

# Chapter 1

## Introduction



In 1950, there were few, if any, zooarchaeologists. Today the number of zooarchaeologists in North America is growing toward equal proportions with those specializing in the more traditional fields of lithic and ceramic analysis (Zeder 1997). In earlier days, archaeologists sent the more complete bones and shells from their sites to zoologists or paleontologists who provided a list of species present. Lyman (2016a) reports that over 78% of North American reports on archaeofaunas published between 1900 and 1944 fell into this category. Faunal reports were usually in monographs' appendices, listing taxonomic groups, sometimes with "rare," "common," or other quantitative estimates noted. In the 1960s and early 1970s several visionary paleontologists and zoologists began training young archaeologists in taxonomy and anatomical identification. Today, zooarchaeology is a self-reproducing field taught in many university departments of anthropology or archaeology. As archaeologists have literally taken faunal analysis into their own hands, they have debated how best to use animal remains to study everything from early hominin hunting or scavenging to animal production in ancient market economies.

### 1.1 The Relevance of Archaeofaunal Remains

The term "zooarchaeology" (Olsen 1971) aptly describes faunal analysis aimed at addressing archaeological questions. Archaeological study of animal remains naturally requires knowledge drawn from zoology and paleontology, but reading them for evidence of past human behavior calls for a unique combination of supplemental strategies. Like its parallel field of study, paleoethnobotany (Pearsall 1989; Piperno 1988), archaeological faunal analysis combines natural historic methods with approaches drawn from archaeology, anthropology, and other social sciences. Zooarchaeologists today research a great range of topics, including whether slaves in the antebellum American South provisioned themselves from the countryside,

how cities of ancient Mesopotamia were supplied with animal food, and whether Neanderthals foraged similarly to anatomically modern humans.

The zooarchaeological literature is growing so swiftly that even specialists have difficulty keeping pace. Some impetus for this explosion in zooarchaeological research arose from application of new technologies to faunal research. Starting in the 1970s, stable isotope analyses of human bones were used to reconstruct diet (van der Merwe and Vogel 1978). More recently, stable isotope analyses have been applied to animal remains to explore herd management, seasonality, climate, biogeography, and paleoecology (see Chap. 20). Application of scanning electron microscopy (SEM) in the 1980s greatly facilitated definition of “signatures” of non-human and human bone modifiers (Potts and Shipman 1981). However, key developments in zooarchaeology often arose from novel perspectives on the basic evidence and from new assertions that zooarchaeological analysis could testify to aspects of human behavior previously deemed inaccessible, such as hominin foraging strategies.

## 1.2 This Book’s Focus and Orientation

Animal remains from archaeological sites have been used to infer three kinds of information: the age of deposits (chronology); paleoenvironment and paleoecological relations among humans and other species; human choices and actions related to use of animals as food and raw materials. Methods for reconstructing human diet and behavior have undergone the greatest growth over the last four decades, and most of this book addresses the second and third areas.

This book deals with what I know best: vertebrate zooarchaeology, and within that, analysis of mammalian bones and teeth. A literature on identification and analysis of fish from archaeological sites exists (Brinkhuizen and Clason 1986; Casteel 1976; Wheeler and Jones 1989), as does that for birds (Carey 1982; Dawson 1969; Howard 1929; Gilbert et al. 1985). An online resource for North American bird bones is found at the Royal British Columbia Museum’s “Avian Osteology” web pages [http://www.royalbcmuseum.bc.ca/Natural\\_History/Bones/homepage.htm](http://www.royalbcmuseum.bc.ca/Natural_History/Bones/homepage.htm). Cheryl Claassen’s work (1998) on analysis of molluscan remains offers a fine theoretical overview.

The text’s main focus is archaeological faunal analysis as practiced in Canada and the United States, with some attention to its practice in Britain and other parts of the English-speaking world. This linguistic grouping forms a logical unit, not only because of ease of communication in a common language but also because of the degree of shared perspectives on archaeology. However, from my own experience as a non-Americanist researching and teaching overseas, I am aware of the productive work of and linkages among zooarchaeologists in the Americas and their counterparts in Europe, Africa, and Asia, and these will also be mentioned as relevant.

