Advanced Review

Prospects and challenges for an archaeology of global climate change

Mark J. Hudson,[1,2]* Mami Aoyama,[1] Kara C. Hoover[3] and Junzō Uchiyama[4]

Archaeology has a long history of research in reconstructing past environments and in attempting to understand the interactions between climate and human societies. So far, however, there has been little attempt by archaeologists to employ this knowledge in the debate over current global climate change. This paper provides a broad overview of the relevance of archaeology to the problem of global climate change, yet also attempts to consider some of the challenges that require further debate. We propose five areas where archaeology may be able to make significant contributions to global climate change discourse: (1) the study not just of past social 'collapse' but of how ancient societies attempted to manage decline and recovery in the face of long-term environmental change; (2) the ability to rethink the nature/culture divide; (3) the use of public archaeology to further education and awareness on environmental links and impacts; (4) the study of social injustice and how it may affect societal responses to the environment; and (5) the building of common 'intercultural' responses to climate change. Challenges identified are (1) making clearer in public debate the relevance of archaeology to present and future climate change; (2) the contexts in which people really learn from the past; (3) how different (national) traditions of archaeological research may affect our ability to relate archaeology to global climate change; and (4) how human-induced climate change on a global scale alters traditional historical approaches to human agency.

How to cite this article:
WIREs Clim Change 2012. doi: 10.1002/wcc.174

INTRODUCTION

Archaeology is a historical discipline that studies material remains left by our ancestors. At a time of unprecedented anthropogenic global climate change, can archaeology move from the study of our ancestors to suggest ways in which we can become '*good* ancestors'[1] for future generations? This review starts from the premise that archaeology *does* have an important contribution to play in current debates over global climate change. In particular, archaeology is uniquely well placed to investigate interactions between climate and human cultural evolution over the very long term. So far, however, archaeology has not played a conspicuous role in contemporary climate change discourse and this paper attempts to consider some of the reasons why archaeology has struggled to demonstrate its relevance in this respect. This paper is not an attempt to summarize the voluminous literature on prehistoric environmental changes and how they affected human societies. Nor do we discuss how global warming may impact archaeological fieldwork or heritage conservation.[2,3] Instead, we focus on broader epistemological issues relating to how archaeology may contribute to climate

*Correspondence to: hudsonm@nisikyu-u.ac.jp

[1]Faculty of Rehabilitation Sciences and Human Activity and Sustainability Group, Nishikyushu University (University of West Kyushu), Kanzaki, Saga Prefecture, Japan

[2]History Working Group, Center for Ainu and Indigenous Studies, Hokkaido University, Sapporo, Japan

[3]Anthropology Department, University of Alaska Fairbanks, Fairbanks, AK, USA

[4]Research Institute for Humanity and Nature, Kyoto, Japan

change knowledge and discourse. Although we use the term 'archaeology of global climate change' in our title, it is not our intention to specify a particular definition or agenda for such a subdiscipline. What such an archaeology might entail is, we suggest, still very much open to discussion. At the same time, we propose that one major contribution of archaeology to climate change discourse lies in *its ability to reduce distance and therefore reduce uncertainty*.

ARCHAEOLOGY, CLIMATE, AND THE ENVIRONMENT

In comparison with other social sciences and humanities, the natural environment and climate change have always played a comparatively important role in archaeology. Almost from its beginnings, archaeology has included attempts to reconstruct the living environment of past peoples using geological, faunal, and other data. Sociologist David Goldblatt notes that, 'The primary ecological issue for classical social theory was . . . how premodern societies had been held in check by their natural environments, and how it was that modern societies had come to transcend those limits'.[4] While most social sciences have focused their attention on the second of these problems, archaeology alone has attempted to understand how ancient societies were not just 'held in check' by the environment but how they adapted to environmental and climatic change. As briefly summarized below, archaeology has developed a large body of research that deals with the role of climate in the evolution of human societies.

Despite the importance of such approaches, however, some archaeologists have been reluctant to place too much emphasis on links between prehistoric people and the environment. The idea that such people were 'close to nature' is feared to mean 'far from culture and history' and thus to constitute a thinly disguised prejudice against primitive peoples. As Richard Bradley quipped, for many archaeologists it has appeared that, 'successful farmers have social relations with one another, while hunter-gatherers have ecological relations with hazelnuts'.[5] Environmental approaches have sometimes been seen as depriving preliterate peoples of history and thus supporting colonialism.[6] This last fear is well expressed by Japanese archaeologist Takurō Segawa in a recent book on the archaeology of the Indigenous Ainu people when he writes that, '[I] do not deny approaches which attempt to learn about coexistence with nature in Ainu history. In most cases, however, [such approaches] . . . appear to be only emotional arguments that include desires for atonement for a "civilization" that has progressed through the destruction of "nature" and for a "civilization" that has justified aggression by seeing Ainu as a part of 'nature'.[7] Part of the problem here is how we actually define 'ecological'. Harkin and Lewis separate out three usages of this term.[8] What they call 'Ecological$_1$' is the relations that all peoples necessarily have with the natural world in order to sustain life. 'Ecological$_2$' refers to the sustainability of adaptations and lifeways at the regional or local level. 'Ecological$_3$' is what is usually termed 'environmentalism', i.e., ideologies of conservation and sustainability which, by definition, are products of modern industrial society and thus not directly appropriate to most cultures studied by archaeologists.[9] Like scholars in other fields, archaeologists often confuse these three usages.

Climate and Environment in Archaeological Research

A detailed history of the role of environmental and climate change in archaeology would require another article, but a brief outline can be sketched here. For the purpose of this overview, 'climate' is subsumed within the 'natural environment' and several separate but related strands can be identified within the broad area of 'archaeology and the environment'. The first strand is the analysis of environmental remains from archaeological sites, comprising what is usually termed 'environmental archaeology'. Such analyses began at a very early stage, partly because remains such as animal fossils were important in demonstrating a great antiquity for humankind in the 19th century. This field of research has expanded exponentially in recent years due to new technical developments. However, this growth in technical sophistication has only served to increase the level of detail required to link paleoenvironments with human activity, an area that forms a second strand of research.

