Journal for Nature Conservation **15** (2007) 163—173

Available online at www.sciencedirect.com
ScienceDirect

Journal for Nature Conservation

www.elsevier.de/jnc

Sustainable use of wildlife: The view from archaeozoology

J. Frazier*

Conservation and Research Center, National Zoological Park, Smithsonian Institution, 1500 Remount Road, Front Royal, VA 22630, USA

KEYWORDS
Archaeology;
Collaboration;
Conservation;
Interdisciplinary;
Integration;
Interpretation;
Multidisciplinary;
Zooarchaeology

Summary

The concept of "sustainable use" is a polemic, especially when referring to wildlife and other "natural resources." Claims vary from persistent overuse to traditional practices of sustaining the resource base. Arguments for either side routinely draw from contemporary situations, relying on relatively short time periods. But, if the notion "sustainable" is to be consequential, the period under consideration must be meaningful – claims that trends over a few years or even decades are representative of long-term phenomena are questionable, for they depend on numerous untested, if not untestable, assumptions. Research in anthropology, biology, biological conservation, ecology, policy, restoration ecology, social development, and wildlife management is routinely constrained to relatively short time periods, and such results are of limited value for evaluating sustainable use. Archaeozoology provides unique tools for investigating trends in human-resource relations over periods of centuries and millennia; it is one of the few disciplines explicitly dedicated to the study of material evidence over significant time periods that bears directly on the question of sustainable use. Hence, objective, scientific evaluation of sustainable use must contemplate archaeozoological evidence.

Yet, archaeozoology often does not provide definitive answers: it is wrought with fundamental problems in sampling, data gathering, analysis, and interpretation (e.g., varying screen sizes; meta-sampling procedures; comparisons across diverse spatial, temporal, and environmental continua; etc.). Typically data must be evaluated through inference, rather than through direct observations and experiments. Moreover, environmental variation (e.g., climate change, sea level change, tectonic movement, etc.), as well as changes in societies, confounds the interpretation of long-term human–environmental trends. But, those challenges are not unique to archaeozoology, for biological and ecological phenomena are no less subject to multiple sources of environmental and social variation. The difference is that archaeologists are patently cognizant of these sources of variability, and they openly debate them when interpreting data, while in other disciplines these sources of change are routinely ignored. Nonetheless, despite the

*Tel.: +1 540 635 6564; fax: +1 540 635 6551.
E-mail addresses: kurma@shentel.net, frazierja@si.edu (J. Frazier).

doi:10.1016/j.jnc.2007.08.001

unique relevance of their work, few archaeozoologists have ventured outside their discipline to engage natural scientists and policy makers in issues of biological conservation and wildlife biology, and particularly the root questions of sustainable use. In addition to considering data and hypotheses regarding long-term prehistoric human–wildlife interactions, it is essential to view this information within broader perspectives, linked to other disciplines as well as to contemporary social and policy issues. Because sustainable use is mandated in international instruments and national policies, the notion has relevance in arenas far beyond academia, where archaeozoologists must be integrated into interdisciplinary teams.

Introduction – Why a Special Issue on sustainable use and archaeozoology?

Initiatives to understand and mitigate unwanted impacts that *Homo sapiens* make on the environment are as varied and ancient as human societies (Grove, 1995; Heizer, 1955). Expressions such as "biological conservation," "conservation," "ecosystem management," "ecological/environmental restoration," "nature conservation," and "wildlife management" convey complimentary aspects of structured, disciplinary approaches to ameliorate human-environmental concerns. While there is overlap and ambiguity in the conceptual and operational limits of these various disciplines and sub-disciplines, a central objective for all of them is to promote the long-term availability of resources for human benefit. The resources in question can range from inanimate, non-renewable substances, to living organisms that are potentially renewable for indefinite periods. They can be subjected to diverse forms of utilisation, spanning directed exploitation and intentional removal from the environment (e.g., killing) to benign types of use, such as observation and investigation, or emotional and spiritual enrichment, in which the object involved is intentionally left undisturbed in its "native habitat;" these two extremes are commonly categorised as "consumptive use" and "non-consumptive use," respectively – although the former is most usually assumed. Independent of the social and environmental conditions involved, or which type of use is implicated, a central tenant of conservation is that utilisation be at a level that permits it to be maintained, or sustained, indefinitely.

