ENDURING FOUNDATIONS TO A HOLISTIC SCIENCE: LESSONS IN ENVIRONMENTAL ARCHAEOLOGY FROM ELIZABETH S. WING

Kitty F. Emery[1]

The chapters contributed to this volume honoring Elizabeth S. Wing's research at the Florida Museum of Natural History (FLMNH) provide an excellent overview of some of the most intriguing issues and controversies in zooarchaeology and environmental archaeology today. Analyses from nine countries spanning the New and Old worlds illustrate the global nature of Wing's influence on the science of environmental archaeology, while the predominance of research from the eastern U.S. highlights the particular importance of her work in this geographic region. The authors tackle topics from the effects of sieve gauge on bone recovery to the impact of human predation on ancient environments, reflecting the breadth of Wing's influence in these varied arenas. Many of the contributing authors were taught in the FLMNH Environmental Archaeology (EA) laboratory, but whether student or colleague, all their research has been touched in some way or another by Wing's work.

Most important to the value of this volume is the fact that all these chapters emphasize one of the fundamental principles of Wing's research: that our interpretations, whether of ancient ecology, diet, or ritual, are only as strong as the methods we use to gather our data. This principle, a central tenet of her work, has guided her research in all areas of zooarchaeology. Wing is recognized worldwide for her incorporation of innovative techniques borrowed from the biological sciences, her interest in addressing broad theoretical issues, and her encouragement of a holistic view of ancient human/environment relationships in environmental archaeology. The value of her pioneering work rests both in her enthusiasm for all aspects of the developing science and in the emphasis she has always placed on rigorous methods as a foundation to any environmental research. An understanding of the importance of strong methodological foundations has also been passed on to her students and to all of us who continue to learn from her example. It is one of the strongest commendations to our science that, although we have often moved cautiously in the study of the cultural aspects of the human/environment relationship, our conclusions are based on generations of intensive evaluation of the efficacy of our analytical methods.

In the following pages I will review some of the issues pertinent to environmental archaeology and zooarchaeology as illustrated in these chapters. The choice of these particular issues and themes is not intended to provide a comprehensive review of environmental archaeology (see Dincauze 2000, Evans and O'Connor 1999, and Reitz and Wing 1999 for excellent surveys) or to suggest that these are the only areas in which Wing has been influential. I am guided instead by the current research interests of the authors, themselves influenced by Wing's ongoing work. My discussion will highlight the important unifying theme that binds the chapters of this volume together: Elizabeth Wing's principle of methodological strength at all levels, from initial project assessment to the middle range theory required for accurate interpretations of cultural processes.

THEMES IN THIS VOLUME

Analytical and interpretive methods differ among branches of environmental archaeology, but requirements for methodological accuracy do not. Samples must reflect both the archaeological questions at hand and the area under investigation. They must be sufficiently large to overcome sample-size dependencies in statistical analysis. Recovery methods used for their acquisition must provide for sufficient detail in the assemblage, and subsequent handling and preparation of the samples must follow protocols that diminish loss and destruction of data. Once samples have been recovered, specimens must be accurately identified and the broadest possible range of data must be acquired from each. Methods of quantification must be appropriate to both the sample and the questions under investigation. Finally, whether the specimens are pollen grains or bivalves, interpretations must be similarly well supported by a clear understanding

[1]Assistant Curator of Environmental Archaeology, Florida Museum of Natural History, University of Florida, Gainesville, FL 32611, USA.

of biological and cultural contexts. These must be well informed with regard to biological taxonomy and habitats, the taphonomic history of the assemblage and its possible effect on distributions, and the cultural context within which the assemblage was recovered. The authors contributing to this volume recognize, both implicitly and explicitly, that these requirements are fundamental to all investigations in environmental archaeology.

METHODS AND DATA

Environmental archaeology and, in particular, zooarchaeology are still seen by some as simply an answer to the archaeologist's "identification problem" (Wing this volume). This is unfortunate because Wing and others have been using direct faunal, floral, and geomorphological data for complex environmental and cultural research since the early 1960s, when they already were aware of the need for methodological accuracy, especially appropriate archaeological sampling and collection methods to create assemblages that included the broadest possible range of taxa or specimens.

