced and becomes regionally defined (Straus 1983).

Discussion of Proposition One. Assuming that the lack of directional change of the Mousterian technocomplex over 75,000 years is a valid reflection of Mousterian and Neanderthal cultural capacities, it is difficult to comprehend in terms of recent cultural systems. Such a classic case of homeostatic equilibrium suggests different cognitive, communicative, or neural capacities. On the other hand, the succession of material innovations and stylistic shifts characteristic of the Upper Paleolithic implies accelerating change and a dynamic equilibrium mode. The tempo of replacement is similar to that of ethnic/linguistic groups in the European protohistoric and historical record. How distinct the various Upper Paleolithic components were in adaptive, social, or cultural terms remains speculative. But one can posit an incremental increase in experiential information, magnified by an increasing number of permutations and recombinations of exchanged information. It appears that anatomically modern people introduced a more familiar, "human" dynamism of culture to Western Europe.

Proposition Two. Site frequency per unit time increases exponentially towards the end of the Pleistocene, both in Europe and Africa. In northern Spain the number of identified archaeological sites increases from 0.2 per 1000 years about 75,000 B.P., to 1.4 about 28,000 B.P., 8.8 about 19,500 B.P., 9.5 about 13,500 B.P., 14.3 about 10,000 B.P., and 25.7 about 8000 B.P. (Butzer 1986). At the same time site areas and horizon thickness also increase substantially. In a more comprehensive survey of a small basin in southern Africa, this ratio is 1.0 about 350,000 B.P., 9.7 about 100,000 B.P., 312.5 about 12,000 B.P., 753.8 about 4000 B.P., and 4800 about 1000 B.P. (Sampson 1985; Butzer 1988b). Numbers of artifacts and lithic debitage per site also increase exponentially. This suggests some 30 to 70 times as many sites about 10,000 years in age compared with those preserved from about 75,000 years ago. The increase in site frequency begins at different times in different regions: about 22,000 B.P. in northern Spain, 18,000 B.P. in the Nile Valley, 13,000 B.P. in Northwest Africa, 12,000 B.P. in southern Africa, 14,000 B.P. in northeastern Siberia and Japan, 11,500 B.P. in North America, and 5,000 B.P. in Australia (Butzer n.d.2).

Discussion of Proposition Two. The steep increase in site frequency per unit time probably reflects exponential population growth, more than it does better site preservation or visibility in

younger time ranges. During Mousterian/Middle Palaeolithic times, population levels appear to have been very low, oscillating in a steady-state equilibrium. Shortly after introduction/development of Upper Palaeolithic-type technologies (beginning between 40,000 and 20,000 B.P.), population began to increase (dynamic equilibrium), followed by a take-off to a notably higher equilibrium level at some point between 22,000 and 5,000 B.P., depending on the area. The threshold of rapid expansion coincides with the appearance of large projectile points (spear or javelin heads) and micro-blades (probably used as transverse cutting-edges on arrow tips or antler points). These technological innovations suggest effective, offensive weapons that should have dramatically improved hunting efficiency. This in turn may explain the demographic pattern: improved food procurement would theoretically have allowed a spurt of population growth, followed by slower but continuing growth as scheduling and other strategies were adjusted (Butzer n.d.2).

Proposition Three. In southern Africa the selection of game and the age-profiles of species taken ("catastrophic" versus attritional) suggest that Middle Stone Age people (about 125,000-80,000 B.P.) were relatively ineffective hunters, concentrating on very young bovids; only in the case of eland, a large and docile bovid, is there a large proportion of prime-age adults, such as would result by driving a small herd over a cliff (Klein 1976, 1989). Later Stone Age peoples (especially after 12,000 B.P.) actively fished, collected marine invertebrates, or hunted flying birds, took a high proportion of dangerous warthog/bushpig, and exploited a wide variety of plants foods, including roots and bulbs (Klein 1976; Deacon 1984). In northern Spain, nimble-footed ibex and chamois as well as ferocious wild boar were already taken in Mousterian times, and the subsequent increase in ibex mainly reflects more frequent, seasonal use of mountain sites. However, Upper Palaeolithic levels show that herds of red deer could be taken at once, and fishing gear such as harpoons become important. After 10,000 B.P. shell middens indicate regular exploitation of marine, estuarine, and riverine resources, while grinding stones are interpreted as integral to plant food preparation (see Butzer 1986). The North Spanish evidence demonstrates that a greater range of environmental and food types was exploited towards the end of the Pleistocene (Clark and Yi 1983), and similar trends are suggested by other regional studies.