Hence, "sustainable use" has become a much-lauded principle, with enormous political ramifications. It has been championed in various international conventions, such as the 1983 UN World Commission on Environment and Development[1] (WCED, 1987, p. 348); Agenda 21 of the 1992 United Nations Conference on Environment and Development[2] details the concept of sustainable use in Chapter 15 (Conservation of Biological Diversity); and the 2002 United Nations World Summit on Sustainable Development[3] also makes repeated mention of the term (UNDESA-DSA, 2002). Sustainable use is enunciated and codified in international law, national legislation, and countless policy statements of diverse organisations. For example, international treaties under the United Nations, such as the Convention on Biological Diversity (CBD) explicitly *mandate* sustainable use of biological diversity (CBD Article 10). Sustainable use is sponsored in statements of the Secretary-General of the United Nations (Ki-Moon, 2007); and organisations such as the Food and Agriculture Organisation of the United Nations actively promote the concept (FAO, 2007; Sombroek & Sims, 1995), while the World Conservation Union (IUCN) – which also has global impacts on perceptions, policies, and political positions related to resource use and management – has specialist groups, policy statements, and publications that promote sustainable use (e.g., Christoffersen, Campbell, & du Toit, 1998; IUCN, n.d.).

Like many terms that acquire extra layers of relevance, particularly in economic, political, and social arenas, sustainable use has become a much used (and abused) mantra that routinely evades clear definition and objective evaluation. Basic concerns go far beyond the obvious question: What is to be used? Complex socio-political and economic riddles include: Who will partake of the use? Who will be advantaged by the use, and who will be disadvantaged? The responses to these simple, but habitually ignored, questions depend on unending debates about intertwined cultural, economic, political, and social values and priorities. Similar concerns have been raised in regard to the sister

[1]Also known as WCED or the Brundtland Commission.

[2]Also known as UNCED or Rio Summit.

[3]Also known as WSSD or Johannesburg Summit.

expression "sustainable development" (Frazier, 1997); and while these issues are outside the scope of both this article and the Special Issue, it is important to keep them in mind.

Leaving aside the complex socio-political issues, there is an apparently simpler question that is fundamental to the concept of sustainable use: How does one identify when use is sustainable? Common attempts to define or explain the concept offer general platitudes stating that the resource(s) in question should be available "in perpetuity," "for future generations," and other expressions that indicate that temporal considerations have no limits. This basis on infinity and timelessness may serve political means, but it does not facilitate an operational definition: not to mention the underlying assumption that environmental and social conditions will remain constant while the resource in question is utilised, and time flows on endlessly.

An unspoken conceptual dilemma is the persistent disjunction between theory and practice in the design, implementation, and interpretation of investigations in the natural as well as social sciences. Despite the fact that the life sciences are unified under the theory of organic evolution – which implicates time spans of hundreds of thousands of years or more – modern ecology is founded on a corpus of research that is not only spatially but also temporally limited; ecological theory has been based on studies that rarely involve more than 10 m^2 in area and 10 years in duration (May, 1994). Indeed, numerous authors, from various disciplines, have explained – lamented – that ecologists and conservation biologists routinely base their conclusions and recommendations on short-term evidence, and ignore information from historic and prehistoric sources of human–environmental interactions, even though long-term information is essential to understanding ecological complexities, and designing realistic conservation initiatives (e.g., Bayliss-Smith, Hviding, & Whitmore, 2003; Bowman, 1998; Briggs et al., 2006; Butzer, 1996; Lyman, 2006a; Roosevelt, 1995, 2000; van der Leeuw & Redman, 2002).

As these and numerous other authors explain, in many parts of the planet, environmental features – soil, water courses, vegetation, wildlife, landscapes – are legacies of previous conditions modified by past human activities. In other words, the structure and function of many contemporary ecosystems have been shaped by humans during earlier – prehistoric and historic – times (e.g., Balée, 1989; Blackburn & Anderson, 1993; Bottema, Entjes-Nieborg, & van Zeist, 1990; Bowman, 2002; Chapman, Delcourt, & Delcourt, 1989; Collins et al., 2000; Cronon, 1983, 1996; Day, 1953; Delcourt & Delecourt, 2004; Denevan, 1992, 1996; Heizer, 1955; Hoffmann, 1996; Roosevelt, 1999, 2000; Roosevelt et al., 1996; Russell-Smith, Ryan, Klessa, Waight, & Harwood, 1998; Stahl, 1996; van Gemerden, Olff, Parren, & Bongers, 2003).