There are many vital issues in the discussion of accuracy in assemblage sampling. Despite years of controversy, one of the most contentious debates today is still the utility of fine-gauge sieving (Cannon 1999; James 1997; Shaffer and Sanchez 1994; Vale and Gargett 2002). First discussed in the literature of the early 1970s (Clason and Prummel 1977; Payne 1972), screening of archaeological deposits was already seen by environmental archaeologists as essential, not only to increase the number of biological taxa and individuals recovered, but also to effectively answer questions about species composition and population dynamics (Grayson 1984; Lyman 1982). By the 1980s, it became clear that the issue was not whether deposits should be screened, but at what gauge. In the 1979 volume *Paleonutrition*, Wing and Brown stated clearly that 5 mm (1/4") screen was not fine enough for samples containing fish or other species with small elements, and research in the FLMNH laboratories helped determine that a 1.5 mm (1/16") screen was more appropriate to environmental research goals. Wing's insistence on fine screening has been pivotal in many areas of the world, and all the authors in this volume discuss its importance. "[T]he work of Elizabeth Wing and her students, through their insistence on fine-gauge recovery techniques, revolutionized the picture of subsistence among prehistoric southeastern Indian groups" (Scott this volume).

Here, Quitmyer and Stewart and Wigen tackle the screen-size issue directly. Quitmyer's studies over the last decade have shown conclusively that in fine-screened assemblages from Caribbean and Florida aquatic habitats the representative size-classes of fish recovered are expanded and that the proportion of fish in the sample increased (Reitz and Wing 1999; Wing and Quitmyer 1985). Stewart and Wigen's work in Canada reveals similar results. Assemblages recovered using fine-gauge screens are significantly different from those recovered using coarser meshes. Among sites in this area, interpretations of diet can vary from mammal/salmon dominated to herring dominated, depending on the screen size used. Their work is substantiated by similar results from other researchers (e.g., Gordon 1993) who have found that smaller taxa and often smaller diagnostic elements are missed when deposits are not fine screened. Surprisingly, despite evidence from direct analyses of the impact of differential recovery method, archaeologists in many regions still remain unconvinced of the value of such detailed sampling strategies. Worldwide, the realities of budget and time limitations discourage the use of many of the methods so necessary for the recovery of environmental data (Vale and Gargett 2002).

While other issues related to sampling are equally important (including sample size, variable sampling across cultural contexts, and the effects of taphonomic variation in archaeological deposits), the ongoing debate over fine-mesh screening typifies the chasm that continues to exist between archaeological method and the needs of environmental archaeologists. It also suggests a two-fold solution that first begins with increased participation by environmental archaeologists in defining archaeological hypotheses and objectives and in designing sampling strategies to fit those objectives. The second solution to the problem is a simple awareness of the potential biases inherent in our samples. In this volume, Reitz's paper on the Preceramic remains from Paloma, Peru, and Bartosiewicz's regional analysis of the Carpathian Basin of Hungary are both excellent examples of this awareness and treatment of bias. Reitz provides specific and detailed descriptions of sampling, quantification, and secondary analysis methods and correlates findings with a discussion of potential bias created by each of the methods used. Bartosiewicz has the more challenging task of coordinating data from multiple excavations. Although it is impossible to standardize the methods used in sample collection or treatment in multiple datasets collected over many years, his statistical correlations bridge the inherent biases in the analysis. Such work also emphasizes the importance

of encouraging the creation and dissemination of "standards" for gathering environmental data from archaeological deposits.

COMPARATIVE COLLECTION

Issues of methodological accuracy are not confined to the field. Many arise in our own labs during identification and analysis. It is self-evident that one of the fundamentals of our science is the accurate identification of our specimens, whether they be sand grains, corn kernels, canid phalanges, or oyster valves. Yet another controversial issue in modern environmental archaeology is the use of appropriate comparative collections for specimen identification. Accurate identifications are based on comparison with a broad modern taxonomic collection and recognition of the essential diagnostics for each taxon or skeletal element. However, a lack of appropriate resources (and sometimes a lack of recognition of the nature of appropriate resources) means that much of the environmental archaeological research being conducted worldwide is based on limited and often unvouched comparative collections and untrained eyes.