Discussion of Proposition Three. Beyond the general improvement of hunting skills and efficiency towards the end of the Pleistocene, new macro- or micro-environments as well as new types of animal foods appear to have been exploited in a more systematic way. These included montane, aquatic, and marine resources. Plant foods, presumably used in a complementary or seasonal fashion throughout human prehistory, were now searched out and systematically harvested. Not only fruits and nuts but also tubers and seeds were exploited, with a higher investment of labor. In some areas, such as the cold steppe of Eurasia, increased hunting efficiency seems to have led initially to a measure of specialization, but even here the trend eventually shifted to greater niche width and niche variability. No later than the early Holocene, hunter-foragers just about everywhere were adapted to a broad spectrum of available resources within each environmental mosaic, as suggested by increasing spatial variability of the archaeological record. Greater procurement effectiveness, diversification, and demographic growth were probably linked by positive feedbacks, perhaps favoring greater socioeconomic complexity.

Agricultural Transformation

The fundamental shift from hunting-foraging to farming-herding lifeways represents a revolutionary change that began in some areas about 11,000 to 6000 B.P. Basic themes include: the domestication of plants and animals, the dispersal of agricultural traits and complexes, the intensification of agricultural exploitation, and the environmental impacts of agricultural land use.

Proposition Four. "Hard" evidence for successful domestication of plants and animals comes in the form of plant materials or animal bone that show specific morphological divergences from their wild progenitors. The Near Eastern record, based on multiple archaeological sequences, is strongest. At Jericho, the earliest Neolithic level (PPNA) at 10,500-9,200 B.P. has remains of domesticated barley, emmer wheat, and pulses; a similar horizon (Bus Mordeh) at Ali Kosh, beginning about 10,000 B.P., also has domesticated cereals and pulses, while the basal level of Tell Aswad, near Damascus, brings evidence of domesticated peas, lentils, emmer and probably barley (Moore 1982). The subsequent Neolithic levels at these and other sites of the steppe-woodland ecotone, dating about

9,600-8,000 B.P., have bones of one or more genera of domesticated animal (goat, sheep, cattle, and possibly pig), a wide array of domesticated grains (emmer and einkorn wheat, barley), and further vegetables (Harlan 1977), although wild game remained prominent; similar lithic assemblages are also found at contemporary sites patently used as hunting encampments (Aurenche et al. 1981). Only in later Neolithic levels, dating about 8,100-5,700 B.P., is the full range of grains, vegetables, and herd animals consistently verified; initially such sites begin to penetrate the woodlands, subsequently they also appear in the larger alluvial valleys, with the first evidence of improvised irrigation.

In terms of similar, semiarid ecologies, domesticated maize is botanically verified in Tehuacán, Mexico, about 7,000 B.P., while cultivated common and lima beans are found in Guitarrero Cave, Peru, some 700 years earlier, and in Tehuacán and Tamaulipas, Mexico, about a millennium later; domesticated squash was used in the Valley of Oaxaca about 9,400 B.P. (Pickersgill and Heiser 1977; Flannery 1986). Other New World plant domesticates only appear in the "hard" record after 3,000 B.P. Although widely distributed in space, it would seem that plant domestication was an equally long-term process in both Mexico and Peru. Agricultural innovation in humid Southeast Asia is still inadequately documented, but rice may have been in cultivation by 5,400 B.P. in China (Gorman 1977, Harlan 1977).

Discussion of Proposition Four. Relying only on the "hard" criteria, domestication appears as an incremental process in so-called hearth areas, with suitable, indigenous wild forms subjected to deliberate planting or breeding at a very early date. At first there was supplementary cultivation of a few plants, within a broad repertoire of plant foraging and manipulation; in other instances, there was some controlled stockraising within the context of more traditional hunting. At least 3,500 years intervened between the first solid evidence for supplementary cultivation in the Near East and the appearance of a full agricultural repertoire of grains, a range of pulses, and the full complement of four domesticated herd animals. Only with the assembling of this complete agricultural "package" about 8,000 B.P. can one speak of a standardized agrosystem. In Mexico, Peru, and Southeast Asia this process of agricultural transformation may have been more attenuated.