Significant human impacts on the environment have been documented from the Neolithic, some seven millennia ago (Köhler-Rollefson & Rollefson, 1990), and may date even farther back to the Paleolithic (Heizer, 1955; van der Leeuw, 1998). Ancient human perturbations on the environment are found on all continents and many islands (Butzer, 1996; Gilson & Willis, 2004; Mann, 2006); and prehistoric human impacts may include such actions as intentional forest management as early as 4000 BC (Stevenson & Harrison, 1992). While evidence from terrestrial settings is far easier to obtain and interpret, various prehistoric anthropogenic impacts on marine environments are documented (Jackson, 2001; Jackson et al., 2001). Relatively low density human populations can leave substantive environmental legacies on vast areas (Briggs et al., 2006; Fish, Fish, & Madesen, 2006), including the distributions of living organisms (Gómez-Pompa & Kaus, 1990; Heckenberger et al., 2003). Hence, while these large-scale environmental impacts are outside the scope of this Special Issue, they must be kept in mind when interpreting prehistoric – as well as contemporary – information on the abundance and distribution of wildlife: prehistoric animals had to live in these ancient environments, and adapt to conditions and variations that occurred therein, often with alterations to their geographic distributions, abundance, and survival.

On the other hand, the economic and political realities of short-term funding cycles, pressures to publish or perish, and other "real world" factors not usually contemplated in the development of ecological investigation and theory result in the operational horizon of most ecologists and conservationists being limited to periods of a decade or less. Hence, it is usual for a period of a generation or two to be considered as long-term; and the understanding of sustainable use is tinted by these implicit temporal perceptions. While archaeology, including archaeozoology (or zooarchaeology), is also subject to socio-political and economic limitations, the publish-or-perish syndrome, and other "real life" conundrums, this discipline stands apart. By the very nature of their research paradigm archaeologists must contemplate time periods of hundreds and thousands of years: "deep time." The data must be interpreted with careful consideration of an enormous diversity of environmental and social variables. Hence, while archaeozoologists may not flavour their writings with liberal reference to sustainable use or nature conservation, they constantly investigate questions about human interactions with the environment, particularly the resources that were exploited by prehistoric societies. It is this unwavering disciplinary position that makes archaeozoology invaluable for both understanding and resolving fundamental questions about sustainable use: a central pillar in conservation biology, nature conservation, wildlife management, and other related fields. "The sub-discipline of archaeology is in a unique position to contribute to modern management policies that will ultimately determine the nature of our planet's future environments" (Broughton, 1997, p. 859).

Previous initiatives to integrate archaeozoology with ecology and conservation biology

The understanding of human–animal interactions is embedded within broader issues of human–environmental interactions, as well as basic beliefs about the place of humans in the world; and these epistemological frameworks vary according to the times. For example, in the mid 19th century Marsh broke with tradition and argued that humans, around the world, actively modify various components of the environment, including soil, vegetation, wildlife, landscape, and geography of the planet; hence, he challenged the commonly accepted view that people were simple witnesses to environmental change (Marsh, 1864). By the late 19th century numerous other scholars provided evidence from various parts of the world, showing that prehistoric peoples have been significant ecological agents in diverse environments (Heizer, 1955); and by the early and mid 20th century several ecologists emphasised the need for greater attention to prehistoric data, explaining the importance of past human actions on ecological processes (Adams, 1935; Day, 1953). Particular importance has been given to botanical evidence that pre-Columbian peoples impacted, or actively managed, tropical forests, and as a result, the structure and composition of contemporary forests are the result of many generations of human activity (e.g., Delcourt & Delecourt, 2004; Gómez-Pompa & Kaus, 1990; Heizer, 1955). For decades, specialists in the social sciences, particularly archaeology, have explained the fundamental importance of studying past human practices to understand modern resource exploitation and conservation (e.g., Minnis & Elisens, 2000; Orlove & Brush, 1996). Nonetheless, as a rule ecologists and conservationists have ignored the importance and prevalence of human action (Bayliss-Smith et al., 2003), and much contemporary "understanding" of "nature" and ecological processes is based on myths that derive from cultural views of European colonists who came to the western hemisphere in past centuries (e.g., Bowden, 1992; Denevan, 1992; Dods, 2002; Nash, 2001; Roosevelt, 1995).