Despite trends at the time emphasizing research at a cellular level, Elizabeth Wing began her career as a zoologist with an interest in whole animal biology. Her earliest publications stemmed from Master's thesis research on reproductive behavior of the Florida pocket gopher, while her Ph.D. dissertation on fauna from the Trinidad tar pits was an important bridge from zoology to zooarchaeology. As a zoologist, she has continued to conduct research on modern comparative collections as well as environmental remains from archaeological assemblages.

One important and early innovation at the FLMNH EA laboratory was Wing's emphasis on the essential importance of the study of whole communities. Consequently, while many zooarchaeologists ignored segments of the faunal taxa, she included all vertebrates and most invertebrates in her analyses. FLMNH's regional scope, with its emphasis on southeastern U.S. and Caribbean coastal sites, fostered Wing's early interest in marine fishes and the utility of fisheries and ichthyological data for archaeological studies. As a result, she actively encouraged the incorporation of marine fishes into comparative collections. The EA collections currently contain more ichthyological skeletal remains than most other zooarchaeological labs and certainly more than many ichthyological research centers (Poss and Collette 1995).

The EA laboratory's modern faunal comparative collection with its 9000 specimens comes close to Wing's initial objective of providing a representative collection of all taxa from the southeastern U.S. and the Caribbean (Wing this volume). The collection also contains representative species from Central America (Mexico and Guatemala) and northern South America (Peru, Ecuador, and Panama), reflecting her continuing interest in Peruvian and Mesoamerican research. The EA collections also contain representative modern botanical and soil reference materials and, while these collections are small, they are growing rapidly in tandem with Wing's focus on holistic research on environmental materials. Over 3500 cataloged soil samples represent 34 sites, 25 in Florida and 9 in the Caribbean. The botanical collections contain over 500 reference specimens (predominantly from the southeastern U.S.), as well as a growing collection of carbonized seeds for comparison with archaeologically burned examples. Both zooarchaeological and archaeobotanical collections are being digitized to create virtual-image files for use by a wider audience.

Research at the Community Level

Wing's work on tropical fishes is of primary importance to coastal research, but her emphasis on comparative work with invertebrates has been equally influential in the expanding science of zooarchaeology. Zooarchaeological analyses in the EA laboratory have included mollusks and common invertebrates like crabs and have extended to studies of shrimp mandibles and other robust microinvertebrate remains. Work on marine bivalves is pivotal to both cultural analyses and environmental reconstructions in the EA laboratory (Quitmyer this volume; Quitmyer et al. 1997). The importance of this emphasis on mollusks is reflected in Prummel's metric analysis (this volume) of mollusks from Sourpi Bay, Greece, and the information this provides on local habitat changes over time. Prummel distinguishes molluskan morphological changes that indicate habitat change from those attributable to human predation.

Biological information on both the modern and the zooarchaeological specimens in this collection and an emphasis on the habits and habitats of the species have always been fundamental to Wing's interpretations of animal use. Early in her career, a detailed understanding of marine fish habitats allowed her to move beyond simple species lists to discussions of fishing practices, catchments, and environmental change based on the feeding habits of marine fishes. Fradkin and Carr's chapter on Preclassic aquatic resource use in Belize follows the path laid down by Wing's early work on fish

behavior and habitat requirements and her later analysis of other collections from the same site (Wing and Scudder 1991). Fradkin and Carr combine turtle habitat details with ethnographic information on both acquisition and taste preferences to correlate their findings with other environmental indicators, suggesting use of the local resources as opposed to those from a broader catchment. The findings are important in view of current discussions in Mesoamerican archaeology about Preclassic trade in marine products (Powis et al. 1999; Shaw 1991, 1999; Stanchly 1995).

Collections Research: Identification and Application

In keeping with a true biological collection, all biotic specimens collected for the EA laboratory include information on sex, age, size, body weights, habitat, and season of capture. The availability of such detailed biological information has allowed those who use this material to fine-tune the identification process. This work has defined and in some cases increased the number of diagnostic elements and element characteristics useful for identification (e.g., Kozuch's use of gastropod columellas, this volume) and delineated those similarities that restrict accurate identifications beyond the level of genus or, in some cases, family (Reitz and Wing 1999:154). Walker's chapter (this volume) is an excellent example of this type of collection-based research. Based on detailed use of modern comparative specimens from the FLMNH, she expands the roster of diagnostic elements useful in separating Florida cottonmouth from diamondback rattlesnakes to include mid-precaudal vertebrae. Wing's work on the domestic dog has also emphasized the caution that must be taken in identifications at the species level, but has shown that with a substantial database it is possible to find markers even for the identification of domestic breeds and types.

