INTRODUCTION

Research does not occur in an intellectual vacuum. When developing research designs, scholars should be familiar with both the history of their discipline and the current theoretical climate in the field in which they work. Zooarchaeology is such a diverse field that it is impossible to do justice to its history on a global scale; therefore, our emphasis is on zooarchaeology in the context of anthropological archaeology, primarily in the United States. Despite regional variations, it is surprising how similar zooarchaeology is internationally. This may result, in part, from international networks and the focus on animal remains. It may also be that the biological background of many zooarchaeologists and the relative youth of the field are responsible for the many shared features (Horton 1986). Nevertheless, it is important that students review literature from their study locale to learn about zooarchaeological trajectories in that specific area. Obituaries and dedicatory reviews are good sources of information about the field and collegial networks.

Zooarchaeological research has two related goals: (1) to understand, through time and space, the biology and ecology of animals, and (2) to understand the structure and function of human behavior. To address these goals, theories and methods are drawn from a number of sources. The biological and physical sciences are one source. The second source is anthropology, particularly those methods and theories pertaining to the relationship of humans with their natural and social environments. A third source is archaeology itself, especially where anthropology and archaeology are separate disciplines. The role of zooarchaeology in biological and anthropological research, as well as the questions zooarchaeologists address, reflect shifts in prevailing research interests in these spheres.
Anthropological theories about the relationship between humans and the world around them are closely linked to the development of zooarchaeology. The relationship between environmental studies and anthropology is fundamental. Exploring environmental relationships is a major theme in anthropology. Concepts about the relationships among environment, subsistence, technology, human populations, and other aspects of cultural life may be broadly classified as environmental determinism, environmental possibilism, cultural ecology, ecological anthropology, and historical ecology (Crumley 1994; Ellen 1982; Hardesty 1977:1–17; Jochim 1981:5–10; Vayda and Rappaport 1968:479, 483). The ascendancy of one or the other of these theories influences the study of animal remains in archaeological research.

Environmental Determinism

In the late nineteenth and early twentieth centuries, one of the most prevalent theories was that the environment caused cultural phenomena (Hardesty 1977:1–4; Jochim 1981:5–6; Moran 1979:24–33). Environmental determinists argue that environmental characteristics limit the development of material culture and technology. In extreme interpretations, the environment, especially climate, is said to dictate the level of cultural development achieved. Environmental factors may include topography, vegetation, or soil. Regardless of the identity of the causal agent, culture is viewed as a passive rather than an active agent, and cultural phenomena are explained by the environment in which they are found. Although this perspective does not preclude faunal studies (e.g., Fewkes 1896), most current zooarchaeological studies are conducted under other theories.

Environmental Possibilism

In contrast to the causal role proposed by environmental determinists, environmental possibilists argue that environments may permit certain cultural developments, but there are always cultural alternatives (Ellen 1982:21–32; Moran 1979:33–7). According to the possibilist position, the environmental role is a broadly limiting one explaining the absence of traits but not their presence (Kroeber 1939). Environmental possibilists argue that cultures act selectively, or even capriciously, on their environments but that the environment itself is passive. Kroeber (1939:205) notes that “no culture is wholly intelligible without reference to the noncultural or so-called environmental factors.
with which it is in relation and which condition it” (see also Harris 1968:339–40; Kroeber 1939:3). However, he also argues that historic and geographic research is relevant only because of an “archaeological preoccupation” with these concepts (Kroeber 1939:3). The limited role played by faunal remains in the early twentieth century is also related to the historical particularist approach advocated by Boas, who argues that cultures are individually unique phenomena that should be studied only in terms of their own histories (Harris 1968:274, 326).

From this perspective, faunal remains, subsistence strategies, and economics are of little interest. However, many of the cultural areas defined by environmental possibilists correspond to natural areas, with the relationship explained in terms of what a natural area would or would not permit. Cultural areas are often defined using extensive trait lists. Similar lists of traits are found in the archaeological literature. Lists of large-bodied mammals available in a given area are particularly common, but the archaeofaunal remains are not identified. These lists are considered to be an adequate study of animal use because of the assumption that people at a site naturally used the animals that were abundant near the site and that animals abundant near the site today were common when the site was occupied. In the absence of anthropological theories relevant to animal remains, most faunal research influenced by environmental possibilism focuses on biological issues. The results of faunal research are rarely published in anthropological sources. Zooarchaeology, as a social science, does not flourish under this theoretical perspective.