An excellent summary of this second strand of research is provided by Hassan, who emphasizes how new knowledge in the environmental sciences has continually influenced archaeological theory.[10] The growth of the science of ecology, for example, transformed many aspects of archaeological thinking from the 1960s.[11–13] Stimulated by ecology and systems theory, one of the most zealous attempts to link humans and their environment was made by Lewis Binford and the so-called processual archaeology. Binford tried to identify uniformitarian factors in the archaeological record that would support this endeavor.[14] While processual archaeology generated many useful ideas about how human societies relate to ecological factors, however, as a research tradition it was unable to find a sufficient way to incorporate the diversity

of cultural expressions by which humans 'adapt' to their environment through the 'songs, poetry, humor, and arts' that Kehoe notes had so impressed Franz Boas during his fieldwork with Inuit in the 1880s.[15] Another, perhaps more theoretically significant tradition within recent archaeology has been the work on evolutionary ecology by Bettinger and others.[16] Researchers working on earlier human prehistory have also made extensive use of ecological and climate models, although biological anthropologists have played a significant role in this work.[17]

A perennial problem in ecological archaeology has been the extent of communication between what we are here terming the first and second strands of research. Of course, these strands have never existed in isolation from each other. For example, one of the earliest archaeological theories of human–environment interaction, V. Gordon Childe's 1928 'oasis theory', has been continually revised in the light of new paleoenvironmental data.[18] Despite such examples, however, recent archaeology has been characterized by a growing gap between these strands whereby 'Social and environmental perspectives became separated or even opposed' (Ref 19, p. 509). The rise of postmodern theory in archaeology since the 1980s can be identified as the main cause of this trend. For many archaeologists in both postprocessual and critical/Marxist traditions, the natural environment has served to distance people from their history and culture. Although some postprocessual analyses have used environmental remains,[20] many key texts in this tradition have almost nothing to say about the environment.[21] Duke and Wilson claim that, 'Postprocessualism denies the primacy of the natural environment as a deterministic factor in cultural change'(Ref 22, p. 7) but there is a clear gap between such a claim (which few archaeologists would dispute) and ignoring the relations between humans and the environment (without which humans would quickly have become extinct!). As Hassan notes, 'climatic events do not determine culture change, which ultimately depends on local ecological conditions, previous cultural modalities and norms, and unpredictable social dynamics.' (Ref 23, p. 61). Despite such caveats, postprocessual critiques have tended to polarize archaeology into two camps: one which regards 'nature as a purely cultural construct' and one which retains a more traditional emphasis on how past environments influence human evolution.[24] For many practitioners these two camps are seen as incompatible, but we argue below that this reflects a naïve view of nature, incompatible with recent research in the environmental humanities.

An exception to postprocessual archaeology's lack of interest in human–environmental interactions has been landscape studies. Developing out of human geography, landscape studies began to proliferate in archaeology in the 1990s. Postprocessual archaeologists criticized earlier landscape archaeology for losing sight of people in the environment and began to develop deeply humanistic approaches to their subject.[25] Although these approaches have not been without controversy,[26] they have stimulated debates within archaeology over how humans relate to the environment.[27,28] Furthermore, while different national traditions of archaeological research have significantly affected how the discipline approaches the question of human–environment interactions, landscape archaeology has been able to overcome some of these differences and has been widely adopted in many countries. The NEOMAP landscape project directed by one of the authors (JU) is an example from East Asia.[29] Landscape archaeology also lends itself to applied approaches that may be useful in considering problems of social justice associated with global climate change.[30]

A third and final strand that can be identified is one relating to archaeological responses to contemporary global climate change. Archaeological concerns with conservation and 'Green' issues can also be included here.[31–33] While this strand is the most relevant to the topic of this review, it remains the least developed. Given archaeology's long history of concern with matters relating to climate and the environment, this is something of a paradox. Explanations for this paradox may include the rarity of explicit environmentalist positions within archaeology. Another reason may be that it is only very recently that we have developed the necessary detail of paleoenvironmental analyses to integrate them with human history (Ref 34, p. 4). A third possible factor is that the idea of 'climate' has itself changed in recent years. Previously, archaeologists were concerned with *regional* climates—and Watsuji's influential concept of *fūdo* is an excellent example from Japan[35]—but now 'climate' is more usually understood as a holistic global system. In other words, 'The idea of climate has been changing as much as, if not more than, the physical climate itself'.[36] Whatever the reasons, archaeology has been much slower to respond to the problem of global climate change than many other humanities and social sciences.

Modeling Human–Climate Interactions in Archaeology

The previous section has summarized some of the debates and controversies within archaeology over the role of climate and the environment in human history. As we have shown, many archaeologists have

been very critical about the role of environmental factors. While these critical debates are important, however, we should not lose sight of the considerable achievements made by archaeology in this area. There is a vast literature that uses archaeological data to link climatic and environmental change with the histories of human societies. How that literature might be used to develop responses to current and future climate change is a topic for another paper, but we have no doubt that this research will be useful in that respect. At the same time, for an interdisciplinary readership it is worth making two general points about the nature of archaeological research on climate change.