Detailed direct research on the EA comparative collections has encouraged refinements in quantification of ancient animal use. For decades, environmental archaeologists have debated the means by which we quantify the "proxy measures" found in the archaeological and sedimentological record. Pollen grains, animal bones, and chemical soil signatures do not accurately represent the patterns of ancient environmental variation. No one debates this essential truth. The challenge lies in the way these remains can be quantified to best reflect ancient environments and use of its resources.

A central issue in zooarchaeology is the relationship between bone fragments (NISP), individual animals (MNI), and actual contribution to diet or other activities. NISP and MNI are now well-accepted measures used by most zooarchaeologists (and most authors in this volume) to create a bracket of maximum and minimum counts for each species. Wing was one of the earliest to see both the validity of careful quantification (Wing 1963) and the dangers of unfettered use of MNI measures, particularly in the analysis of complex societies where resources are shared among community members (Wing and Brown 1979). Her early application of skeletal and whole-body allometry formulae to bone weights, skeletal counts, and MNIs (based on studies of modern animals) provided impetus for more complex analyses of the relative ancient contribution of different species in the archaeological record (Reitz and Wing 1999:69-72; Wing and Brown 1979). Her methods are used by Quitmyer and Reitz (both this volume) as a basis for interpretation of the relative contribution of species to ancient diet. These more complex estimates allow us to move beyond such strictly data-centered questions as "What are they and how many did we find?" to the more intriguing questions of ancient environments and the relationships between these and the human communities we study as archaeologists.

RECONSTRUCTING ANCIENT ENVIRONMENTS

One of our most enduring efforts in environmental archaeology has been the reconstruction of human impacts on their environments, from the creation of anthrosols (soils resulting from human activities) to the creation of new species through domestication to the eradication of others through habitat modification and direct predation. Two goals of environmental archaeology are particularly relevant to modern environmental awareness (or the lack thereof): first, determining whether or not humanity has ever sustainably managed an environment and, second, determining if there are lessons that can be learned from both the mistakes and successes of past human-environment interactions. Accurate reconstructions of the effects of human interaction with the environment are also premised on accurate reconstructions of natural environments and on the clear differentiation between anthropogenic and non-anthropogenic processes.

Scudder's complex reconstruction of the landscape history of the Blueberry site in Florida emphasizes the importance of direct evidence for evaluation of processes and perpetrators of environmental change. Using soil micromorphology and elemental analyses, Scudder describes the development and use of a "subsurface

landscape" and ties the local landscape genesis to global patterns of climate change. As the volume's only soil scientist, Scudder does a superb job of highlighting the importance of strong methodological foundations in this branch of environmental archaeology for separating human from non-human environmental modifications, for defining the details of geomorphological change, and for linking these to broader issues.

Morales-Muñiz and Antipina clarify the methods used for identification of the effects of human versus non-human activity on archaeological assemblages. In their preliminary survey of birds from Bronze Age Russia, they provide markers to differentiate among human, predatory birds, and other agents involved in the deposition of bones in separate assemblages. Combined criteria devised by detailed study of agency in archaeological deposition allow these authors to quantify with certainty the human activity in the accumulation of the different assemblages.

Human Impact on Environments

It is not a simple process to separate the effects of natural variation from that caused by humans. An important issue within the broad theme of environmental reconstruction is the controversy surrounding models of anthropogenic faunal extinctions, particularly with first human incursions into pristine ecosystems. The North American Pleistocene overkill hypothesis has been an enduring model (Alroy 2001; Martin 1967; Martin and Steadman 1999) despite arguments that these continental extinctions should be attributed to the environmental conditions associated with the Pleistocene/Holocene boundary. But over the past decades a robust archaeological and paleontological database provides clear evidence of a direct association between human colonization and extinction events on many islands (Steadman 1995; Steadman and Stokes 2002; Wing 2001). The characteristics of island biogeography make these locales particularly susceptible to extinction, and the effect of human colonization is most dramatic on smaller islands.