Cultural Ecology, Ecological Anthropology, and Human Ecology

A different perspective on the human–environment relationship is provided by cultural ecology (Ellen 1982:52–65; Hardesty 1977:8–10; Joirim 1981:7; Moran 1979:42–58, 1990). According to Steward (1955:31), cultures and environments are part of a total web of life. Each can be defined in terms of the other, with the environment playing an active, reciprocal role in human affairs rather than a determining or passive one. Steward (1955:30) urges cultural ecologists to study the processes by which cultural features are influenced by adaptations to the environment. He argues that resource utilization is more strongly related to the environment than to other cultural phenomena. Thus, characteristics associated with subsistence and economics, especially technological ones, constitute the cultural core. Secondary features are less strongly related to the cultural core and may be determined by purely historical factors. Steward advocates that attention should be paid to the resources of specific habitats in order to identify the subsistence and demographic patterns that influence political and social relationships.
Cultural ecology is often associated with studies of adaptive strategies and is distinguished from human ecology. In biological or human ecology, theoretical concepts derived from plant and animal ecology dominate efforts to describe, interpret, and predict the interaction between humans and their environments, with an emphasis on holistic, evolutionary, and systemic models (Bates and Lees 1996; Buzer 1990; Ellen 1982:66). These perspectives stress cultural behavior in both natural and social environments (Ellen 1982:73–9; Joehim 1979:9, 1981:4; Moran 1990; Vayda and Rappaport 1968:494). Ecological concepts, such as niche breadth, evolutionary ecology, and systems theory, are particularly important (Clarke 1972:30; Winterhalder and Smith 1992). Although some studies emphasize ecological populations (e.g., Moran 1979), others focus on networks and ecological systems (e.g., Geertz 1963) or economic, political, and other social dimensions (e.g., Bogucki 1988). A consequence of such studies is a holistic view of human life and an awareness of the complex, interactive relationship that exists among cultural systems, human populations, and the environments within which they operate. Historical ecology provides the temporal perspective of a changing landscape to studies of both structural and functional properties (Winterhalder 1994).

Cultural ecologists and ecological anthropologists do not interpret the relationship between humans and their environments as deterministic. Instead, the relationship is viewed as part of a dynamic process that may result in alternatives to specific behaviors or institutions (Joehim 1981:3–4). Cultural ecologists may focus on the adaptive relationship between humans and their environments, including subsistence strategies and reactions to environmental change. The selection and consequences of food acquisition and intake are based on a combination of cultural, environmental, and technological considerations. It was within this multidisciplinary, ecological framework that zooarchaeology has assumed a prominent role in archaeological research.

ZOOARCHAEOLOGY IN ARCHAEOLOGICAL RESEARCH

These anthropological theories have influenced the history of zooarchaeology. This section emphasizes the development of zooarchaeological research within archaeological research: on classification and descriptions in the nineteenth century, on cultural history in the early twentieth century, and on context and function into the twenty-first century. Although this review is organized chronologically, many research questions from earlier centuries guide modern zooarchaeological research, albeit with methods unheard of in earlier centuries (e.g., Albarella 2001; Evans 2003; Evans and O’Connor 2001; Hesse 1995; O’Connor 2000b; Roskams 2001; Wilkinson and Stevens 2003; Willey and Sabloff 1974; Zeder, Bradley, Emshwiller, and Smith 2006; Zeder, Emshwiller, Smith, and Bradley 2006).
Classification and Description

After a period of speculation about the relationship between the environment and human society, scholars began purposefully gathering evidence to support or refute popular perceptions of natural history. It was during this time that scientific geology and Darwinian concepts of evolution developed. Archaeologists became somewhat more rigorous in their work and began to classify artifacts on the basis of factual descriptions (Daniel 1981; Willey and Sabloff 1974:42). Such interests dominated archaeology throughout the nineteenth century and into the early twentieth century.

Faunal studies were largely conducted by individuals with biological interests. Although most of these studies were descriptive, some foreshadowed future directions in zooarchaeology. One of these directions was interest in the historical association of humans with environmental change. Faunal remains from archaeological sites proved that humans had contact with extinct animals and demonstrated that changes had taken place in the geographical distributions of nonhuman species (e.g., Eaton 1898; Hay 1902; Loomis and Young 1912; Mercer 1897; Wyman 1868a, 1868b, 1875). In other cases, faunal remains defined chronological and stratigraphic changes in animal use. Lartet, for example, argued that the Upper Paleolithic should be divided into the Cave Bear, Woolly Mammoth and Rhinoceros, Reindeer, and Aurochs or Bison periods (Daniel 1981:63). A similar approach was taken by Dall (1877), who classified the strata of several Aleutian shell mounds using animal remains, the weapons by which these animals were obtained, and the utensils used to process them (Figure 2.1).
Some cultural interpretations were made. Sometimes the animal remains received more attention than did either the lithic or the ceramic artifacts. Swiss veterinarian Ludwig Rütimeyer influenced much of the future direction of zooarchaeology with his 1861 report on fish and early domestic animals at Swiss lake-dwellings (Clason 1973, 1986). Eaton’s (1898) unquantified vertebrate and invertebrate species lists were accompanied by zoological and geological notes, a discussion of human remains, descriptions of worked faunal remains, observations on butchering habits and other modifications unrelated to tool manufacture, a suggestion that the shell mounds were occupied throughout the year, and a zoogeographical note about the extinct great auk (Pinguinus impennis). Mills (1904, 1906) described both modified and unmodified animal remains, estimated dietary contributions, discussed capture techniques, and reviewed food preparation methods in his reports (Figure 2.2). The work of Loomis and Young (1912) is particularly interesting because their vertebrate and invertebrate lists were quantified in terms of the number of individuals. Their paper included descriptions of the species recovered, hypotheses about their dietary importance based on frequency and butchering patterns, inferences about the season in which the site was occupied, and descriptions of modified animal remains. Although most of the animals in their shell middens were consumed, Loomis and Young (1912) observed that some probably were not.