This text is not a guide to identification. Many visual guides to faunal identification exist, and notable examples will be cited in Chap. 6. Neither is this book a “how-to” manual, with instructions for zooarchaeological analysis. Instead, it reviews the considerations that underlie decisions about identifying, recording, and quantifying zooarchaeological data. Most of us understand that no two sites are alike and that an irredeemable loss of data can result from digging according to a rote formula rather than with thought to their sites' special aspects. So, too, no two faunal assemblages are identical, nor are conditions under which a zooarchaeologist must analyze a given sample. My intention here is to encourage readers to develop their own knowledge bases that allow them to formulate a systematic and appropriate research plan.

Moreover, zooarchaeology is in a state of swift theoretical and methodological development. Specific current issues discussed in this book may be modified substantially in light of new research within only a few years of its publication. I therefore believe it more useful to review broader factors that must be taken into account at various stages of analysis rather than pushing my own or anyone else's detailed agenda. We do need greater standardization of data classes and scrupulous attention to conservation and documentation, but optimal research design requires a flexibility that no one-size-fits-all approach can offer. If pressed for the absolutely proper way to practice zooarchaeological analysis, I'd say, “thoughtfully.”

Persons familiar with the zooarchaeological literature may ask how this book differs from my friend and colleague R. Lee Lyman's (1994) *Vertebrate Taphonomy*. This is especially a fair question because Lyman and I have generally similar methodological perspectives. I believe the difference between our books is not orientation but focus. I agree with Lyman (1994:33) that hominin modifications of animal remains fall under the larger rubric of taphonomic effects and that there is no *a priori* reason to set human effects apart from those of other agents that can leave their marks on bone, shell, or other organic remains. My book narrows the focus from taphonomy as a whole to the practice of zooarchaeology, because most archaeologists, including those who work with animal remains, ultimately want to study human behavior and its contexts. From this perspective, the main questions addressed in the present book are: what can animal remains from archaeological contexts tell us about the people who handled them, in what kinds of environmental context did they act, and what was the nature of interactions between humans and animals?

However, this book does not ignore the effects of nonhuman actors because zooarchaeological analysis must distinguish such evidence from that which reflects human activities. The need to specify effects of non-human processes on a sample does not stem from the aim to correct for their effects or to “un-bias” a sample. Chapter 3 explains why I believe this is an unrealistic goal. Rather, it stems from the view that all evidence of pre- and post-mortem agency in archaeological faunal samples tells us something that is relevant to the lived human past. A substantial part of this book will address recognizing the traces of the action of non-human bone-modifiers and the implications of their effects for zooarchaeological analysis.

Likewise, it is fair to ask how this book differs from *Zooarchaeology*, by my colleagues Betsy Reitz and Elizabeth Wing (2008). That book, like this one, focuses on humans and their interactions with animals, as testified to by zooarchaeological materials. My own approach overlaps considerably with that of Reitz and Wing because we consider similar research problems using similar methods and techniques. This book devotes much less time to invertebrates, relatively less to laying out ecological theory and basic comparative anatomy, and relatively more to presenting an epistemological framework in which to place and coordinate zooarchaeological knowledge and practice. As well, this book provides more detailed information on bone surface modifications and debates over the meanings of element frequencies. I believe that our respective books are thus largely complementary.

In much these same ways, this book differs from Nerissa Russell's (2012) *Social Zooarchaeology* in its presentation of a conceptual framework for producing and integrating zooarchaeological knowledge, emphasis on documenting bone modifications, and relatively less stress on applications of zooarchaeology to explore social relationships. In fact, my own inclinations have always been toward this goal, and I endorse Russell's approach.

This is a methodologically focused book. It discusses the logic of zooarchaeological method, including uniformitarianism, the potential and limits of analogy, as well as how one's analytic categories, sorting choices, quantification and statistical analysis, and other analytic decisions can ultimately affect one's inferences. However, methods come into being within theoretical perspectives, explicit or implicit, and this text will also explore theoretical perspectives that stand behind the methods examined. Given this, one may well ask from what theoretical position I have written a methodologically focused book. The answer to that question is twofold. One relates to my general view of theory, and the other relates to specific theoretical viewpoints I bring to my own research in zooarchaeology.