The first point is that the causal relationship between climate and culture is always problematic. This is in part a technical question of how, given the limitations of the archaeological and paleoenvironmental records, we can be sure of the relationship between climatic change x and cultural change y.[37] The most successful studies linking environmental change and cultural outcomes have been those where intensive archaeological research has benefited from exceptional preservation of sites and artifacts.[38] Long-term trends in climate and environmental change are now relatively well known and can be linked with long-term trends in human evolution.[39] However, shorter-term cultural responses are much harder to reconstruct and to dovetail with climate dynamics. New discoveries can also lead to sudden re-evaluations of existing theories, a recent example being arguments that rats were a major cause of deforestation on Easter Island.[40] The question of causal relationships also involves the nature of human cultural responses to climate and environmental change. Archaeology demonstrates not only the importance of climate to human history but also shows the great diversity in human cultural responses to environmental change even in earlier prehistory.[41]

Secondly, in attempting to understand the relationship between climate and history archaeology has for the most part begun with theoretical models borrowed from other disciplines. Archaeological research has, however, taken and expanded these models using its own data spanning long-term time frames. A good example here is the 'cultural ecology' framework developed from the 1930s by cultural anthropologist Julian Steward.[42] This approach has been extremely influential in North American archaeology and later researchers have built on Steward's work by analyzing various approaches to the dynamic relationships between environment, technology, population density, and ethnicity.[43] Historical ecology is another approach that has roots outside archaeology but has flourished within archaeological contexts.[44–46]

Both cultural and historical ecology have benefited from fruitful synergies with cultural anthropology. Recent cultural anthropological research on global climate change has, however, taken a different turn resulting from ethnographic fieldwork with peoples experiencing major ecological transformations that directly affect their livelihoods.[47] Although some archaeologists continue to assume that a consideration of the environment necessitates a playing down of human agency, recent work in the ethnography of climate change has attempted 'putting the human face on climate change'.[48] Such work has enormous potential for archaeology: perhaps for the first time we are able to see how climate change affects people as a 'lived reality that they struggle to apprehend, negotiate, and respond to' (Ref 49, p. 9). Contrary to the rather static view of the environment held by some archaeologists, contemporary ethnographic research is complicating the issues, finding that 'Climate change is having impacts on culture, ways of life, spirituality, and in other arenas that are not "obvious"' (Ref 49, p. 21). This type of research goes by several new names, including 'human dimensions research', 'environmental social science', and 'sustainability science'.[50] Such research has exposed the gap between the often rather static discussions of climate change in archaeology and the very dynamic experiences of contemporary peoples. Archaeological research within this third strand has been growing steadily to include issues related to global change, sustainability and what one major project calls the 'integrated history and future of people on earth'. This IHOPE project began in 2005 and has produced a major volume in which archaeology plays a significant role.[51] More traditional archaeological concerns with the rise and fall of civilizations have been revitalized by sustainability theory.[52] The influence of resilience theory on archaeology is discussed below.

CHALLENGES TO AN ARCHAEOLOGY OF GLOBAL CLIMATE CHANGE

Of the three strands of archaeological research summarized above, this article is especially concerned with the third. In the rest of the paper we discuss how archaeology might become more involved with the problems of global climate change. We begin by examining some potential challenges to such a role, before moving on to propose five possible contributions that archaeology might make.

Making Archaeology Relevant

If pressed, probably few if any archaeologists would deny that archaeology is relevant to questions of how

humans have adapted to environmental changes over the long term. As summarized in the previous section, however, archaeology has a history of sometimes acrimonious debate over the role of human *versus* environmental agency that has, in our opinion, served to distance archaeology from contemporary debates about the environment. Many scholars working on climate change discourse have emphasized the problem of *distance*. For many people in industrialized nations, for example, climate change seems to be something that lies some distance in the future. Such views are reinforced by the modernist conceit of a distance between 'nature' and 'culture'. Another distance is that between the scientific understanding of climate change and public knowledge of that phenomenon.[36] Perceived distance from the effects of climate change leads to the paradox described by sociologist Anthony Giddens: 'since the dangers posed by global warming aren't tangible, immediate or visible in the course of day-to-day life, ... many [people] will sit on their hands and do nothing of a concrete nature about them'.[53] Against this background, it might seem that archaeology occupies an academic and public space some considerable distance from the problems of current global climate change. If people today pay little attention to what will almost certainly happen in the near future, what is the use of thinking about the distant past? Most archaeologists deal with ancient peoples, such as the Romans and Aztecs, whose lives were based on very different economic systems from those of today. Anthropogenic climate change, in contrast, is very much a problem of modern industrial capitalism, particularly of the massive expansion of capitalism and consumption over the last 50 years. Global climate change is an issue of the present and (especially) the future, but archaeologists deal with the past, usually the ancient past. The apparently tenuous connection between global climate change and archaeology would seem to be borne out by the paucity of research in this area. Although there is a large literature on the effects of environmental change in prehistory, much less has been published on the archaeological aspects of current global climate change.[54]

Knowledge and narratives about the past are clearly important in all human societies and the challenge is make them more relevant to our contemporary situation. One important area of relevance for archaeology is providing 'lessons' from the past and this topic is discussed below. As also explained below, modernity has built its identity on 'overcoming' the past, but this break with tradition may have now reached its limit. Sociologist Ulrich Beck[55] argues that the 'risk society' in which we now live shifts our responsibility toward future generations: 'As risks are now potentially of high consequence and global, future generations must be incorporated into decision-making'.[56] Paradoxically, it may be a renewed emphasis on the *future* that leads to a new role for archaeology and the ancient past.

Do We Really Learn from the Past?