Over the past two decades several archaeologists have made concerted efforts to explain why information from prehistoric times is basic to ecology and conservation biology, calling for greater integration between these disciplines. For example, archaeozoologists have edited books that directly address this need, such as *The Future from the Past: Archaeozoology in Wildlife Conservation and Heritage Management* (Lauwerier & Plug, 2004) and *Zooarchaeology and Conservation Biology* (Lyman & Cannon, 2004). Some, such as Grayson and Lyman, have actively nurtured inter-disciplinary bridges by publishing numerous papers in scientific journals directed at ecologists, conservation biologists, and wildlife managers (e.g., Grayson, 1967, 2001, 2005, 2006; Grayson & Delpech, 2005; Lyman, 1996, 2006b, 2006c; Lyman & Wolverton, 2002; Wroe, Field, & Grayson, 2006). Others have developed complimentary arguments, again publishing in disciplinary books and journals of natural scientists (e.g., Blondel & Vigne, 1993; Briggs et al., 2006; Willis & Birks, 2006).

Several scholars have shown that simplistic explanations of the environment that ignore information from past eras – and particularly the effects of humans – are flawed. They explain this lack of communication and integration on erroneous theoretical constructs, romantic assumptions of untested hypotheses, and also political influences within the scientific establishment (Roosevelt, 1989, 1995). For example, there is ample evidence that prehistoric peoples affected the spatial occurrence of certain species of animals, including turtles, frogs, ungulates, and birds, through hunting and/or habitat alterations (e.g., Adler, 1970; Beebee et al., 2005; Grayson, 2005; Grayson & Delpech, 2003; Lyman, 2003; Paxinos et al., 2002). In addition to population declines and extinctions of wildlife that are related to human agency, there is evidence of introductions of not only domestic species and cultivars, but also "non-domesticated," free-ranging animals (e.g., Barnes, Matisoo-Smith, & Hunt, 2006; Blondel & Vigne, 1993; Haeming, 1979). This includes human induced diminution of body size through introductions of individuals of smaller subspecies (Lyman, 2006b), as well as breeding and hybridisation of animals during prehistoric and ancient times that has resulted in geographic, altitudinal, climatic and habitat distributions of certain species being extended significantly (Potts, 2004). On the other hand, there are cases where prehistoric human introduction has been suggested as the explanation of an anomalous distribution, but then rejected after archaeological evaluation (Gompper, Petrites, & Lyman, 2006).

Although the attempt to excise *Homo sapiens* from the picture has dominated natural science research, it is becoming ever clearer that this position is academically and politically untenable. The realisation that urban areas – ever larger in today's world – have enormous effects well outside the city limits has resulted in renewed calls to engage ecological theory to understand human activities and urban ecology (Collins et al., 2000), thus heeding the arguments of ecologists of nearly a century ago. Special issues of professional journals directed at natural scientists have also made clear the undeniable fact that *Homo sapiens* have major impacts on ecosystems, and resource bases around the world. For example, volume 277, no. 5325 (25 July 1997) of *Science* focused on "Human-Dominated Ecosystems," and volume 39, no. 3 (May 2007) of *Biotropica* had a special section on "Pervasive consequences of hunting for Tropical Forests." These, and many other, professional writings show why ecology and conservation biology must take into account humans and their actions, both past and present.

Articles in this Special Issue

Many different agents (physical, chemical, biological and cultural) can act on archaeozoological specimens between the time that the animals are captured and removed from their "natural environment," to when the remains are deposited in the ground, and finally recovered by the archaeologist; and these taphonomic considerations present serious challenges to data interpretation. The simplest index of sustainable use is the continual availability of the resource in question. However, for a variety of reasons, ranging from taphonomic effects to research protocols, archaeozoological studies are not amenable to evaluations of absolute numbers of animals taken by prehistoric peoples; and even measures of relative abundance must be interpreted with caution (e.g., Grayson, 1981, 1984; Lyman, 1984; O'Connor, 1996). Hence, other indicators of long-term availability and the status of the exploited populations are needed to provide a more enlightened understanding of the question of sustainable use. For example, demographic trends in prey populations (such as relative age and/or sex ratios) are more sensitive indicators of the status of the population than just abundance indicators.