But the process of domestication was even longer than the "hard" evidence demonstrates. Intensified harvesting and possible manipulation of wild seed plants are suggested before 15,000 B.P. by grinding equipment and lithic blades with lustrous "sickle sheen" in the Near East (Henry 1988), while selective hunting and possible control of gazelle, fallow deer, onager, and "wild" forms of goat, sheep or cattle were widely practiced by 12,000 B.P. (Moore 1982). In the central United States, essentially sedentary utilization of rich, riparian resources preceded the appearance of standard domesticates by several millennia, with some measure of controlled use of a variety of minor plant foods (Ford 1985). This suggests several, if not many millennia of manipulation, familiarization, and experimentation with a wide range of potential domesticates, prior to the type of agriculture documented by the "hard" evidence. Only after the positive feedbacks, both human and biotic, between the traditional foraging systems and the new "management" techniques began to co-evolve into a new, interactive system, did the selection of a few of these plants or animals for systematic domestication meet the necessary conditions for morphological change. Domestication was, therefore, a very long and punctated process, co-evolutionary in trajectory, revolutionary only in its ultimate impact.

Proposition Five. The problem of agricultural origins is distinct from that of agricultural dispersal, via stimulus diffusion or migration. Even before the full crystallization of a standardized agrosystem in the Near East, large coastal villages, with evidence of grain and vegetable cultivation, and dependent on domestic stock rather than game, appeared in Greece and on Cyprus and Crete 8,400-7,900 B.P. By 7,800 B.P. hunter-foragers in southern France and eastern and southern Spain kept domesticated sheep, apparently driving them in the course of seasonal hunting rounds (Lewthwaite 1986). About 7,300-6,500 B.P. a culturally distinctive agrosystem was established along the coastal plains of the western Mediterranean from Yugoslavia to Portugal (Cardial Neolithic). Another was established in the Balkans 7,400-7,100 B.P. (Starčevo-Körös), and a third in Central Europe 6,500-5,700 B.P. (Linear Pottery) (see Barker 1985). Initially the domesticates themselves were introductions, rather than derived from in situ domestication of local plants or animals. But in some areas where wild prototypes were found, resident hunter-foragers domesticated local stock prior to agricultural penetration (Yugoslavia) or outbreeding produced new

stock or cultivar varieties (Hungary). Subsequent expansion of agriculture into Northwest Europe, before 5,000 B.P., represented a selective adaptation of agricultural traits by autochthonous populations (Barker 1985).

Discussion of Proposition Five. The very rapid dispersal of agriculture or selected agricultural traits, so well documented for Europe, presupposes a measure of migration but also identifies examples of preadaptation. A range of case studies in the Balkans and the western Mediterranean show that domesticated cattle or sheep were used by autochthonous hunter-foragers several centuries prior to the appearance of intrusive groups with distinctive pottery and cultivars; in the former case, local animals were domesticated, in the latter, domestic stock were somehow introduced from outside (Lewthwaite 1985). Excavations in Italy verify the interaction between small settlements of intrusive farmers with nearby hunter-foragers, who gradually switched from hunting to stockraising (Barker 1985).

Complex processes of stimulus diffusion, both local and long distance, are therefore implicated. Selected agricultural traits must have seemed highly desirable, despite the need to readapt them within a different lifeway or to different regional ecologies. In the case of actual migration, dispersal was nodal, along attractive segments of the Mediterranean coastline, or from one fertile basin to the next in Central Europe. Pulse-like surges of migration are indicated, interrupted by some five centuries of filling in, ecological adjustment, and perhaps experimentation in forward areas, characterized by different ecological parameters. The initial delay in advance of standardized agriculture into the western Mediterranean may have been predicated on improved navigational skills; the advance into the Balkan basins certainly required an adjustment to summer (versus winter) rainfall and, eventually, colder winters. A significant development in regard to agricultural dispersals has been the explicit recognition of a complex interplay between: (a) stimulus diffusion, (b) ecological readjustment (Butzer 1988a), (c) indigenous innovations, (d) complementary interactions between resident hunter-foragers and intrusive farmers (Gregg 1988), and (e) ultimately the "indigenization" of agriculture or agricultural traits (Kristiansen and Paludan-Müller 1978). A similar co-evolutionary trajectory is emerging in North America (Ford 1985; Johannessen 1988), and is suggested by ongoing research in subsaharan Africa.