Throughout history, the past has been widely used to provide 'lessons' for the future and there is little question that such potential lessons are a central justification for climate change archaeology. In the premodern era, cultural traditions served as guides to balancing short-term productivity against long-term resilience (Ref 34, p. 4). With the advent of modernity, the past took on an increasingly idealized and rhetorical role, but there is now a need to rehabilitate more practical linkages between past and present. The question of how the past might be used in the context of global climate change has yet to be rigorously examined by archaeologists, but existing approaches to environmental change in archaeology are relevant to our current situation. Archaeological research has so far examined two main types of environmental change: (1) anthropogenic alterations to local or regional ecosystems caused by overhunting and other unsustainable uses of resources or by pollution from mining, metal working and other technologies; and (2) nonanthropogenic global and regional environmental and climate changes, such as the Pleistocene–Holocene transition, and their effects on human societies. In practice, of course, these two types of change are often interwoven together in complex ways, one example being the work by Geoff Bailey and colleagues in Greece.[57] Archaeologists possess an ever-growing database of these transformations, some of which have been studied over very long time scales. These studies clearly demonstrate that human activity can easily damage or destroy ecological systems under a broad range of social and economic structures and also that humans have always attempted to develop adaptive responses to such changes.

Despite the long history of this type of research, an objection might be made that the sheer number and range of archaeological examples of ecological degradation only proves that humans rarely learn from the past. One of the earliest appearances of climate change in public culture is the 1967 horror film *Quatermass and the Pit*. In this movie, Professor Quatermass asks an archaeologist, 'If we found our earth was doomed, say by climatic changes, what we would do about it?' The archaeologist replies: 'Nothing: just go on squabbling as usual'.[58] This problem is inadvertently raised by Ian Whyte in a book that sets out to show that a long-term, historical perspective is essential in

managing for sustainability but which, as evidence for this approach, cites the 1992 collapse of the Newfoundland cod fishery as a failure to learn from a previous similar disaster in the 1970s.[59] If it takes less than two decades for humans to forget the past in our media-soaked society, then what is the point of learning about a limited picture of events that occurred 2000 or 20,000 years ago? Even after 1992, Mark Kurlansky wrote that 'one of the greatest obstacles to restoring cod stocks off of Newfoundland is an almost pathological denial of what has happened. Newfoundlanders seem prepared to believe anything other than that they have killed off nature's bounty'.[60] This is an extremely important problem for an archaeology of global warming, one equal to the paradox identified by Giddens.

How are we to understand such failures to learn from the past? Philosopher Slavoj Žižek argues they are a direct result of a capitalist ideology that attempts to mask its deep contradictions.[61] Archaeologist Fekri Hassan argues that human societies are inherently conservative, preferring to follow traditional ways of relating to the environment. Hassan thus suggests that, 'People are likely to respond to climatic signals if they are within the scope of their perceptual span. Climatic events that are not perceptible or too distant in the past are not likely to be effective in the way people react to their environment' (Ref 23, p. 44). Both Hassan and Giddens are probably correct that most people react most immediately to environmental phenomena that are closely related to their everyday experiences. But where does this leave archaeological examples that are for the most part quite distant from the 'perceptual span' of people today? Hassan argues that 'veneration for old habits' may be 'harmful if adhered to dogmatically' (Ref 23, p. 42), but to what extent are arguments that (past) people follow 'tradition' based on empirical evidence as opposed to ideological assumptions that stress 'the ''realism'' of being guided by what is possible (rather than what is desirable)' (Ref 56, p. 123)? These are difficult philosophical questions which an archaeology of global climate change will need to consider further. Costanza and colleagues propose that 'If we can *really* understand the past, we can *create* a better, more sustainable and desirable future' (Ref 34, p. 17), but understanding the past is clearly not simply a question of more historical facts.

To complicate things further, the modern era has in part defined itself by its *rejection* of the past and its ability to 'overcome' tradition. Under modernity, 'Reverence for the past is commonly seen to inhibit change, embargo progress, dampen optimism, stifle creativity'.[62] This view became especially associated with America, a continent whose lack of 'ruined castles' made it 'untroubled by useless memory' according to an 1812 poem by Goethe (Ref 62, p. 110). Emerson's 1870 comment that 'Whatever is old is corrupt' (Ref 62, p. 105) found its ultimate literary expression in Bram Stoker's 1897 novel *Dracula*. At the same time as it rejected tradition, modernity developed a new concept of 'heritage' to bolster the nation state. This view of the past as heritage has since become intrinsic to all modern nations, focusing attention on past national heritage, often at the expense of issues of contemporary justice. Simple desires to escape to a nostalgic past are no doubt a part of this 'heritage', but global climate change limits the indulgence of nostalgia due to the growth of feelings of psychosocial distress deriving from rapidly changing environments—what Albrecht terms solastalgia.[63]

National heritage works both for and against an archaeology of global climate change: *against* because it tends to focus on narrow, national concerns at the expense of the global; *for* because heritage sites may play an important role in relating people to the environment in a way that events in more distant places do not. The significance of heritage sites is emphasized by Schneider and colleagues who propose the loss of such sites due to climate change as one negative impact on the quality of life.[64] Like the heritage industry, archaeology works simultaneously both to increase and decrease our familiarity with the past. In Britain, for example, archaeology has greatly increased our knowledge of the distant Mesolithic and Neolithic eras, but at the same time we have largely lost ready familiarity, not just with classical and biblical heritage (Ref 62, p. xxiv), but also with more recent experiences of human relations with nature. If resilience to environmental change is increased by historical continuity with the legacy of landscape and its heritage, we may be in trouble at a time when a breach with such legacies means that we are 'surrounded by monuments and relics we can barely comprehend and scarcely feel are ours' (Ref 62, p. xxiv).

Alternative Archaeologies and the Environment

Environmental scholars have noted that data on past socioecological systems 'vary enormously in quality, selection, interpretation, resolution, [and] dating/chronologies' (Ref 34, p. 15), but there has been little research on the causes of such variation. Over the past few decades, archaeology has displayed considerable interest in how archaeological interpretations are part of their historical, social, and political contexts, and we suggest that different contexts of archaeological research can also affect our understanding of human-environment interactions. Since

Bruce Trigger identified 'nationalist', 'colonialist', and 'imperialist' types of archaeology in 1984,[65] there has been a tremendous growth in what might be termed 'alternative archaeologies',[66] but this multivocality has rarely included ecological issues. A tremendous growth in gender archaeology has not led to a strong eco-feminist approach as in other fields such as environmental history.[67] One exception was an interest in Green issues in British archaeology in the 1980s and 1990s,[31,32] but this 'Green Archaeology' has not developed into a mainstream movement.