Some early concerns with methods and the processes involved in the formation of these deposits are evident. Lartet demonstrated that species richness increases...
considerably when the remains of small animals are studied (Clermont 1994). Although his observations were not quantified, Wyman (1875) expressed interest in improving analytical approaches.

Cultural History, Chronology, and Trait Lists

Early efforts to describe archaeological materials were followed by chronological and methodological concerns (Daniel 1981; Dunnell 1986; Willey and Sabloff 1974). The stratigraphic and stylistic interests that dominated archaeological research in the first half of the twentieth century produced complex chronologies and cultural histories based on descriptive typologies. The focus on cultural history and the prevailing environmental possibilist theories did not encourage archaeologists to study archaeological materials deemed to be of little chronological significance (Barker 1985:4). Typically, archaeological accounts included only those faunal remains associated with human burials (e.g., Webb 1928) or those that were modified (e.g., Boekelman 1936, 1937). In much of Europe and southwestern Asia, zooarchaeology was synonymous with the study of domestic animals (Clason 1983, 1986). Reflecting the emphasis of archaeology on nonbiological issues, most zooarchaeological papers are in biological rather than anthropological publications. In those rare cases where animal remains were included in archaeological reports, the attributions sometimes were inaccurate because people familiar with animal remains were seldom consulted (Figure 2.3; Smith 1937).

Although archaeologists interested in chronology rarely incorporated faunal remains in their studies, many biologists pursued the environmental information offered by these remains. Zoologists were directed to archaeological materials for information about animal distributions, extinct forms, morphological change, and pathologies (Wintemberg 1919). Hargrave (1938) published a similar list 20 years later. Examples of this literature are very common. For example, van Giffen studied fish remains from dwelling mounds known as terpen in the Netherlands (Clason 1983, 1986). Many of these studies reported associations of humans with extinct animals (e.g., Eddy and Jenks 1935; Miller 1929a, 1929b).
Some anthropological questions were considered. For example, in her report on the Emeryville avifauna, Howard (1929) reviewed both biological and cultural aspects of the materials. She discussed plant and animal communities around the site, provided a biological description of the bird remains, and considered modified specimens, exploitation of juvenile birds, hunting range, and evidence for year-round occupation of the site. Although he concentrated on biological issues, Baker (e.g., 1923, 1931, 1941) noted that some of the invertebrates he identified provided evidence for trade routes in the southeastern United States, and he interpreted vertebrate and invertebrate remains in terms of meat resources.

Growing methodological sophistication is reflected in papers addressing the importance of recovery techniques and curation of faunal remains. Weigelt’s (1989) important taphonomic work, published in 1927, reflects this early concern with procedures. Several papers called attention to factors affecting preservation and urged recovery, retention, and study of all specimens (e.g., Wintemberg 1919). Hargrave (1938) urged his colleagues to save all faunal materials and to have them identified by a zoologist rather than be satisfied with wild guesses. Methodological concerns were reflected in notes about accurate identifications (Merriam 1928) and calls for measurements (Clason 1983). Howard (1929) also discussed archaeological recovery methods and provided illustrations that could be used to identify bird elements. She observed that although paleontologists might think that archaeological specimens were in good condition, most zoologists were unimpressed with these dirty, broken fragments (Howard 1929:311).

Context and Function

In the 1940s, archaeologists began to develop research interests requiring knowledge of the context and function that went beyond descriptive trait lists, chronology, and cultural history (Barker 1985:5; Daniel 1981; Willey and Sabloff 1974; Wilkinson and Stevens 2003:246–54). These studies showed a greater awareness of the information about cultural behavior and former lifeways that artifacts provide. During this period, Steward (1955) defined cultural ecology and Taylor (1948) proposed the conjunctive approach. Interest in cultural adaptations required considering the role that local plants and animals play in human endeavors. Although most biological and geological disciplines continued to make minor contributions to the research of conventional archaeologists, by the 1960s, they had assumed a significant place in ecologically oriented archaeological research.