Much of my own published work could be classed as "methodological" rather than "theoretical," according to the view that archaeological theory can be divided into distinct realms of "high" or general theory, middle-range or interpretive theory, methods, and techniques. I have devoted much of my career examining how archaeological reasoning, analogy, and "uniformitarian" assumptions work themselves out in zooarchaeology in terms of assigning meaning to archaeological materials (epistemology) and of inference. The latter is what David Clarke (1973) called "archaeological metaphysics," that is, how archaeologists reason, why we feel that certain steps in reasoning are sound, why and how some interpretations or scenarios seem more plausible than others, and how we check ourselves. According to the classification outlined above, these are methodological concerns, yet they are intimately involved with linking data to general theory and to how we construct plausible arguments. Such metaphysical issues, I believe, underlie several debates in the last 30 years' zooarchaeological literature. Chapter 3 of this book explores this area in more detail.

But if we accept that all method is theoretically informed, what kind of knowledge is zooarchaeology? After only a little reflection, it is apparent that some

archaeological knowledge is cumulative and enduring, despite major paradigmatic shifts in “general theory.” Such enduring understandings involve both theory and method, and they are so fundamental that we archaeologists usually do not consider their unique qualities. The principles and practices of stratigraphic analysis, passed down to us from sixteenth-century antiquarians and eighteenth-century field geologists, are lasting components of archaeological concepts and practice. These abiding fields of archaeological knowledge are largely based in consistent relations between cause and effect. In this, they link to other areas of scientific research that continue to contribute new and useful refinements to archaeology, as in the case of accelerator mass spectrometry (AMS) versus conventional radiocarbon dating. They build upon earlier understandings of the world in logical ways, and they are cornerstones of archaeological reasoning. Both stratigraphy and radiocarbon dating aid the temporal ordering of objects and sites, a fundamental archaeological operation. They have carried on from one archaeological paradigm to another and are accepted as valid and used by people with quite disparate theoretical agendas. For example, archaeologists with divergent theoretical commitments may debate the social and ideological roles that Stonehenge played for ancient peoples, but all will incorporate stratigraphic reasoning and radiocarbon dates in their arguments.

As a field of systematic knowledge, zooarchaeology is not yet on equal footing with stratigraphy and radiometric dating. However, I believe it is similar in nature to them and is in the process of developing into a parallel body of theory, method, and practice. Like them, it focuses on materials with properties that are uniform over the time and space we study as archaeologists. These properties govern how humans, animals, plants, and geological processes interact with animal bodies and how those interactions produce the traces we study. Zooarchaeology has continual and fruitful interactions with anatomy, physiology, zoology, veterinary and nutritional science, ecology, paleontology, and geochemistry for information on “source side” (Wylie 2002) processes and their outcomes.

Given this view of zooarchaeology as an emerging field of theory and practice, my goal in this book is to outline some of its fundamental and logically connected building blocks. I thus hope the book will, like a handbook on stratigraphic documentation and analysis, prove useful to students and researchers investigating a variety of cases from a range of theoretical perspectives.

It is fair to ask what “general theory” (Binford 1978) I mobilize in my own zooarchaeological research. I have been working with archaeofaunas from African sites yielding pastoral livestock for about 40 years (Gifford et al. 1980; Gifford-Gonzalez 1998, 2000, 2004). I have also spent time with contemporary pastoralists and read widely about pastoral adaptations. This literature is written from a variety of theoretical perspectives that I have assessed for their usefulness and fit with the way I suspect the world works. I have also read ecology and evolutionary biology. My questions include: how different were these earliest owners of pastoral livestock from ethnographically documented groups in their mix of species herded, mobility, age-specific slaughtering practices, consumption, and refuse disposal practices? How diverse were they in all these, from central Kenya to Tanzania's Serengeti Plains? Do any of these zooarchaeologically investigable questions shed light on how these human communities were organized?

I presently find two theoretical perspectives useful in thinking about these research questions. The first is evolutionary ecology, including human behavioral ecology, which holds that human behavior over the long term can be accounted for in evolutionary terms. The second is structural Marxist theory, which focuses on the human relations of resource acquisition, and control of production and distribution, on a shorter-term time scale. My personal experiences compel me to view pastoral stockowners as part of regional ecosystems, responding to the non-negotiable demands that weather and herd animals make on them. Likewise, my own experience compels me to see pastoralists as participants in social, economic, and ideological systems that both mediate and clash with environmental trends and that affect their day-to-day choices in managing livestock, households, and social relationships. My perspective allows “production” as both an ecological and a social concept, switching perspectives from one to the other in an attempt to view people and animals in both conceptual worlds and granting that animal remains might “make sense” in either or both theoretical contexts.