How different types of archaeology may affect understanding of human–environment interactions is a topic for future research, but some links are already clear. One example is the historical emphasis on how primitive peoples adapted to the environments of North America within archaeology in the United States, an emphasis that contrasts with British archaeology, which has been more interested in how civilizations 'overcame' ecological parameters.[68] The box below uses the example of Japan to discuss how the historical context of imperialism within which Japanese archaeology originated affected research on environmental issues. One of the most explicit calls for an archaeology of global environmental change has, in fact, come from Japan. In 1999, Yoshinori Yasuda proposed that archaeology can be a type of 'salvation' for the problems of global climate change and that 'environmental archaeology can save the planet and humanity'.[69] In order to understand why Yasuda's work has been almost completely ignored by most Japanese archaeologists, we have to analyze how the problem of the environment has been approached in archaeology in Japan (Box 1).

BOX 1

SCIENCE, IMPERIALISM, AND THE ENVIRONMENT IN JAPANESE ARCHAEOLOGY

Japanese archaeology provides a good example of how different traditions of archaeological research influence the discipline's ability to respond to climate change. Although Japan was never colonized by the West, Japanese archaeology developed within, and in reaction to, homogenizing Western narratives of modernity. American zoologist E. S. Morse, a pioneer in shell midden analyses, conducted the first excavation in Japan in 1877. As Japanese scholars began to develop their own native archaeology, however, they distanced themselves from non-Japanese pioneers such as Morse.[70] Archaeology became a branch of Japanese history and, after the defeat of fascism in 1945, dedicated itself to a critique of social inequality and the emperor system. Influenced by Marxist theory, the historical sciences in Japan separated themselves from 'nature' as a phenomenon that was thought to be incompatible with social change.[71] Postwar Japanese archaeology took its lead from historian Gorō Hani who wrote, 'The most important, nay the only necessary principle that should be used to construct theory for our world history is not geography or environment or climate, or even race or ethnos, but the principle of evolutionary stages'.[72] Marxist approaches became less explicit in Japanese archaeology by the 1970s, but their legacy remains important.[73] This history of Japanese archaeology as social critique seems to explain the widespread negative reaction within that discipline to theories and research that have emphasized human interactions with the natural environment.

Global Climate Change and the Study of the Past

Historian Dipesh Chakrabarty has recently argued that global climate change presents a fundamental challenge to the way we study the past.[74] Using the work of Collingwood, Braudel and others, Chakrabarty describes how the historical sciences developed within a framework that separated nature from culture. Recent anthropogenic climate change has, however, begun to collapse this distinction: humans are now themselves a geological force of nature and, according to Chakrabarty, the concept of the 'Anthropocene'[75] completely changes the way we think about history. Specifically, Chakrabarty raises the problem of how history can involve the universal, the human species, in its theorizing about the past: 'How do we relate to a universal history of life—to universal thought, that is while retaining what is of obvious value in our postcolonial suspicion of the universal?' (Ref 74, p. 219–220). While Chakrabarty has more questions than answers, we believe his essay is important because his status as a well-known postcolonial historian will lead the historical profession to reconsider its epistemology in the context of global climate change.

The issues raised by Chakrabarty also affect how we think about archaeology. Like history, archaeology has also been based on an assumed dichotomy between culture and nature, as for example in the concepts of 'artifact' and 'ecofact', a distinction that climate change has completely collapsed. Traditional archaeology separated nature and culture and attempted

to see how the two interacted, but it is now clear that these are part of same very complex system. The *global* scale of current climate change also impacts archaeological epistemology, forcing archaeologists to think about new scales of response and adaptation.

POTENTIAL CONTRIBUTIONS OF ARCHAEOLOGY

Archaeology has great potential to contribute to debates over global climate change and its social impacts, but the discipline has so far made few concrete suggestions as to the roles archaeology might play in this respect. Here we propose five areas where archaeology might develop unique contributions.

From Collapse to Resilience

Social collapse has long been an important theme in archaeological research. Archaeology can work to both over-emphasize and underplay collapse. Apparently sudden discontinuities in archaeological sequences may derive from poor preservation as much as actual disaster. On the other hand, even good preservation may lead us to underestimate the extent of human suffering associated with environmental changes. Studies of disasters that have *already* happened may, in a perverse way, serve to distance and isolate ourselves further from the social and ecological disasters we are now facing. In his call for 'apocalypse no', Timothy Morton argues that apocalyptic writing postpones the disaster that is already here.[76] Environmental writer Bill McKibben suggests that, in many cases, archaeology provides examples of what he calls 'collapse porn', titillating apocalyptic tales of disaster and decline.[77] Archaeologists now know a lot about the 'collapse' of the Greenland Norse or the Classic Maya but such cases may only further support Fredric Jameson's point that 'it is easier to imagine the end of the world than the end of capitalism'.[78] Naomi Klein argues that global capitalism exploits catastrophes to remove old constraints and impose new controls.[79] Stories of the collapse of civilizations offer comforting narratives of power and its limits but such narratives may contribute to fear and thus to authoritarianism.[80] How can archaeology develop critiques of such powerful narratives of collapse within capitalism?