The discussion of human impact on ancient environments extends beyond the land. Wing's years of research on marine fish communities have provided extensive information on the impact over time of human predation on marine fish populations. Her recent studies of the ancient process of "fishing down the food web" adapt modern trophic-level methods described by Pauly et al. (1998) for modern aquatic populations. The method requires appropriate samples derived from fine-gauge sieving (1/8"or smaller), an estimate of biomass using average body weight calculated from appropriate allometric formulae, and the application of a mean trophic level index for each species, as provided by modern research (Pauly et al. 1998; Wing 2001). Using trophic level analyses, Wing has shown the effects of ancient human predation on reef fishes from various Caribbean islands and has emphasized the remarkable similarity between ancient and modern processes despite differences in hunting or fishing techniques.

Other researchers in this volume test the specific predictors from Wing's studies of human impact and discuss both overall correlations and important additional considerations. Quitmyer's analysis of faunal assemblages from Cinnamon Bay in the U.S. Virgin Islands expands on Wing's trophic level research by suggesting the importance of ceremonial activities as an additional factor in human predation. Reitz correlates trophic level shifts on the Archaic Pacific coast of Peru with climate fluctuations associated with the Hypsithermal. As in any other reconstruction of human impact on environments, the possible effects of non-anthropogenic changes and the variations introduced by cultural complexity must be considered.

Needless to say, the process of human impact on plants and animals continues far beyond initial contact. Ruhl provides a glimpse of the archaeobotanical perspective on ancient environments, describing environmental changes associated with secondary human impact on natural and anthropogenic landscapes, in this case Hispanic intrusion on the inhabited Georgia Bight region. Combining archaeobotanical, zooarchaeological, and documentary evidence, Ruhl reconstructs the prehistoric environment and documents the marked differences resulting from Old World-introduced domesticates and land-use practices. She also emphasizes that our increase in knowledge has come only as a result of the use of specialized recovery methods and an awareness of the special conditions of wetland preservation.

RECONSTRUCTING SOCIAL REALMS

While environmental archaeologists have often been accused of methodological navel-gazing and of seeing little beyond the biological characteristics of ancient environments and the resources they provide for the sustenance of life, the papers in this volume demonstrate quite the opposite. The attention paid to methodological rigor by environmental archaeologists has led to substantial concentration on the accuracy of our

reconstructions of the environment as a baseline for understanding human activity. As the papers in this volume show, the authors have not neglected the cultural aspects of the human/environment relationship. Even early studies of diet and domestication of plants and animals incorporated aspects of the symbolic nature of landscapes and the ritual associated with domesticated species in most societies.

It is true that environmental archaeologists have often avoided discussions of ritual, cosmogeny, and symbols as interpretations unreachable by current methods (for a detailed discussion, see Albarella 2001). Within the cultural sphere, these papers also show attention directed at processual issues well supported by both data and analogies as bridging arguments.

Synanthropization and Domestication

Environmental archaeological research on human impacts extends beyond early interactions with pristine environments to consider direct and often intentional manipulation of species communities through the creation of new habitats, transportation of species to new locations, and the process of domestication. The timing and process of early domestication were among the first issues explored by environmental archaeology. Wing and other zooarchaeologists have had an abiding interest in the cooperation, necessitated by domestication, between humans and animals, and Wing's work in the Peruvian Andes has been important to continuing research on New World domesticates.

Domestication involves gradual processes, and some of our recent questions address precursor behaviors (both plant/animal and human). Rindos's (1984) early proposal of co-evolutionary adaptation as a mechanism for domestication is an excellent model within which to view the process of synanthropism. Any human manipulation of the environment, even the establishment of temporary encampments, provides a new niche for animal activity. Clearly human refuse was one precursor to dog domestication, and current research like that presented by Morales-Muñiz and Antipina (this volume) identifies other species in the archaeological record likely to be attracted to human-modified environments. Their survey of occupation and subsistence economies in Bronze Age Russia (Boev 1993) relies in large part on the definition of certain bird species as seasonal synanthropes, passive synanthropes, and synurbanists to provide a guide to the levels of cooperative living achieved by humans and their avian neighbors.