In the abstract, these theoretical worlds are rather compatible, since human behavioral ecology and Marxist paradigms share a fundamentally economic approach (see also Bird and O’Connell 2012). Both have a concern with the costs and benefits of effort exerted by humans in achieving goals within a social milieu, although viewed in very different ways and calibrated with different currencies. Sometimes these two paradigms grate against each other in troublesome ways. This friction produces interesting insights that I see no reason to eliminate, by favoring one in place the other – or even asserting that it is imperative that a single theoretical perspective “win out” over another (Conkey and Gero 1997). The present book’s aims exclude exploring these aspects of theoretical consonance and dissonance further.

One more theoretical inclination should be noted: I have written this book in a way that discloses my personal standpoint, rather than invoking a neutral, objective “voice of authority” for my opinions. This is not because I believe my opinions are superior to those of others, but rather because I want to take responsibility for those times I do go out on a limb. I am mindful here of Orwell’s (2013 [1946]) essay, “Politics and the English Language,” with his appeal for the personal responsibility of direct prose, and Haraway’s (1997) analysis of the “modest witness” mode of scientific writing that may cloak opinion in an seemingly objective style. I agree with neither writer on some points, but both have made me to be more directly accountable for passages that voice my own point of view.

### 1.3 This Book’s Aims

This book’s intellectual framework builds upon my 1991 article, which I had hoped would help clarify what I saw as some murky problems in assigning causation using zooarchaeological evidence (Gifford-Gonzalez 1991). In my own thinking, I found it useful to move systematically from the concrete individual specimen, with its surface modifications and so forth, out to the fullest kind of contextual

reconstruction one might ever hope to make of past human life from such materials, including social and ecological relations. I proposed a schematic framework (Gifford-Gonzalez 1991: Fig. 2) with which to conceptualize zooarchaeological materials and the inferences we wish to draw from them. That same orientation organizes this book and will be discussed in detail in Chap. 3.

One of the most important contributions a book like this can make is to offer a means of *organizing knowledge*, both old and new, to enable understanding of the significance of new findings and to facilitate systematic research in a coordinated way. I believe that the approach articulated here allows one to fit new information, whether one obtains it oneself or gathers it from other researchers, into an intelligible intellectual structure. New discoveries that merit concentrated attention today soon are folded into our scientific practice as “givens,” and current debates may be passé in a year or two book. My hope for this book will provide students of zooarchaeology with such a framework that will be helpful to them long after most of the hot new topics in this text are old news.

This book’s second aim is to provide the reader with an *array of tools for addressing zooarchaeological research problems* using vertebrate remains. No prescribed outline exists for defining zooarchaeological research questions, identifying key variables to address them, collecting relevant data, and drawing inferences from them. I would not venture to propose one, because zooarchaeological research will never involve a simple set of instructions. Each case will demand different methodological and theoretical approaches to address the research questions and circumstances of the assemblages studied.

Instead of step-by-step “recipes,” we might imagine what a well-equipped “toolkit” of conceptual and methodological approaches should contain to address the ranges of research problems that we can expect to encounter and pursue. This is what I hope to share through detailed chapters that follow describing bone’s intrinsic properties, modifications to bone surfaces, recording zooarchaeological data, and key issues in working with such data in aggregate. This approach is manifest in Chap. 25, since inferring social relations from zooarchaeological material mobilizes many tools outlined in earlier chapters as well as some new conceptual ones. A table in the book’s final chapter will summarize tools in the toolkit, with relevant references. As with this book’s overall structure, my hope is that these will be an enduring – and evolving – contribution to readers’ toolkits for their own work.

## 1.4 Some Basic Definitions

It is useful to define several terms that will be used frequently in this book. *Zooarchaeology*, defined as the study of animal remains to elucidate archaeological questions (Olsen 1971), is one of several disciplines that study faunal remains.