McKibben argues that 'collapse porn' shifts our attention away from managing for '*relatively graceful decline*' (Ref 77, p. 99). It is, in fact, this question of 'relatively grateful decline' that has structured some of the most significant contributions to the archaeology of global warming through research on the resilience of past social-ecological systems. A recent book titled *Questioning Collapse* suggests that collapse 'is a rare occurrence' but perhaps goes too far in downplaying this phenomenon.[81] When Costanza et al. (Ref 34, p. 15) call collapse 'probably the most critical question facing current society', they mean there is a need to ask under what conditions do societies actually collapse? As noted above, the preservation of the archaeological record is always going to be a limiting factor in answering such questions and some of the best-known archaeological examples of human response to environmental and climatic change are based on phenomenal preservation and multidisciplinary analytical detail. Recent research such as the *Questioning Collapse* volume is important, however, in shifting emphasis toward resilience and the longer-term history of social–ecological collapse and reorganization (Box 2).

BOX 2

ARCHAEOLOGY AND RESILIENCE THEORY

Resilience can be defined as 'The amount of change a system can undergo (its capacity to absorb disturbance) and remain within the same regime—essentially retaining the same function, structure, and feedbacks'.[82] Developing out of ecology in the 1970s, resilience theory represents several fundamental shifts in the way archaeologists approach change.[83] Firstly, change is seen as the norm and not the exception to phases of equilibrium. Following Holling's concept of the adaptive cycle, this change can be both sudden and creative, containing the seeds of cultural and ecological reorganization.[84] Secondly, social and ecological change are not viewed as separate phenomena that may or may not be related. Instead, analysis begins from the assumption that both the social and the ecological are always interconnected as part of linked or coupled social–ecological systems.[85] Thirdly, the resilience perspective requires the analysis of very long-term cycles of change and thus the long-term, ultimate causes of change. This long-term perspective, together with an emphasis on the role of human activity in building resilience, makes archaeology an important partner in resilience research. Few archaeologists have yet become involved in resilience studies, but there seems little doubt that this approach has enormous potential for the archaeology of global climate change. Although the measurement of resilience is difficult even in contemporary societies,[86] an important start in the methodology of resilience analysis in archaeology has been made by Hegmon and colleagues.[87]

Toward an Archaeology of the Nature/Culture Divide

It has been widely argued that one reason for our current ecological crisis is the modern conceit of separation between nature and culture. Although archaeology has so far largely worked to maintain this divide, we argue that it holds considerable potential to rethink these categories and how they impact everyday life. It is difficult to exaggerate the importance of such an endeavor at a time when we 'face a profound failure of knowledge: most people are unaware of their most basic ecological dependencies.'[88] Of course this is not just a question of knowledge. Today the links between our lives and the natural environment—particularly the real costs of our economy—are deliberately ignored or confused in order to make short-term profits. One of the great strengths of archaeology is that it deals with societies where 'the vast majority of people have always been exposed to the natural world in a way difficult for contemporary consumer-driven, urban-based, industrial (or post industrial) populations to grasp' (Ref 54, p. 1096). The basic processes of production are different in contemporary industrial societies from those in most societies studied by archaeologists. Everyday life today is destructive of the environment in ways that were not imaginable until recently, a process that environmental sociologist Koichi Hasegawa calls 'everyday life pollution': 'The primary characteristic of everyday life pollution is that it generates severe environmental destruction through the ordinary consumption behavior of general citizens'.[89]

As noted, postprocessual archaeology has often been dismissive of the role of 'the environment' in human affairs. Yet such arguments have relied on a reified view of 'nature' as something outside of culture and society. Ironically, the most radical critiques of this view in recent years have been developed within postmodern theory. Ecocritics such as Timothy Morton have argued that nature is a 'queer' mess in which everything is connected in ways that often disturbingly undermine our sense of the human.[90,91] Similar ideas are being discussed in environmental history[92], and archaeology also has to develop new ways of thinking about the environment which transcend the rather strict division between 'nature' and 'culture' that dominates at present. The concept of linked or coupled 'social-ecological systems' is a potentially important approach here.[85]

One, perhaps surprising, way in which archaeology can think about the nature/culture divide is through artifacts. Archaeological research is centred on material artifacts such as pottery and stone tools. A major challenge of archaeology is how to relate such everyday objects to other aspects of culture. A basic assumption of contemporary archaeology is that artifacts are indeed related to other social and ideological aspects of culture—but in complex ways that require considerable effort to reconstruct. Thinking about artifacts is important in the context of global climate change because they remind us that the everyday things we use are intimately connected to society *and* the environment. In archaeological cultures, most artifacts were produced and used within the local community. Cycles of artifact production and consumption were more or less sustainable in the Ecological$_2$ sense.[8] Part of this sustainability was related to the reuse and recycling of artifacts. Such activities could be 'symbolic' as in the case of the 'sending back' ceremonies held by Indigenous Ainu people in Japan, for objects such as iron pots, as well as for animals they had killed, in the hope that those things would once again return to the land of the Ainu.[93]

Such cycles have been profoundly transformed by industrial capitalism, which has changed the way everyday objects are produced, consumed, and discarded. In the Global North we live with the conceit that artifacts magically disappear after disposal. It is a commonplace that we live in a 'throw away' society that contrasts with the more frugal lifestyles of the past—and of many less industrialized nations today. Today most of us are happy never to see our rubbish again and dangerous waste is shipped to countries in Global South for 'processing'. Many people today continue to believe in an 'archaeological' view of trash: used objects (artifacts) are discarded in discrete disposal areas (middens) that are more or less separate from habitation areas. Scholars and activists working in environmental justice acknowledge that disadvantaged groups often experience exceptions to this scenario.[94] Yet the reality is that many artifacts produced today contain toxic substances such as PCBs, phthalates, triclosan, and PFCs that are retained in our bodies in potentially harmful quantities.[95] If artifacts are things made by humans, then our bodies must now be counted as a type of artifact. Industrial toxins do not worry about distinctions between wild and urban, organic or inorganic: 'Everything on Earth, living or otherwise, is integrated into one interconnected, bufferless web that is neither artifice [read *artifact*] nor nature' (Ref 92, p. 16). Archaeology, we suggest, may be a particularly useful way to think about such disturbing connections between nature and artifice and to study actual processes of production, use and discard of artifacts in the context of global climate change.