One intriguing consideration that is emphasized by the Rindos (1984) model, but often neglected in examinations of proto-domestication, is the human response to synanthropizing species. Scott (this volume) reintroduces the Linares (1976) model of tropical garden-hunting in a North American perspective. Scott uses fine-screened assemblages from late prehistoric New York State to provide a detailed analysis of species use. In the small agricultural hamlet of Spaulding Lake, her data suggest seasonal occupation and the exploitation of fauna attracted to gardens and clearings. Her results indicate that traditional perspectives on Iroquois diet and settlement may have been skewed by early archaeological studies of hilltop villages.

Complexities in Social Reconstruction

Our understanding of the role of domestic plants and animals in both ancient and historic societies is further complicated by the nature of human society. Again, the difficulty lies in the methodological realm. To understand the process of domestication, the effects of synanthropism, and the eventual dynamic of social control over domesticated natural resources, we need accurate counts of the remains. This simple factor is compounded many times over by the effects of social interactions, market economics, and complex ritual beliefs (e.g., Crabtree 1990; Zeder 1991). Several excellent examples of research that directly confront these complications are presented in this volume.

Bartosiewicz's regional review of the shift from nomadism to sedentism in the Carpathian Basin of Hungary reveals the effects of territorial circumscription on generations of mobile pastoralists. Shifts in faunal species over time mark the transition to sedentary pastoralism, but his work also suggests that traditional foodways are often retained even under unfavorable conditions. While optimization models might predict the transition to sedentism under pressure from declining territorial sizes, more structural models of social responses to perceived circumscription could explain retention of ineffective subsistence systems.

Kozuch's discussion of shell bead manufacturing methods at Cahokia reminds us of the importance of long-distance trade of resources and the movement of secondary products through communities. Recognition of markers of artifact production allows us to consider implications for both quantification of species use and the role of environmental products in defining social structure (in this case the evidence for economic centralization).

In this volume, two papers effectively illustrate the

advantages and difficulties of working with historic samples. Crader's evaluation of the "stock economy" of Medieval Italy takes into account the diametrically opposed effects of economic autonomy versus market economies on the zooarchaeological record. Mortality profiles provide useful information on domesticates, but these data are also well contextualized with reference to the varied uses and distribution of these animals. Campana and Crabtree face similar difficulties in their evaluation of soldiers' diets in Pennsylvania during the Revolutionary War. Combining documentary and zooarchaeological evidence lets them determine not only the quantity, but also the quality, of foodstuffs available to soldiers at the Valley Forge encampment.

BEYOND METHODS: FINAL THOUGHTS

I would like to suggest that attention to the details and accuracy of scientific conclusions has become even more important in view of our current role in providing ancient examples for solving environmental problems (Amorosi et al. 1996; Cannon and Lyman 2002; Lyman 1996). At FLMNH, the EA laboratory provides a broad array of services to academic, professional, and public audiences, chief among these services data for governmental (local, national, and international) and non-governmental organizations' environmental management. Can zooarchaeological information define natural population dynamics and habitat extents for endangered populations? Can archaeopedology provide substantive information on the effects of wetland clearing? Can archaeobotanical models be used to predict global warming? As many academics ponder the potential utility of our science for modern decision-making, the EA program under Elizabeth Wing's direction has met the immediate need to contribute. While the chapters in this volume underscore the importance of accurate data in a purely intellectual forum, if the future of our environment rests even in part on our interpretations of the archaeological record, the value of these strong methodological foundations becomes even more relevant.

Two primary concerns in environmental archaeology are the accuracy of our methods for providing secure baseline data and our ability to conceptualize and describe the full extent of the ancient relationship between people and their environments. This volume addresses these concerns through discussions of research from around the world, touching on issues from allometry to women's roles. The geographic and cultural breadth of these chapters, in combination with their theoretical and methodological unity, is a tribute to the strength of the foundations upon which the science is built. The research of these authors reflects Wing's emphasis on the fundamental importance of methodological accuracy for interpretation in environmental archaeology.

Wing's impact on environmental archaeology goes far beyond the methodological foundations. Her more important influence lies in the development of environmental archaeology as a multidisciplinary and holistic science. Following her lead, environmental archaeology has come to be defined in large part by the enthusiasm of its participants and their adventurous exploration of the multiple ways of integrating the biological and cultural sciences. This spirit is amply reflected in the research presented in this volume.

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