*Zoologists* study living organisms, but they can use shells, skins, teeth, bones, and other constituents, including stable isotopes and DNA, to assess the age, sex, health status, and taxonomic relationships of individuals, regional populations,

species, and higher taxonomic groupings. *Paleontologists* study the preserved remains of ancient animals to learn more about their evolution, systematic relationships, and ancient ecology. *Zooarchaeologists* study faunal remains from deposits created by humans at some time in the past. Here I define *zooarchaeologists* as practitioners with training *as archaeologists* who pursue their research with animal remains. I differ in this from my friend and colleague R. Lee Lyman, who has a broader, and equally valid, definition that assigns the term to all analysts of animal remains from archaeological sites, regardless of the disciplinary training of the practitioner (Lyman 2016a, b). With Lyman's definition, zooarchaeology began decades earlier than the mid-twentieth century starting point on which I focus here (see Chap. 2).

Archaeologists working with animal remains have in fact labeled themselves with a variety of names, including archaeological faunal analysts, *osteoarchoeologists* (Uerpmann 1973) and *archaeozoologists*. These terms need a bit more clarification. In the early 1970s, when I began to study animal remains from an archaeological viewpoint, we called this kind of work "faunal analysis" or "archaeological faunal analysis." These are still accurate terms. I have chosen to use the term "zooarchaeology" throughout this book for two reasons: it lends itself more gracefully to adjective and adverb forms than do these other phrases, and it expresses well the specific type of faunal research we do: archaeology using animal remains.

Persons preferring the label "zooarchaeologist" tend to be concerned primarily with what animal remains say about humans' interactions with them. They have their primary academic background in archaeology and may have supplemental training in zoology or paleontology. They may spend considerable time describing and comparing patterns of bone breakage, cut marks, and other modifications. They normally devote less time to details of species classification, seeing themselves primarily as archaeologists who happen to use animal remains as a way of researching human adaptation and history. Most researchers cited in this text fall into this category.

Other researchers who work with archaeological faunas prefer the term "archaeozoologist." Archaeozoologists tend to be more interested in the evolutionary and ecological status of the animals found in archaeological sites and generally less concerned with what bones can tell us about details of human behavior and social relations. They focus on reading the history of certain species, such as wild cattle, from their remains in sites, on morphological and size transitions from wild to domestic forms of some species, and on regional variability of ancient domesticates. Persons preferring to be called archaeozoologists often obtained their primary training in the biological sciences rather than archaeology. They are inclined to approach archaeological assemblages as well-dated local samples of the species of interest, to be compared to other archaeological samples by detailed metrical and morphological analyses. Human modifications to bones such as butchery marks, breakage, and evidence of cooking were not heavily emphasized (von den Driesch and Deacon 1985; Bökönyi 1984), nor are detailed reconstructions of human behavior necessarily seen as a major goal. Thus, as their name implies, archaeozoologists aim more toward constructing the zoology of ancient faunas from archaeological sites.

Although it oversimplifies a complex situation, most North Americans studying archaeological faunas would probably, if pressed, call themselves zooarchaeologists, while many but not all continental Europeans would probably call themselves archaeozoologists. British researchers may select either of the two labels. Some bone researchers, preferring to reserve detailed taxonomies for their faunal collections, are content with the label “faunal analyst.” The title of the journal *Archaeozoologia*, published in Grenoble, France, reflects the dominant perspectives in continental Europe.

Notable exceptions to these simplistic dichotomies exist. Some U. S. researchers have engaged in both kinds of work (Frison 1970, 1974; Grayson 1984b, 1991; Grayson and Delpech 1998; Wheeler 1982, 1984; Zeder 1991, 2001), and some continental European faunal analysts focus more on reconstructing behavior (Grayson and Delpech 1994), often in collaboration with North American researchers. Some European researchers have questioned the underlying assumptions of “animals-first” analyses (Legge 1978; O’Connor 1996). Moreover, with time, younger researchers on all continents are converging more in their interests. I expect the dichotomies that held true in the late twentieth century will not survive long in the twenty-first.

Returning to terms used in this book, it is sometimes helpful to refer to all studies of animal remains regardless of goals or the disciplinary grounding of the practitioners. In this book, I will use *faunal studies* or *faunal analysis*, to signify any research with animal remains, whether undertaken by zoologists, paleontologists, physical anthropologists, or archaeologists, regardless of aims. Mainly to have a word that can readily be used as an adjective, I will use the term *archaeofauna* to refer to a sample of faunal remains recovered from an archaeological site. This use follows Grayson (1984a) and is less cumbersome than phrases like “archaeological faunal remains.” I will use this term for historic archaeological faunas as well as more ancient prehistoric samples, although “archaeofauna” may not resonate as well for some when applied to Monticello’s animal remains as when used for samples from Olduvai.