Although functional and contextual concepts required systematic collection and analysis of faunal samples and anthropological rather than biological interpretations, many archaeologists still thought environmental data to be unimportant to the study of cultural phenomena. Much of the increase in faunal studies during this period was in
unquantified descriptions. Often worked specimens would be described in the text, while unmodified materials appeared in a brief appendix or note (e.g., Hadlock 1943; Tyzzer 1943; Webb 1959), if at all. Unmodified faunal remains were often discarded.

However, a growing number of archaeologists wanted their faunal samples identified competently and quickly, and this caused a number of problems (Gilmore 1946; Taylor 1957). For most of this period, there were no zooarchaeological specialists. Most attributions were done by biologists or people with no formal training in archaeology. Yet, as anthropological interest in animal remains grew, biologists increasingly considered archaeological identifications an unmitigated drudge (Gilmore 1949:163) – an attitude not improved by the fact that archaeologists wanted a report as soon as possible (Gilmore 1949). By this time, most biologists specialized in single groups of animals. They could not do an integrated study of the archaeological materials, and most lacked an anthropological background for interpreting archaeological faunal remains in human terms. Trying to improve the situation, Gilmore (a biologist) provided biologists and archaeologists with examples of the information that could be obtained from animal remains by publishing similar articles in both American Antiquity (1946) and Journal of Mammalogy (1949). Gilmore (1946) recommended that archaeologists become involved in preparing reference collections, quite rare at the time, in order to appreciate the variety of information animal remains might provide.

Without a thoughtful research objective for the archaeological project, in general, and the faunal data, in particular, little could be expected from faunal studies other than lists. Taylor’s (1948:7, 1972) definition of the conjunctive approach, the study of the interrelationships that exist within a culture, provided an important step forward. Taylor called for holistic studies of the relationship between people and their environment. To study human subsistence, Taylor (1948:188–9) advocated archaeologists collect adequate faunal samples and have them studied. He suggested that such studies be funded so that specialists would view archaeological studies as legitimate research rather than spare-time projects (Taylor 1948:200). He stressed the importance of publication and quantification (Taylor 1948:156, 169). Taylor’s (1957) edited volume on the identification of what he called nonartifactual archaeological materials included chapters by Barbara Lawrence, Paul Parmalee, and Charles Reed, all of whom influenced zooarchaeology in the latter part of the twentieth century. It is probably significant that Gilmore and Taylor were colleagues (e.g., Gilmore 1947).

Campaign-style projects, such as those in Asia (e.g., Bate 1937; Braidwood and Braidwood 1982; Braidwood and Howe 1960; Hole et al. 1969), Mexico (Byers 1967), and Peru (Izumi and Sono 1963; Izumi and Terada 1972), contributed to the development of zooarchaeological specialists. Some of these projects began in the early part of the twentieth century, lasted for many years, and excavated large quantities of material. Project personnel included faunal specialists who worked as part of multidisciplinary teams, often in the field. There they had an opportunity to learn about the context of
the faunal remains and provide advice about their treatment and recovery. The most important contribution of these projects may have been the training they provided for students who eventually became leaders in the field.

As a consequence of these developments, zooarchaeology became a recognized field with a greater role in archaeological studies. With this growth came concerns about site-formation processes, methods, and interpretation. Some of the most significant zooarchaeological reference collections and laboratories trace their roots to the mid-twentieth century (e.g., Chaplin 1965; Driesch 1991; Schibler and Chaix 1994). The impact of cultural and natural transformations on the archaeofaunal record became a greater concern (Byers 1951; Dart 1957; Efremov 1940) as did sampling issues (e.g., Parmalee 1957a, 1957b; White 1956). White (shown in Figure 2.4) published a series of important methodological papers (1952, 1953a, 1953b, 1954, 1955, 1956) based primarily on butchering marks and techniques. He is probably best known for introducing archaeologists to a technique used by paleontologists (e.g., Stock 1929) to estimate the minimum number of individuals (MNI), (White 1953a). Lawrence (1957) urged changing the emphasis from identification to interpretation so that the work would be more intellectually exciting and attractive. Meighan and his colleagues (1958a, 1958b) published a two-part series proposing a number of ecological interpretations that could be made using archaeological materials. Methods for studying dietary components and population size were proposed (e.g., Cook and Treganza 1947). Many of these topics remain important research themes in zooarchaeology.