Public Archaeology and Climate Change

Public archaeology attempts to make archaeological research more accessible and meaningful to the general public. Previous work in public archaeology has focused on topics such as tourism, education, and site preservation. The use of archaeology in environmental education has received much less attention,[96,97] but we suggest that an additional focus on climate change and issues related to the environment might play an important role in fostering debate and education. One of the authors is currently developing a children's book that uses archaeology in environmental education.[98] Global climate change is a complex process that is difficult for most people to comprehend or even imagine until they experience its direct effects. Global warming 'exceeds the experience of everyday life' and sociologists tell us that people 'are slow to react to issues that lie outside of their everyday experience' (Ref 89, p. 53 and 64). In this sense archaeologists occupy a privileged position in that they study things that are largely outside of our everyday experience and yet attempt to frame those things in terms of contemporary issues. Paul Ehrlich has stated that, 'Arguably, no challenge faced by humanity is more critical than generating an environmentally literate public'.[99] Ehrlich's broad view of environmental education includes many topics commonly considered by archaeology such as technology, demography, and human evolution.

As well as more formal contributions to environmental education, popular writings about the archaeology of climate change have proven to be enormously influential.[100,101] In many countries archaeology has a prominent popular image which, while sometimes quite removed from the reality of archaeological research, has considerable potential for promoting discussion over issues of ecology and sustainability. 'Indiana Jones and the Temple of Sustainability' is a movie that is probably *not* coming soon to a cinema near you, but such a film could have enormous resonance at the present time. Finally, archaeological sites and museums also have great potential to introduce visitors to ecological and climate change issues.

Social Inequality and Climate Justice

If archaeology was simply the study of the material remains of the (distant) past, its relevance to current climate change debate would be rather limited. It is, however, the ability of archaeology to use the past to rethink the present that gives it a significant voice in this debate. Humans adjust to climate and other environmental changes through culture and 'responses to environmental stress may also be strongly influenced by conflicts in goals and agendas set out by ruling classes versus those of other segments of societies' (Ref 24, p. 2). Flexibility is a crucial factor in the ability to adapt to climate change yet social inequalities such as those deriving from class, race, and gender may adversely affect such flexibility. Social inequalities from the past affect the ability of groups to adapt to climate change in the future: 'We live in a world where future climate injustices are likely to compound past injustices, such as underdevelopment and colonialism, that themselves have resulted in the uneven patterns of development in today's world'.[102] Climate change 'magnifies and exacerbates existing social, economic, political, and environmental trends, problems, issues, tensions, and challenges' (Ref 49, p. 11). Global climate change will almost certainly increase inequalities and violence across the world, reducing human freedoms (Ref 74).

If intergenerational justice is an important element of climate change debate, then archaeology provides a way of thinking about this through emphasizing our own debt to past generations and thus our duty to future ones. Climate change science emphasizes the importance of identifying populations that are especially vulnerable to the impacts of global climate change.[103] Archaeology, with its long-term perspective on social inequalities, can help identify such populations. Fekri Hassan has already provided a detailed historical analysis of how sustainability is related to inequality.[104] Previous archaeologies of political action have focused on race, class, and gender, but global climate change raises new agendas. Growing interest in the archaeology of childhood might be expanded to consider the unequal impacts of climate change on children.[105] An archaeology of global climate change requires a praxis, which can be understood as 'a process of gaining knowledge of the world, critiquing the world, and taking action to change the world'.[106] Archaeology can only play an indirect role in political action for climate change yet it deals with important issues of power, lifestyles, and environment that have clear resonance for the present. 'Because climate change has effects on the myriad of rights necessary to lead a productive and healthy existence, including subsistence rights, economic rights, cultural rights, intellectual property rights, and the like it is implicitly a human rights issue' (Ref 49, p. 15).

Climate change is a question of justice/power in which 'The interests of the unborn and the unseen' have to be defended.[107] Archaeology does not, of course, deal directly with the unborn, but can be said to hold a privileged position with respect to the 'unseen'. By this we mean that archaeology often focuses its attention on the everyday life worlds of

nonelite groups, people who even in historic times received little attention in written texts but nevertheless leave material records of their behavior. Archaeology often takes a materialistic approach, which mirrors historical and political ecology in attempting to understand how class conflicts influenced interactions between humans and the environment. Rosen reminds us that 'To understand the interactions between societies and their environmental milieu it is critical to remember that communities are segmented in innumerable ways and consist of subgroups and individual actors whose goals and motivations may differ, thus leading to differing responses to environmental factors' (Ref 24, p. 9). Archaeological examples of the role of such factional interests in building responses to environmental change have great potential to influence the terms of current debates.

Building New Networks of Intercultural Understanding

Since the 1980s, there has been a tremendous growth in different types of archaeology—Indigenous, feminist, Third World, community, and more.[66] Is the archaeology of global climate change simply one such new archaeology? To some extent the answer is yes, but at the same time it goes beyond 'alternative' archaeologies to deal with common, global issues that affect us all. The previous section focused on factional interests and their justice implications but we wish to conclude with a brief consideration of shared responses.

Existing disciplines in the humanities and social sciences each have their own contributions to make to climate change research, yet global climate change affects all aspects of life in ways not necessarily anticipated by existing academic subdivisions. Recognizing interconnections with nature reduces the efficacy of studying the world through distinct traditional disciplines and calls for transdisciplinary synthesis.[108] New interdisciplinary networks are required to meet this challenge. In many cases this means a more 'global' approach to both theory and practice. Although archaeology is already more interdisciplinary than many disciplines, further links are needed with new, perhaps unexpected fields such as ecocriticism, the health sciences, economics, and environmental justice. As Cornell et al.[88] warn, 'meeting the challenge of providing a new integrative understanding means we need to do unfamiliar and even uncomfortable things'. Resistance to the development of such networks may be expected where they disrupt existing academic power structures.