The term, *archaeobiology*, includes not only zooarchaeology but also study of all ancient biological material, including that from animals, plants (in the U.S., usually called paleoethnobotany) or microorganisms not readily divided into either realm.

The term *taphonomy* has already been used in this chapter and requires further definition. It was coined by Soviet paleontologist I. A. Efremov (1940) to describe studying animal remains to elucidate their circumstances of deposition or to better define the agencies that modified them before deposition. The term is derived from the Greek words for burial (*taphos*) and rules or system (*nomos*). Considerable overlap exists in concepts and analytic methods in vertebrate taphonomy and contemporary zooarchaeology, and researchers in each area communicate and engage in projects that blur the boundaries between these fields. As noted earlier, from a paleontological taphonomist’s point of view, human modifications to animal remains, as well as human actions that influence their burial, are just another set of forces affecting biotic materials. From the point of view of an archaeologist, taphonomic analyses are essential for distinguishing traces of human action from those of

other creatures or natural processes that can affect animal remains. Taphonomic research will therefore be prominently featured in this book, and its history will be sketched in Chap. 2.

Finally, some basic terms should be defined. At the outset, it is important to distinguish between a skeletal *element* and a *specimen*, as these terms will be used in this book. An *element* is an anatomical unit in a vertebrate body, such as a humerus or a femur. A *specimen* is an actual archaeological remain of an element, as recovered and studied, which may be either a whole element or, more commonly in archaeofaunas, a portion of an element. I follow Lyman in arguing that terms such as “bone” or “tooth” are too imprecise, as is “fragment,” for much of formal zooarchaeological writing.

When referring to humans, their ancestors and their close relatives, this book will use the term “hominin,” the vernacular form the *tribe* Hominini, a level of classification between that of the subfamily (i.e. Homininae) and the genus (e.g. *Homo*, *Australopithecus*). This results from a taxonomic reclassification of humans and their nearest relatives in the 1990s, largely as the result of new genomics findings on of living species (Wood and Richmond 2000). It parallels many other, molecularly-based taxonomic reclassifications of vertebrate groups. While only humans, their ancestors and collateral relatives were formerly placed into the family Hominidae, under this revised systematics, all great apes are also included. The African apes are grouped with *Homo*, *Australopithecus*, *Paranthropus* and other former “hominids” within the subfamily Homininae, again based on genetic evidence for the greater similarity of these groups to one another than to the orangutan (*Pongo pygmaeus*). Below this classification is the tribe Hominini, which includes *Homo*, *Australopithecus*, et al., plus the genus *Pan* (chimpanzees and bonobos). These two species have the greatest genetic similarity with us and only 5–6 million years of evolutionary divergence. Practically, this means that most paleoanthropologists now refer to what were formerly called “hominids” as “hominins.” Although I use the term “hominin” throughout the text, many references and some quotes in this text include the older “hominid” because it was current during the time articles or books were written.

## 1.5 A Caveat and a Perspective

Before turning to hundreds of pages of single-minded examination of vertebrate faunal remains, it is necessary to acknowledge the importance of other types of evidence for human subsistence, behavior, ecology, and social context. This is especially necessary for someone who wrote an article entitled “Bones are not enough” (Gifford-Gonzalez 1991). Animal remains are only one line of evidence concerning human environment, subsistence, and behavior. The last half-century of anthropological research on people who gather and hunt has shown the importance of plant foods in their diets, to say nothing of the centrality of plant foods among farmers or members of horizontally and vertically integrated complex societies. Thus,

paleoethnobotany has equal importance as zooarchaeology in research on human diet and resource use. Isotopic analyses of human remains can provide a wealth of specific dietary information to complement faunal and botanical evidence from archaeological contexts (Chap. 22). Ultimately, all biological data serve limited and rather pedestrian uses if not juxtaposed with artifactual, architectural, and settlement data within a well-reasoned analytic framework. For a variety of reasons, one should play off the significant information derived from faunal assemblages against other types of archaeological and contextual data (Chap. 3).