As is routine in archaeozoology, each of the authors in this Special Issue had to deal with numerous inherent obstacles, beginning with the recovery and identification of prehistoric animal remains. In numerous cases it was only possible to reach the taxonomic level of genus, and occasionally only family. Once the remains were identified other challenges had to be dealt with, particularly in regards to data interpretation. In this light it is relevant that each author in this Special Issue has employed different approaches for exploring the question of sustained consumptive use of the wildlife resources at the respective sites where they worked, and all four authors have developed arguments that take into account different ecological and cultural concepts relevant to the question of maintaining levels of population abundance and replenishment.

Jeffrey Blick reports on two archaeological sites at San Salvador Island, Bahamas, from about AD 950 to 1500 (Blick, 2007). Fine-meshed screens allowed recovery of remains of land crabs, intertidal mollusks, and coral reef fishes, including pharyngeal grinding mills and atlases of fishes, which in turn enabled detailed measurements and analysis of fish body sizes over time. Several lines of evidence indicate that over a period of about 500 years, these invertebrates and fishes became less abundant, and at one site the declining trends in body sizes of fishes indicated growth overfishing, a symptom of over exploitation. Measures of weight and also number of identified specimens (NISP) show significant declines over time for land crabs and mollusks. Boney elements (indicators of body size) decrease in size over time in both serranid and scarid fishes, significantly in the case of the later. Species richness, as well as average trophic level of the vertebrate faunal remains also decreased over time. The interpretation of these results depends on the environmental and social conditions that operated over the period since the faunal remains were deposited, and Blick summarises some of the more important assumptions, arguing that there is no evidence that changes in environmental or social variables were responsible for the decreasing trends in ***all*** of the various measures of resource availability. The multi-pronged results from this study, consistent with other zooarchaeological investigations on other Caribbean islands, indicate not only that there was over-exploitation of marine and coastal resources, but that even relatively small pre-Columbian human populations, estimated to have been between 500 and 1000 people, were capable of affecting abundance and population structure of prey species in a period that represents less than two dozen human generations.

Kitty Emery uses the theory of optimum foraging strategy to evaluate samples from 25 Maya sites in Guatemala and Mexico, spanning some 3500 years (Emery, 2007). The theory, which postulates that predators select prey on the basis of hunting efficiency and nutritional profitability – the larger the body size of the prey the more food obtained per unit of effort – provides archaeozoologists with an innovative way to evaluate the imperfect information with which they are obliged to work. Emery included data from sites only if they met specific criteria such as sample size and veracity of taxonomic identifications, thus reducing problems from sample biases. Two ratios were calculated and evaluated, based on the largest bodied prey items most commonly taken by prehistoric Maya hunters: the proportion of all large mammals in relation to all vertebrate species and the proportion of just *Odocoileus virginianus* (Zimmermann 1780), white-tailed deer, in relation to all vertebrates. Although *O. virginianus* was among the most widespread and abundant species identified, and large game mammals were common in all deposits, there are no trends in the proportions of these preferred prey that are consistent over time. Rather, the relative proportions of large prey provide evidence for both reduction and recuperation of prey populations during different periods: changes that relate to varying social and environmental conditions. All large game, as well as just *O. virginianus*, had statistically higher proportions during the Late Classic Period (AD 600–850) than during the Terminal/Postclassic Periods (AD 850–1519). Remarkably, the earlier period is characterised by greatest human population density, political activity, social stratification and demands by elites, and increased deforestation and soil erosion, as well as climatic stability, while the two later periods were a time of dispersed human populations, reduced social and political complexity, and extended droughts. The study shows that there is no evidence that the collapse in the Classic Maya civilisation was related to depressed prey populations, and also that there is no simple unifying paradigm to explain more than three millennia of hunting by the Maya.