**RECENT ZOOARCHAEOLOGICAL RESEARCH THEMES**

Cultural ecology and ecological anthropology theories dominate most of the recent archaeological research (Renfrew and Bahn 2004:37–42; Willey and Sabloff 1974:189). The focus of these studies is on adaptive aspects of behavior, especially subsistence strategies and economics, in order to study functional relationships between humans and their environments (Barker 1985:19–25; Butzer 1971; Dunnell 1986; Hesse 1995; Wilkinson and Stevens 2003:249–52). Recent archaeological research often incorporates interdisciplinary studies of human behavior, cultural adaptations, cultural change, and environmental processes. Often, explicit hypotheses test general laws about the interactions among humans economies, technologies, and environments, and guide this research (e.g., Clarke 1968:32–42; Jochim 1981). Ecological principles form the basis of these hypotheses and are tested with empirical archaeological evidence. The combination of ecological anthropology, processual explanations, and cultural resource management (salvage or rescue archaeology) changed the role of archaeofaunal materials in the direction advocated by Taylor. A second trend in recent archaeological research
is the renewed interest in structural and ideological interpretations of human behavior and of animal remains.

Many zooarchaeological studies conducted after the mid-twentieth century are more analytical and anthropological than those that preceded them. Another consequence is a dramatic increase in the number of zooarchaeological studies. Two concepts that emerged in this period are particularly important for zooarchaeology. One is middle-range theory, which is based on observations of technology, subsistence, and settlement patterns in extant populations. The other uses ecological and economic models to examine strategic decisions in the acquisition and allocation of natural and social resources. These concepts share many ecological ideas (see Chapter 4) and are, in practice, not mutually exclusive. Biotic as well as abiotic data are central to such studies, and zooarchaeology has flourished under this paradigm.

_Middle-Range Theory_

Middle-range theory relies on empirical observations of the processes and principles responsible for the formation of the archaeological record in order to interpret,
even predict, efficient human behavior and human relationships with the environment (Bettinger 1991:61–2; Binford 1977:6; Evans 2003; Grayson 1986; Raab and Goodyear 1984; Wilkinson and Stevens 2003: 252–53). Understanding the impact of these processes is fundamental to exploring cultural behavior because it is necessary to discriminate between the consequences of human activities and those caused by other processes, for example, to distinguish between cultural and noncultural faunal assemblages (e.g., Thomas 1971). Behavioral archaeology (Schiffer 1976) and ethnoarchaeology (Gould 1978; Mutundu 2005) provide important contemporary observations that may be applied to understanding the development of archaeological sites. Some of these actualistic studies test models based on Binford’s (1980) distinction between highly mobile foragers and highly sedentary collectors as two ends of a continuum described by different combinations of settlement patterns and technologies.

Some of the most influential zooarchaeological studies published after 1960 developed from interest in site-formation processes with which middle-range theory is often equated (Bettinger 1991:77–82; Gifford-Gonzalez 1991; Kroll and Price 1991:310; Thomas 1986). This includes evaluations of sample sizes, methodologies, and taphonomy. Especially prominent is research into butchering and transportation decisions as these relate to the value placed on portions of an animal carcass and distances between kill/butchery sites and consumption sites (Figure 2.5; Thomas and Mayer 1983:Figure 188). These topics are not new to zooarchaeology (e.g., Wintemberg 1919), but they assume a more central role under this model.

**Game Theory and Optimal Foraging Models**

Game theory and optimality models facilitate study of the allocation of scarce resources in terms of costs and benefits (Clarke 1972; Jochim 1976:6–10, 1981:10–12). Cost might be time, effort, risk, or the energy expended. Benefits might be energy acquired, safety, or time saved. Linear programming is a mathematical modeling technique that permits researchers to play simulated economic games in which the best allocation of resources and the consequences of hypothetical choices can be evaluated (Coombs 1980; Keene 1981; Reidhead 1979). It can be used, for example, to identify a nutritionally satisfactory combination of foods or the role of labor minimization in subsistence decisions (e.g., Reidhead 1980). Game theories and optimality models provide the implicit, if not explicit, foundation of many zooarchaeological studies.