## 1.6 Organization of the Text

This book is divided into five parts, each containing several chapters that fit together topically, and one concluding chapter. The purpose of Part I is to develop an orientation to zooarchaeology. This chapter begins by situating archaeological faunal analysis in relation to archaeology as a whole, by distinguishing zooarchaeology from related research fields that use animal remains, and by defining terms and concepts fundamental to zooarchaeology. Chapter 2 recounts how zooarchaeology came to be a distinct specialization within archaeology, primarily in anglophone countries, charting themes and foci of archaeological faunal analysis research in North America and the United Kingdom, but also considers the important influence of continental European researchers. It sketches development of other key regional zooarchaeological research traditions and steps toward greater communication among zooarchaeologists worldwide. Chapter 3 presents the perspective on zooarchaeological analysis that organizes this book. Concepts and themes discussed include uniformitarian methodology, actualistic research, and analogical reasoning in archaeology, a product-focused approach to bone analysis, and a forensic approach to inference of causal agency and context. My perspective is necessarily idiosyncratic. However, I arrived at many of these conceptual components simultaneously with other colleagues working in parallel. The overall perspective presented is thus one I believe is shared by many zooarchaeologists, and I will attempt to stress points of agreement and disagreement. This chapter also presents terms and distinctions useful in understanding the processes that create patterning in archaeological faunal assemblages and their relationship to the contexts in which the actors we study existed.

Part II reviews uniform features of vertebrate bodies that allow zooarchaeologists to reason productively from archaeofaunas. Skeletal elements in vertebrate bodies vary in construction, shape, density of bone tissue, patterns of growth, and associated soft tissues. These variations are properties that zoologists, zooarchaeologists, and paleontologists use to identify an animal's species, age, sex, health status, and, sometimes, even season at death. Although their properties develop as part of living organisms, skeletal elements' structure, bone mineral densities, and associated soft tissues can govern their postmortem fate. These determine an element's attractiveness of bone-modifying animals, including humans, and its

response to postmortem biological and non-biological forces acting upon it. One can work with these traits in formal terms, learning to distinguish species' bones by their distinctive shapes. However, deeper functional understanding of the traits makes methodological sense: if relational analogies are stronger than formal ones, analogies based on functional relations in life or postmortem lend greater level of confidence to inferences.

Chapter 4 reviews qualities of bone and teeth that develop as functional properties of living animals, explaining fundamental variations in bone as a material. Chapter 5 describes bone's nutrient functions in living animals, specifically in mammals, and the nutrient potential of animal bones, for carnivorous organisms. Chapter 6 introduces distinctive functional patterns of osteological growth according to species, sex, and age and provides a brief overview of sources for determining species, age, and sex. Chapter 7 reviews how patterns of dental growth in mammals permit determination of age and addresses some of the complications of ageing based upon dental traits.

Part III outlines analytic approaches of zooarchaeology, from field recovery through sorting and data recording to fundamental quantitative descriptions of bone samples. These practices bring specimens under study, produce data from them, and store specimens and their data. Chapter 8 provides a brief overview of recovery and processing of bones and other faunal remains. Chapter 9 deals with how analysts divide an assemblage into identifiable versus unidentifiable components, and the consequences of such decisions for all later manipulations of data in the zooarchaeological literature. It discusses the usefulness of specimens that fall between specimens identifiable to element and species and fragments so broken that they can only be identified as vertebrate bone. Chapter 10 introduces basic zooarchaeological counting units: Number of Identifiable Specimens, Minimum Number of Elements, Minimum Number of Individuals, Minimum Animal Units, outlining the strengths and weaknesses of each.

Part IV presents specific evidence used to infer the causal processes, effectors, and actors of bone modification, to use terminology introduced in Chap. 3. In keeping with a product-focused perspective, it concentrates on the distinctive traces at the effector-actor level of inference. Some taphonomic traces on bone are so distinctive that they can be linked to specific causal processes, effectors, and actors with relatively high levels of confidence. Others, such as breakage patterns and abrasion, cannot be attributed to a single actor, and this section offers examples of how zooarchaeologists incorporated more than one independent line of evidence to narrow the range of possible causes for such ambiguous evidence. The role of various actors and processes in transporting, dispersing, or aggregating faunal remains is reviewed in Part V.