Proposition Six. The standardized agrosystem that emerged in the Near East before 8,000 B.P. and dispersed through much of Europe by 5,000 B.P. was relatively primitive; it only provided plants and meat, while foraged foods remained important. By 3,500 B.C. (about 5,400 B.P., uncalibrated) a new process becomes apparent in the Near East, and within a millennium its impacts were felt as far afield as Britain (Sherratt 1983). Technological innovations such as the plow and wheel were combined with ox traction, and new animals were eventually domesticated to facilitate transport--horse, donkey, and camel. Wool was skeined and woven into cloth, and new breeds of woolly sheep selected. Cows, sheep, and goats were milked, and the milk converted to butter or cheese, which could be stored. Animal manure was applied as fertilizer, while plowing along hillsides deliberately or inadvertently created stepped slope profiles, that may have suggested the principle of terracing. This fundamental change in the relationships between people and animals also tied the planting and herding segments of the economy into an interdependent system. Called the "secondary products revolution" (Sherratt 1983), it represents a part of what agricultural economists and cultural ecologists refer to as "intensification." But it was not limited to animals and animal products.

Polycropping of olive trees with grains produced a new source of oil that did not compete for space, as did flax, and olive groves could also be planted on marginal hillsides. The range of fruit trees was enlarged, vineyards were planted, and grafting was possibly introduced. These innovations, made in Lebanon and Palestine 3,700-3,100 B.C., produced commodities easy to transport and market--olive oil and wine; they also appear to have proved sufficiently important to incorporate into the symbolic realm, and became the hallmark of Mediterranean arboriculture (Stager 1983, 1985; Butzer 1988a). Simultaneously, systematic canal irrigation and urban growth began on the floodplains of Mesopotamia (Adams 1981) and Egypt (Butzer 1976, 1984b), linking agricultural intensification with urbanization. But commercial crops and urban market-economies only spread westward to Spain by the 6th century B.C., and to Northwest Europe--where drainage techniques replaced irrigation--during Roman times. More closely tied to the rapid diffusion of the plow and the wheel were mining and bronze metallurgy.

Discussion of Proposition Six. Intensification reflected a bundle of positive feedbacks that finally integrated all components of a particular agrosystem, triggering a comparatively rapid sequence of socioeconomic adjustments. It can be further argued, but remains to be convincingly tested, that intensification changed dietary, demographic, and sociocultural strategies more fundamentally than did the initial agricultural transformation. These technological innovations represented labor-intensive shifts, that made large families desirable, and reduced biological selection pressures. This appears to be borne out by increasing settlement sizes and numbers, suggesting higher population densities--despite the increasing probability of epidemic disease and the mutation of livestock viruses to deadly vectors of human disease. Improved technologies, coupled with greater labor investment, imply a greater frequency of cultivation of any one plot. The investment in and dependence upon particular land parcels suggests that more complex rules for the communal use of land were called for, leading to the development of private property in some areas, with similarly complex rules for transgenerational property transmission via arranged marriages (Sherratt 1983). The diversification of domestic tasks central to intensification may also have accelerated the differentiation of age- and gender-specific roles.

Most of the changes implied by intensification were incremental in the sense that they reflected countless personal decisions, rather than changes imposed by a centralized authority. But in some areas intensification was paralleled by and interrelated with a shift to more centralized authority. The differential quality of grave goods or burial structures implies development of self-perpetuating social inequality, without necessarily elucidating the nature of social structures. In large settlements marked by greater social inequality, nutritionally inadequate or unbalanced diets become a real probability. New armaments, the use of horses and chariots in warfare, and destruction horizons within town sites all document an increasing role for warfare, sometimes linked with regional discontinuities it the archaeological record. Mining and metallurgy probably played a pivotal role in this process, since control over critical sources of metal conferred economic power, that could in turn be used to demand food or craft products, such as cloth and pottery. Trade and market institutions would be stimulated as economies became more commercialized, favoring urban growth. Symbolic expression in bronze, stone, or architecture becomes

striking and seems to have been critical to the maintenance of polities and hegemonies.

These broad themes are particularly challenging for hypothesis-building and testing. Unfortunately the best tests for nutritional implications of dietary change and of social inequality must await a greater breadth and intensity of research in physical anthropology, blood typing, paleopathology, isotopic analysis, and paleonutrition. Such work has not kept pace with other modes of archaeological investigation. And all too often the critical human skeletal remains are minimally preserved or were disposed of by cremation.