Michael Etnier looks further at sources of complexity and compares tendencies in pinniped remains between two sites, from two different periods on the eastern North Pacific coast, from the 11th to the 18th century AD and from about 300 BC to AD 350, respectively (Etnier, 2007). Although six pinniped species occurred in both sites during the period of study, the vast majority of the archaeological remains were of *Callorhinus ursinus* (Linnaeus 1758), the northern fur seal. By analysing age and sex of the remains, Etnier was able to evaluate the demographic characteristics of prey that were recovered from the archaeological site, and in that way understand what segments of the population had been subjected to intense exploitation. This allows a more detailed understanding of the predation pressures, and over time these data provide an invaluable indicator of how the prey population responded. At Ozette, the younger site, relative abundance of *C. ursinus* did not show significant variation for about 500 years, and then in the last period there is a decline in pup remains. Since this age group is restricted to breeding colonies, the observation indicates that about the time of European contact overexploitation in breeding colonies occurred rapidly. However, a trend in increasing median age, accompanied by a decrease in the proportion of young animals, indicates that there may have been ever increasing pressure on the breeding colony over the entire period of study. In contrast, at the older site, Moss Landing, the breeding colony was evidently extirpated more than 2000 years ago. The majority of remains from this site were from young of the year. Etnier found no clear relationships between environmental variables and the trends at the two sites. His conclusion is that prehistoric human predation on breeding colonies is the most likely cause for the apparent decline at both sites, and he emphasises the importance of evaluating data on demographic characteristics as well as relative abundance.

Iain McKechnie (2007) reports on Ts'ishaa, an ancient village off western Vancouver Island, Canada, that was occupied for five millennia, illustrating that among the many sources of complexity there can also be substantive differences between different areas within the same village site. Ts'ishaa has a detailed ethnographic history, including traditional leadership structure and resource management practices, as well as the locations of households occupied by intergenerational lineages. These details provide an invaluable context for interpreting the rich prehistoric faunal assemblage recovered from midden deposits which are as much as 3.7 m deep and spread over 300 m of shoreline. Faunal remains excavated from three separate locations dating to between 1800 and 250 years ago were dominated by fish bones, particularly *Sebastes* spp., rockfish, long lived, non-migratory species that are particularly abundant throughout the deposits. Various measures were used to estimate *Sebastes* abundance; and body length was estimated on the basis of detailed measurements of skeletal elements. Indices of ubiquity, density, and relative abundance all show that *Sebastes* was the most commonly exploited fish in all areas of the village. In the oldest area, the relative abundance and density of these near shore fishes declined, while estimated body size also showed a significant decrease over time. In contrast, two other areas of the village less than 100 m away show no evidence of significant decrease in relative abundance of *Sebastes*, nor a significant decrease in body size, with one area showing a significant ***increase*** in body size. McKechnie argues that these contrasting trends reflect different prehistoric fishing practices that can be linked to family lineage-based fishing territories and the concept of traditional ecological knowledge (TEK). In comparing the exploited size distribution between ancient and modern fish, McKechnie notes the ecological justification in targeting smaller sized *Sebastes* which have less reproductive output than older mature females which are the target of modern commercial and sport fisheries. He argues that examining archaeofaunal collections provides a way to rediscover ancient fishing practices and implement more effective fisheries management programs today.

Conclusions

It is a major challenge to be able to prove that human predation caused changes in prey populations; the condition, abundance, and even the presence/absence of prehistoric faunal remains can be affected by many agents other than humans. An understanding of environmental factors that operated during the period under investigation is essential; and among these, climatic change is of particular importance. Climatic variations can occur over tremendous temporal and spatial scales, such as 100,000-year (or 41,000-year or 22,000-year) cycles due to orbital variation of the planet; they include such well-known phenomena as ice ages, periodic global events like El Niño-Southern Oscillation (ENSO), droughts, floods, tectonic activity, eustatic sea level change, volcanic ash, plagues, and much more (Ruddiman, 2005). Clearly, the consideration of climate change in the investigation of faunal remains is fundamental (Wroe et al., 2006).

Other confounding factors are those in the social realm; in addition to – often coupled with – variability in environmental conditions, social and cultural contexts also transform. Human societies change through the technologies they employ, hunting/fishing methods, agricultural and husbandry practices, eating habits, trade activities, and many other socially dependent factors. Even archaeological sampling procedures may introduce sources of bias because of social complexities. For example, excavations associated with elite sectors of society (say, close to monumental structures) are likely to yield very different results from excavations at non-elite locations, even at the same general site and chronological period. Moreover, animals and their parts are used by humans for more than just food (i.e., predators – especially humans – do not invariably maximise prey size); non-nutritional values which are associated with different animal species and parts, for different reasons, can have profound effects on which animals are captured and what is done with their remains (Bliege Bird, Smith, & Bird, 2001; Holt, 1996). Hence, while theoretical approaches, such as optimum foraging strategy, provide valuable analytical tools, they must be scrutinised within the complexities of human societies.