In game theory, decisions are based on budgets of resources, such as nutrients, prestige, raw materials, land, time, energy, or specialized knowledge. These decisions involve all aspects of behavior, including ones not directly related to food acquisition (Clarke 1968:43, 73, 85, 90; Earle and Christenson 1980). Decisions are patterned solutions that may have a variety of outcomes, such as reducing labor, maximizing acquisition...
of raw materials, or reducing risk (Clarke 1968:45–53, 1972). Clarke distinguishes between optimizer strategies and satisficer strategies. Optimizer strategies “try to get the best possible results given the conditions” (Clarke 1968:94). Satisficer strategies meet predetermined, but not optimal, levels. Satisficer strategies may be mixed or randomized. A prudent satisficer strategy “aims at maximizing the minimum outcome (maximin), or put another way, on minimizing the maximum risk (minimax)” (Clarke 1968:95).
Optimum foraging models characterize human diets based on the costs and benefits of search and pursuit (e.g., Ballbé 2005; Grayson and Delpech 1998; Hawkes and O’Connell 1981; Madsen and Schmitt 1998; Outram 2004; Perlman 1980; Smith and Winterhalder 1992; Thomas 1986; Wilkinson and Stevens 2003: 251–2; Winterhalder 1987; Winterhalder et al. 1988). Optimal foraging theorists argue that humans make rational decisions to maximize the net rate of energy captured, measured usually in calories, although other measures could be used (Bettinger 1991:84; Butler and Campbell 2004; Leech 2006; see also Jochim 1981:9–10). Optimal foraging encompasses topics such as dietary choices, scheduling of foraging activities, and decisions about settlement and foraging locations (e.g., Winterhalder 1981). One of the most well-known components of optimal foraging theory is diet breadth, which balances the abundance of resources, the amount of energy produced by each, the amount of energy needed to search for and pursue each, and the amount of time required to process each resource obtained against others. “Search time” is the time needed to find a species, and “pursuit time” is the time required to capture a single animal of that species once it is found. When search time is high, diet breadth may be high as well. However, when pursuit time is high, the response may be specialization in order to manage time spent (Winterhalder 1981). From the perspective of managing subsistence costs, a willingness to use a wide range of common, fairly immobile resources may substantially reduce the amount of time required to find and capture suitable ones. Patch choice, foraging time, central-place theory, resource constraints, and carrying capacity are additional important concepts incorporated into much of this research.

Another important group of theories focuses on site-catchment analysis, locational analysis, and other types of landscape or regional analysis (Figure 2.6; Bettinger 1991:66; Evans 2003; Gamble 1984; Higgs and Vita-Finzi 1972). This involves defining or predicting the areas or resources habitually exploited by inhabitants of a site. Gravity and central-place models are intrinsic to much of this research (Crumley 1979). The gravity model conceptualizes economic behavior between two centers, and the central-place model specifies behavior among centers on a regional scale (Crumley 1979). These are usually considered in terms of adaptive strategies and the distribution of energy or other resources based on least effort.

Important steps in site-catchment analysis include defining a site’s territory and classifying the encompassed resources in terms of spatial and temporal variables (Roper 1979). Seasonal and daily cycles have an impact on the distribution of resources in terms of time and space. These variables, in turn, influence the degree to which the residential pattern is mobile or sedentary. They may influence the development of economic exchanges with other communities and domestication of crops and animals. Therefore, periodicity in resource availability and schedules for their use are important components of territoriality. Differences in length of occupation, season of occupation, and the use of animals are related to site function. For this reason, it is important to
know if the site was a village, a residential base camp, or a specialized site, such as a hunt stand, burial ground, or shellfishing station.

**Social Interpretations of Human Behavior**

Because ecological and environmental studies emphasize functional and processual aspects of human behavior rather than social relationships or culture history, symbolic and structural interpretations have received less attention from zooarchaeologists and archaeologists alike (Leone and Potter 1988; Wilkinson and Stevens 2003:254–62). Nevertheless, human behavior is guided by political, religious, and other social objectives as well as by ecological and economic ones. Ideology, ritual, social identity, inequality, urbanization, colonialism, and other social mechanisms are important components of human behavior (e.g., Evans 2003; Hayden 2001). Evans (2003:6) argues that “work in
several animal groups is showing that much behaviour is about establishing, maintaining, and even opposing social relationships.” We can expect humans to express how they relate to each other and to their environments through animals and to manipulate their environments for social purposes. People are, after all, social animals living in a chemical, physical, and biological world.

The obvious symbolic and structural importance of animals cannot be ignored. Many theoretical developments, particularly those subsumed under the terms postprocessual or postmodern, emphasize the critical role animals play in the social life of human communities or examine human behavior in terms of native meaning (e.g., Hesse 1995; Hodder 1982, 1990; Miracle and Milner 2002; O’Day et al. 2004; Ryan and Crabtree 1995; Serjeantson 2000). Some of these studies are reactions to the reductionism or determinism implied when a culture is viewed solely as an adaptive strategy (Evans and O’Connor 2001:17, 217). Many aspects of the archaeological record can be attributed to social behavior, which is the fabric of the cultural filter (Reed 1963). These are among the critical phenomena that must be considered, along with environmental and ecological theory, nonhuman first-order changes, and second-order changes when evaluating evidence that will be used in applied contexts (Mulville 2005).

Heritage and Cultural Resource Management

Another important factor in the field of zooarchaeology after 1960 is the increase in heritage and cultural resource management projects and similar contract or salvage programs in many countries (Choyke 2004; Roskams 2001; Zeiler 2004). Frequently, these projects are brief, and data recovery is extremely limited. To develop competitive proposals with a theoretical basis, many contractors include subsistence, site function, seasonality, and economic studies in their research designs. To address such questions, environmental studies, including zooarchaeology, are needed. The funding made available by these projects contributed to a substantial growth in the field (e.g., Coy 1978, 1979). Although budgets and time schedules frequently do not permit thoughtful integration of zooarchaeological data with other findings about the site or region, the number of zooarchaeologists and the amount of research conducted expanded rapidly. This produced a vast amount of material, data, and literature for which arrangements for long-term curation must be made (Cram 2004; Lauwerier and de Vries 2004).