Proposition Seven. Geoarchaeological research has incrementally served to elucidate the impact of agricultural land use on local and regional environments, with potential significance for resource sustainability. Episodes of low-density human settlement, with only rudimentary Neolithic farming, had unanticipated effects on the landscape of Greece and Spain via deforestation and massive soil erosion (Van Andel and Zangger n.d.; Butzer, Mateu, and Scott, n.d.). Subsequent, more intensive, Bronze Age or later farming provoked different intensities of landscape degradation, not necessarily proportional to settlement density, and implicitly conditioned by different agricultural procedures. Agriculture in northern Europe led to local and temporary vegetation disturbance or to long periods with extensive clearance, the intensity of use reflected in variations of lakebed geochemistry (Edwards 1979; Simmons and Tooley 1981; Kristiansen and Paludan-Müller 1978). Similar impacts of pre-European settlement have been identified in the eastern United States (Delcourt et al. 1986) and in the Maya lowlands (Deevey et al. 1979). Intensive or long-term disturbance had different impacts in semiarid or subhumid areas, where groundwater recharge was reduced and stream runoff became more intermittent, increasing periodic flood damage, whereas in cool and humid settings interference favored growth of acid heath (blanket bog), with essentially permanent landscape degradation (Butzer 1982: chap. 8). Other studies demonstrate the permanent ecological damage to Pacific Islands by their growing populations, to the point where decreasing resource productivity resulted in population decline (Kirch 1980b, 1982).

Discussion of Proposition Seven. These examples show that the environment was a major variable in archaeologically discernible processes. Soil, water, and biota are unstable, changing, and often fragile resources that demand careful attention, not only in terms of abstract site-catchment analyses or potential productivity measures, but as a complex arena for concrete study. Was soil fertility sustained during long periods of occupation? How was the water supply affected by secular environmental change and human interference in the hydrological cycle? How was cultivation or herding conditioned by human intervention in the natural biota and by successional changes thereafter? Was land use exploitative or conservationist? Productivity is not a given, but a systemic variable that responds to management, both good and bad.

As a first step, management techniques deserve far more explicit attention by searching for direct and indirect evidence, and by evaluating ethnographic analogs. But discussion must also be taken to the level of systemic energy flows, in regard to different ratios between work input and energy output, how risk and shortfalls were accommodated, and whether productivity increased or decreased with time. Was all the food produced consumed locally, or did sociopolitical structures subtract part of that productivity? Can demographic change be monitored by archaeological controls or nutritional levels by skeletal data? Far less tangible, but equally important, are several cognitive questions. How were subsistence resources perceived and did this perception change with time? Were trial-and-error in management and dietary strategies incorporated as "experience" into long-term cultural behavior through beneficial ritual and symbolic expression? Only by devoting more attention to this full range of questions can we eventually hope to test whether expanding populations, increasingly costly labor investment, and declining productivity may have precipitated ecological crises of fundamental importance. Both the time depth represented by archaeology and the data resolution that it can provide are critical to long-term questions of resource sustainability.

Social Transformation and Maintenance

On the threshold of "high" civilizations, the archaeological record allows identification of two basic and interrelated problems: the emergence of complex societies, and the recurrence of population cycles. The latter is amenable to empirical investigation, but the former is primarily an interpretative matter.

Proposition Eight. In different regions the late prehistoric trajectory suggests increasing social complexity (e.g., Wenke 1984). This encompasses economic diversification, elaboration of institutional structures, and verticalization of socioeconomic and sociopolitical components into functional hierarchies, that serve to organize energy and information pathways. Intensification appears indispensible in sustaining the comparatively dense, nucleated and sedentary populations that appear to be integral to such social evolution or to such corollary processes as urbanization or state formation.