Even if the effects of human and non-human agents can be separated, it is a major challenge to be able to prove that human predation *per se* was the primary cause of changes in prey populations. Human activities often involve major perturbations to numerous environmental features, including soil, water courses, sedimentation, vegetation, flora, fauna, and even local climatic conditions (see discussion above); and all of these can have profound effects on fauna. To these difficulties must be added the problems of confused concepts and terms often used by archaeozoologists (Butler & Campbell, 2004).

For these reasons, while each contributing author in this Special Issue was free to explore the question of archaeozoology and sustainable use in the way he or she felt most appropriate, this Guest Editor insisted that each paper include a discussion of the most important assumptions that were being made. Of course, archaeozoology is not alone in having to deal with multifarious assumptions: biology, ecology, and especially conservation biology, are replete with assumptions, many of them unspoken, if not ignored. What distinguishes archaeozoology is that by the very nature of its epistemological foundation it must scrutinise sources of temporal variability. Investigations of human–environmental relations from societies that have occupied an area for centuries, or as many as five millennia, have a temporal relevance that cannot be achieved with contemporary projects guided by funding cycles of less than a decade and publish-or-perish approaches.

The studies presented in this Special Issue bear directly on fundamental questions about sustainable use; they inform us about past human interactions with the resource base, and illuminate the concept of human carrying capacity in prehistoric times. The question of carrying capacity, or footprint, is relevant to both small populations, such as El Salvador, Bahamas, that may have been little more than 500 people, as well as to large, complex societies of millions of people, actively involved in tribute and regional trade, such as the Maya. There is often an implicit assumption that relatively small human populations have few substantive impacts on their environment – but this needs to be viewed on a case-by-case basis. On the other side, there is a growing trend in several disciplines, particularly archaeozoology, to claim that prehistoric humans – just like modern, highly technified, globalised societies – inevitably depleted wildlife populations and left significant impacts on their environments. Yet, here again the studies presented in this Special Issue show that such generalities must be treated with caution.

Despite the ever-mounting evidence that prehistoric societies overexploited their prey populations, the studies in this Special Issue, each of which involved the analysis of tens of thousands of archaeozoological remains, show that there were no species extinctions after centuries or millennia of exploitation. A debate on the cause(s) of the Pleistocene extinctions of large animals has been ongoing since the 19th century (Grayson, 1967); and since the late 1960s it has grown almost passionate at times (Delcourt & Delecourt, 2004; Grayson, 2006). The intense interest in extinction is expected, for this process represents a clear and dramatic termination: the end of a species. However, the studies presented in this Special Issue clearly show that evaluations of sustainable use must be much more sensitive and subtle: populations of a species may continue to exist, but with depressed levels of abundance, with reduced/modified geographic distributions, or with smaller average body sizes.

The value of integrating archaeozoological information in conservation research, planning, and implementation is clear, just as there is a clear need to include historic, ethnographic, anthropological information. However, defeating the "sociology of scholarship" to meet "epistemological needs of research" is a constant challenge (Roosevelt, 1994, p. 22). The studies presented in this Special Issue show that generalities about sustainable use must be treated with caution, for there may be profound differences between periods, sites, and even between different areas within the same site. Claims about the presence or absence of sustainable use must be carefully scrutinised for more than just academic reasons: "vague, speculative palaeocological arguments can be used for mischievous political purposes in the intense ongoing debates about the conservation and development of ... natural resources" (Bowman, 1998, p. 404). The collapse of the classic Maya culture has served as a dire warning to modern societies of the consequences of overexploiting natural resources: while the warning is certainly valid, the example may not be.

Acknowledgements

Three of the following papers in this Special Issue were presented at the 2006 Mexico City Conference of the International Council for Archaeozoology, and two of them were part of the symposium on "Archaeozoolgy and Sustainable use" which was part of the Conference, organised by this author: thanks to the organisers and participants in the conference and especially the participants in the symposium for their contributions in the discussions which nurtured this publication. Numerous colleagues took time from busy schedules to provide peer reviews of the papers that are included herein: Drs. Virginia Butler, Chris Darwent, Betty Faust, William Folan, Sharon Jones, Kate McFadden, Madonna Moss, Tony Pilcher, and Tom Wade. Antonio Machado and Cathal O'Mahony gave helpful and patient support during the preparation of this Special Issue. Melania Yánez Q. helped improve an earlier draft of this paper; and grants from the Office of Protected Species, NOAA, and the US Fish and Wildlife Service supported JF.

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