THREE FACETS OF MODERN ZOOARCHAEOLOGICAL RESEARCH

Zooarchaeology now embraces many research orientations. These can be roughly subdivided into methodological research, anthropological research, and biological
research – results in one informs research in the others. Some are traditional zooarchaeological interests with roots in earlier centuries; others represent recent developments either in zooarchaeology or in related fields. Most stem from one of the theoretical paradigms reviewed in this chapter. All are featured in greater detail in subsequent chapters.

**Methodological Research**

The increased demands made on faunal data for explanations resulted in extensive methodological research. In part owing to the presence of specialists in zooarchaeology, increased use of quantification techniques, and the rigor required by the scientific method, most zooarchaeologists are concerned about biases in faunal data. The debate over whether zoologists or archaeologists should study animal remains can be seen as an early concern about how to obtain reliable results while maximizing interpretive potential. Considerable research is directed toward understanding the consequences of the abiotic and biotic processes that contribute to first-order changes (e.g., Lyman 1994c; Peacocke et al. 2005). Second-order changes associated with excavation decisions and identification procedures are widely studied (e.g., Halstead et al. 2002; Outram 2001; Payne 1972b). Many faunal studies are highly quantitative and the numerous analytical methods must be evaluated (e.g., Grayson 1984; Jones 2004; Lyman 2003).

**Anthropological Research**

An increase in theoretical studies of the relationship between humans and animals is characteristic of recent zooarchaeological research (e.g., Byers et al. 2005). Much of this focuses on the causes for continuity and change in ecological and economic aspects of human behavior. Subsistence and economic research requires study of both the biological needs that diets meet and the strategies by which humans procure dietary components.

The biological aspects of subsistence include human nutritional requirements as well as the nutritional contributions of specific taxa. Human nutrition is more often studied by biological anthropologists, who examine human skeletal remains for evidence of nutritional diseases, demographic variables, and subsistence activities (e.g., Larsen 1997; White and Folkens 2005). Many zooarchaeologists use biochemical analysis of isotopic ratios and trace elements to study diets (e.g., Newsome et al. 2004). Some researchers study the nutritional value of specific taxa and translate meat weights and nutritional values into estimates of dietary contributions (e.g., Barrett 1993; De Negris and Mengoni Doñalons 2005; Parmalee and Klippel 1974).
Subsistence strategies are the target of much research. Subsistence strategies encompass procurement decisions and technologies; economic, political, and social institutions; and ritual activities. These studies include efforts to identify general subsistence patterns (e.g., Anderson 1988; Cachel 2000; Hoffecker et al. 1991; Loponte and Acosta 2004; Koike and Ohtaishi 1987; Plug 1987b); settlement patterns and catchment areas (e.g., Davidson 1983; Mengoni 1986; Mondini et al. 2004); and seasonal characteristics based on growth structures and age at death (e.g., Brewer 1987; Higham and Horn 2000; Landon 1993; Tomé and Vigne 2003). Many of these studies consider more than one aspect of subsistence and may use predictive models, such as niche breadth, energy flow, and foraging theory (e.g., Outram 2004; Tchernov 1992a, 1992b). Studies of subsistence technologies are common, especially of animal remains modified into tools, capture techniques, and butchering methods (e.g., Choyke 1987; Noe-Nygaard 1989; Olsen 1987; Rabett 2004; Yerkes 2005). Many of these rely on actualistic studies (e.g., Ioannidou 2003b), geochemical applications (e.g., Pechenkina et al. 2005), and archaeogenetics (e.g., Troy et al. 2001).

Exchange networks, political organization, kinship systems, and belief systems are studied in the context of subsistence systems or in their own right (e.g., Arndt et al. 2003; Miracle and Milner 2002). Such studies may consider trade both as a component of economic and political affairs and as a source of animal products (e.g., Barker 1987; Bowen 1992; Maltby 1994; Rowley-Convoy 2000). Social status and ethnic identity are additional active research avenues (e.g., Crabtree 1990; Lev-Tov 2004; Scott 2007). Humans associate food and animals with important symbolic attributes, and concepts of animals and the natural world reflect symbolic or structural relationships (e.g., Altuna 1983; Cooke 2004; Lauwerier 1993a; Levy 1995; Minic and Smith 1989).