Discussion of Proposition Eight. In place of traditional models that emphasize sociocultural evolution, an alternative model, focusing on spatial integration and hierarchical elaboration, can be suggested. This model is no less speculative than existing ones, but offers a different approach, the components of which are more readily tested. Firstly, intensification should serve to increase the productivity and reliability of resource yields, to favor demographic growth and nucleation of population. Secondly, the unequal distribution of natural and human resources, combined with the relative advantages of some locations over others, may lead to differential increases in settlement size and function (see also Ellen, this volume). As the patterns of settlement "rank" change, a vertical hierarchy of "central places" should begin to emerge, in response to population size, economic function, ceremonial roles, or administrative or military advantages. Thirdly, as this process of verticalization continues, feedbacks would come into play as to (a) economic specialization, resource concentration, and social segregation; (b) increasing demands for raw materials or energy; and (c) regional as well as interregional integration. This human ecosystem model centers on a three-dimensional, sociodemographic and economic integration, but can then be elaborated with historical or ethnographic insights to include sociocultural change. Thus the critical structures of the model are reasonably robust, because they are amenable to archaeological testing, and its value is only enhanced by attempting to accommodate the role and impact of decisions imposed by an empowered elite.

Proposition Nine. Both the archaeological and historical records show that change was not progressive but episodic, and sometimes regressive. Most immediately, archaeologically-verified regional settlement histories, such as in Mesopotamia or the Aegean (e.g. Adams 1981; Van Andel and Runnels 1987), fail to exhibit linear trajectories. Settlement histories vary from one valley or subregion to another, so that composite, regional trends are irregular, rather than linear. By whatever surrogate measure, subregional population trends show oscillating, stepwise progressions, interrupted by periods of stabilization or even decline. Seen in the long-term perspective, whether increasing or ultimately in a steady-state equilibrium, population trajectories display cyclical trends of rapid growth and equally rapid decline, so-called millennial long-waves (Whitmore et al. n.d.).

Discussion of Proposition Nine. Demographic growth is rarely possible without improved technology, a broad social access to resources, or a combination of the two. Decline points to fundamental social, political, or environmental problems. Growth, stability, or decline also suggest different questions about the quality of life. In the case of relatively simple, prehistoric farming societies, we still lack data explaining the common and often long-term settlement breaks between archaeological components. Were they due to sweeps of new epidemic diseases, warfare, or declining productivity of primitive agroecosystems, perhaps even Malthusian "overshoot"?

On the other hand, historical examples from complex societies such as Mesopotamia, Egypt, and Spain (Whitmore et al., n.d.; Butzer 1976, 1980b, 1984a, n.d.1), suggest that demographic long waves ultimately coincided with times of strong and efficient government, pointing to the importance of channeling those centripetal forces that favor the integration of institutions, economic networks, and settlement hierarchies which stimulate higher productivity and sustain higher populations. Periods of decline are tied to times of weak or incompetent government that allow centrifugal forces to impair socioeconomic structures and political institutions, to the point where productivity and population levels decline. Energy and information pathways are critical components of this equation. For example, "decline" may also be precipitated by expansion of an imperial system to beyond its logistical limits, when the friction of distance and decreasing efficiency in managing peripheral resources

begin to outweigh the energy pumped into the system by the control of labor, production, and trade. A complementary perspective to this is suggested by usurpation of the productive base of a regional system, dissipating energy into non-sustaining activities such as excessive construction activities, indecisive or unsuccessful warfare, or tribute to an external power. Ecological simplification suggests a useful analog to examine "decline," as a product of multiple feedbacks and inherent thresholds.

Outlook

The themes outlined above represent examples of significant problems in historical social science that interest archaeologists today, and for which archaeological methodologies are particularly suitable. The difficulties of testing the interpretations are formidable, but not insurmountable in the long run. Each excavation and survey directed towards testing a particular hypothesis is set within a matrix of both similar and different variables. Eventually the number of equations (case studies) equals the number of unknowns (variables), and identification (role) of the variables can be resolved. Both the formulation of the problems and the interpretive structures suggested above are eco-systemic, and systems or subsystems in archaeology should automatically incorporate spatial and, by extension, environmental components. The utility of this human ecosystem approach, focused on specific data sets at an appropriate level of analysis, transcends its scientific clarity for the selection, formulation, testing, and interpretation of problems. It avoids biased "loading" factors while further allowing the incorporation of relevant sociocultural variables, such as institutional structures, symbolic interaction, and cognition. In effect, a problem can first be tested with ecological or material variables alone, after which further tests can add other variables incrementally. Post-processual concerns can therefore be incorporated.

The basic point is that the variables form a complex (algebraic) matrix, and that no single project can hope to verify a particular hypothesis. Many projects are indispensable to establish a set of modal parameters, and to explain the exceptions without weakening the ground rules.

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