Chapter 11 outlines bone breakage and its causes, emphasizing this as a specific case of the concept of equifinality, first noted in Chap. 3. It reviews how bone structure interacts with static, dynamic, and torsional stresses, and how various actors may produce similar effects. Chapter 12 reviews the multiple effects of mammalian carnivores in terms of bone surface modification and selective destruction of sections of elements. Chapter 13 outlines the effects of other vertebrate agents of bone

modification: avian carnivores such as owls, hawks, and eagles, hoofed animals, and rodents. Chapter 14 discusses distinctive hallmarks of hominin carcass dismemberment and tissue removal on bones, surveying cut marks, chops, other cutting-tool mediated marks, and percussion marks. It notes traces of non-hominin origin that closely resemble those inflicted by humans. Chapter 15 considers marks of culinary processing, as well as the nutritional gains and social aspects of this uniquely human way of handling of animal bodies. Chapter 16 briefly reviews microbial (“bioerosion”) and geological effects on bone, especially abrasion and weathering, and more briefly, transport, burial, and diagenesis. Chapter 17 builds on the preceding chapters of Part IV, exploring how zooarchaeologists have worked with bone assemblages likely to have been accumulated or modified by multiple actors. Chapter 17’s consideration of the challenges of analyzing archaeofaunas created by multiple actors and processes forms a bridge to Part V’s focus on element frequencies and other types of aggregate data used to infer behavioral, social, and ecological contexts.

Following the scheme laid out in Chap. 3, Part V discusses methods applied to studying the behavioral, social, and ecological contexts in which archaeological faunal samples were created. Such contexts are the ultimate goal of most zooarchaeological analysis, and inferences at this level depend upon aggregate patterns of data, not simply of a single type but of multiple types in combination. When one seeks to investigate human behavior, social relations, and ecology with archaeofaunal remains moves from discerning concrete traces of effectors and actors to reaching toward the contexts in which these were produced using aggregate data (Fig. 3.1). How to develop and implement these steps is an area of active controversy. This section does not aim to resolve this, but rather to point out key arguments and steps toward consistent methods.

The first two chapters of Part V consider two key aspects of working with the complex datasets needed to address behavioral, ecological, and social contexts. Chapter 18 returns to quantification in zooarchaeology, considering the limitations of common counting and data aggregation tactics outlined in Chap. 8. It reviews commonly used methods of statistical comparison and inference using aggregate data and working with archaeofaunal counting units or other, such as nutritional utilities and bone mineral densities, variables to be introduced in this section. Chapter 19 introduces butchery in the broader context of carcass transport by humans and other carnivores, comparing tool-assisted carcass segmentation, or dismemberment, to natural processes of post-mortem disarticulation. It outlines early zooarchaeological efforts to use element frequencies as proxies for humans’ transport of such body segments from their original locales.

Chapter 20 details zooarchaeological attempts to calibrate associated nutritional values of bone elements to explain human choices in selecting or discarding specific body segments. Chapter 21 reviews how archaeologists have sought to distinguish such nutritionally motivated, selective transport from in-place destruction of skeletal elements, according to their differing bone mineral densities and resultant durabilities. It revisits relevant issues concerning quantification.

Chapter 22 reviews traditional approaches to studying ecological relations from aggregate zooarchaeological data, including species abundance and diversity, and the use of mortality profiles to discern hunters' prey choice and domestic herd management. These analyses also depend upon element frequencies but use other forms of secondary data, namely relative taxonomic abundances, age-at-death data aggregated into mortality profiles, and other derived data. Chapter 23 outlines a range of new methods that enhance more traditional zooarchaeological approaches to ecology, as well as highlighting the emerging importance of zooarchaeology in historical ecology and conservation. Chapter 24 reviews widely applied approaches to archaeofaunal data based upon behavioral ecological theory. Chapter 25 aims to do two things. First, it uses zooarchaeological case studies that place animals in their human socioeconomic contexts, from foragers to farming and pastoral societies to complex, urban systems of production and distribution. Second, the chapter emphasizes the “toolkit” of conceptual and analytic tactics used to study animals in such political economic contexts.

Chapter 26 concludes with some observations on the future of zooarchaeology, as it increasingly incorporates methods from genetics and geochemistry and develops research relative to wildlife management issues. It emphasizes the need as a sustained practice for integrating zooarchaeology with other fields, offers some recommendations for approaching and executing analysis, and presents a perspective on the enduring features of the field in a time of great methodological change. This book includes some citations of publications dating up to 2016–2017, but the cut-off date for a more comprehensive literature review is effectively 2014.

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