Much zooarchaeological research involves the origin, spread, and health of domestic animals (e.g., Benecke 1987; Copley et al. 2004; Davies et al. 2005; Higgs and Jarman 1972; Renfrew 2000; Stahl and Norton 1987; Voigt 1987). These studies include the history of domestication, systematic research into the origin and development of domestic animals, the use of these by humans, and comparative studies of wild and domestic forms. Animal domestication in the context of emerging agricultural systems, complex societies, and urbanization is an important research avenue. Much of this work is informed by archaeogenetics (e.g, Bradley 2000; Zeder, Bradley, Emshwiller, and Smith 2006; Zeder, Emshwiller, Smith, and Bradley 2006).

**Biological Research**

Although the growth in zooarchaeological research reflects increased archaeological interest in anthropological explanations, biological aspects of archaeofaunal remains continue to be important. Biological research is a fundamental aspect of the
domestication of animals and the history of economically important breeds, especially where archaeogenetics and zooarchaeology are combined. Faunal remains offer information about paleoenvironmental conditions and characteristics of nonhuman populations (e.g., Avery 1987; Bobrowsky and Gatus 1984; Bocherens et al. 2000; Haynes 1987). One source of this information is obtained from the morphology of the species involved (e.g., Avery 2004; Hernández et al. 1993; Iregren 1988). Evidence for the size, weight, and health of the animals in a region indicates the conditions under which animals lived (e.g., Luff and Bailey 2000). Alterations in morphological features suggest environmental change, overexploitation, or domestication. Contributions in zoogeography and animal diversity demonstrate the association of humans with extinct fauna and elaborate on range extensions and/or contractions (e.g., Anderson 1989; Graham et al. 1981; Lauwerier and Zeiler 2001; Patton 2000; Steadman 1995). In many cases, changes in biological aspects of animals in archaeological sites indicate environmental changes so that zooarchaeology contributes to historical ecology, conservation, and natural resource management (e.g., Andrus et al. 2002b; Driver and Hobson 1992; Kislev et al. 2004; Langemann 2004; Lyman 1996; Mulville 2005; Plug and Lauwerier 2004).

CONCLUSIONS

Smith (1976) argues that zooarchaeology suffers from what Leone (1972) called “paradigm lag.” While one group engages in ecological research, a second group “twitches off” to compile descriptive species lists. A third group pursues biological research. The first two groups trace their roots to the fundamental difference between two anthropological concepts about the human–environment relationship: environmental possibilism and ecological anthropology. Archaeologists interested in descriptive or chronological questions still operate under the constructs of environmental possibilism. This influence is evident in discussions where environmental aspects of the archaeological record are but a thin cover for a basically descriptive study. In such reports, faunal remains are just one more thing to list. When associated with projects uncommitted to ecological studies, zooarchaeologists persist in producing laundry lists (Clark 1972:i). This deficiency cannot be attributed solely to qualitative or quantitative problems but rather to a continuing interest in descriptive cultural history on the part of many archaeologists. There is no particular reason why studies of cultural history, behavioral adaptations, and social meaning are in opposition. As a holistic discipline, anthropologists should recognize that these are all part of the fabric of human life. Human behavior is inherently flexible and subject to temporal and spatial variations reflecting both the natural and social environment. However, rarely are good zooarchaeological studies associated with highly focused cultural chronologies or studies of social relationships,
perhaps because archaeologists with such interests fail to communicate adequately with
zooarchaeologists or to involve a zooarchaeologist at all. This is exacerbated by the
overpowering influence of cultural resource management on field work. Animal remains
recovered during small test excavations at a few sites along the route of a proposed high-
way that are summarily described, studied by an untrained member of the laboratory
staff, included in reports printed in limited numbers, and filed do not contribute to
sophisticated ecosystem, economic, or social analyses.

Significant research requires a long-term commitment to time-consuming data col-
lection on a regional and interregional basis combined with truly collaborative research.
To understand the use of resources by human populations and the common threads
underlying the diverse adaptations made to different environments, it is necessary to
integrate data from a number of different sources. These include botanical remains,
human remains, vertebrate and invertebrate fauna, as well as physical and chemical
properties of biological materials and the soils in which they are found. Social and histor-
ical interpretations, in particular, require that the archaeological context be thoroughly
explained to the zooarchaeological staff. Only through integration of archaeological,
biological, ethnographic, and geological data can we understand the human past. All
parties must take the time to look at their data from a variety of perspectives and share
their insights freely with collaborating scholars. In such a context, zooarchaeologists
engage in meaningful anthropological and ecological research.

A background in the history of anthropological theory and the development of
zooarchaeology is important because these are reflected in current zooarchaeologi-
cal research. Zooarchaeology’s role in archaeology and the questions zooarchaeologists
address reflect shifts in prevailing theoretical perspectives. Many of today’s philosophi-
cal and methodological debates are best understood from a historical perspective. Some
methods, originally developed in the context of questions that are not popular today,
have new applications. Some questions require the development of new techniques. In
other cases, both the questions and the methods have endured. In subsequent chapters,
these topics are revisited; beginning with the biological and ecological foundations of
modern zooarchaeology.