As noted by ecocritics such as Buell, environmentalism can be said to have emphasized place and sustainable dwelling *in* place.[109] Environmental and conservation approaches in archaeology have also usually been based on place and region and Greeves[110] specifically links archaeology with the work of American environmentalist Wendell Berry who writes that, 'Memory . . . must be a pattern upon the actual country, not a cluster of relics in a museum or a written history.'[111] However, global climate change is by definition trans-local and archaeology will need to develop new ways of approaching such scales—a challenge that is already being taken up elsewhere in the humanities.[112] While in theory archaeology already has a global scope, and the World Archaeological Congress has played an important role in this respect, much still remains to be done to effectively incorporate perspectives from all over the world. Details of particular adaptations to environmental change are certainly important, but one of archaeology's unique strengths is its ability to analyze long-term, 'big picture' views of how humanity has related to nature.

CONCLUSIONS: TOWARD AN ARCHAEOLOGY OF GLOBAL CLIMATE CHANGE

Humanity currently faces a shared crisis of global proportions but unequal burdens. In facing this crisis, the past takes on a greater importance than perhaps ever before. Global climate change affects all academic disciplines, including those not traditionally seen as connected to nature or the environment. All disciplines have their own distinctive responses and contributions and all must develop their own language of discourse over global warming. At a time of increasing ecological stress many such responses will be seen as 'dilettantish luxury', unhelpful to victims of storms or heatstroke (Ref 54, p. 1093). Much of the literature on global climate change suggests that our current situation is unprecedented and is, in large part, caused by recent historical processes of industrialization and the globalization of capital. While modernity has clearly played a unique role in environmental transformations, however, significant climate change has also occurred in the past and only archaeology can confirm just how unique our current predicament really is. Climate change science emphasizes the 'explosion' of uncertainties that occurs in perceptions of climate change impacts (Ref 113, p. 34–35). Archaeology can be useful in reducing uncertainty through analyses of past impacts and responses. For scientists, the particular nature of past adaptive responses is important, but for the general public the simple fact that people altered their lifestyles as a result of

climate change may have a powerful resonance of its own.

This paper has discussed some of the challenges faced by archaeology in developing responses to global climate change, yet has also emphasized the very important contributions that archaeology might make in this area. What we have provisionally called the 'archaeology of global climate change' requires an engagement with issues of sustainability, justice, and the deconstruction of nature/culture dichotomies. Research on paleoclimates and how they influenced human history needs to be extended in new ways that include humanistic as well as scientific approaches to the environment. Many examples already exist of archaeologists applying their expertise to social issues and an engagement with global climate change would not necessarily require a fundamental restructuring of archaeological practice. Archaeology already takes a long-term view of human affairs and it needs to extend that perspective, using the study of our ancestors to promote our own role as 'good ancestors'.

ACKNOWLEDGMENTS

We thank the domain Editor Matthias Heymann and the two anonymous referees for their comments on this paper. This research was supported by a grant-in-aid for Scientific Research on Innovative Areas, MEXT, Japan for the project 'Environmental and cultural changes in the Ryukyu archipelago during prehistoric and proto-historic times' (No. 21101005), Alaska EPSCoR NSF award #EPS-0701898 and the State of Alaska, the NEOMAP Project of the Research Institute for Humanity and Nature, the Social Sciences and Humanities Research Council of Canada for the Baikal-Hokkaido Archaeology Project, and the University of West Kyushu for the project 'Utilizing cultural properties in environmental conservation in Kanzaki'.

REFERENCES

1. Ehrenfeld D. *Becoming Good Ancestors: How we Balance Nature, Community, and Technology*. Oxford: Oxford University Press; 2009.
2. Chapman H. Global warming: the implications for sustainable archaeological resource management. *Conserv Manag Archaeol Sites* 2003, 5:241–245.
3. Howard AJ, Challis K, Holden J, Kincey M, Passmore DG. The impact of climate change on archaeological resources in Britain: A catchment scale assessment. *Clim Change* 2005, 91:405–422.
4. Goldblatt D. *Social Theory and the Environment*. Cambridge: Polity Press; 1996, 4.
5. Bradley R. *The Social Foundations of Prehistoric Britain: Themes and Variations in the Archaeology of Power*. London: Longman; 1984, 11.
6. Wolf E. *Europe and the People Without History*. Berkeley, CA: University of California Press; 1982.
7. Segawa T. *Ainu no Rekishi: Umi to Takara no Nomado (Ainu History: Nomads of Ocean and Treasure) [in Japanese]*. Tokyo: Kōdansha; 2007.
8. Harkin ME, Lewis DR. Introduction. In Harkin ME, Lewis DR, eds. *Native Americans and the Environment: Perspectives on the Ecological Indian*. Lincoln, NE: University of Nebraska Press; 2007, xix–xxxiv.
9. Nadasdy P. Transcending the debate over the ecologically noble Indian: indigenous peoples and environmentalism. *Ethnohist* 2005, 52:291–332.
10. Hassan FA. Ecology in archaeology: from cognition to action. In Bintliff J, ed. *A Companion to Archaeology*. Oxford: Blackwell; 2004, 311–333.
11. Harris DR. Agricultural systems, ecosystems and the origins of agriculture. In Dimbleby GW, Ucko PJ, eds. *The Domestication and Exploitation of Plants and Animals*. Chicago, IL: Aldine; 1969, 3–15.
12. Flannery KV. The ecology of early food production in Mesopotamia. *Science* 1965, 147:1247–1256.
13. Butzer KW. *Archaeology as Human Ecology: Method and Theory for a Contextual Approach*. Cambridge: Cambridge University Press; 1982.
14. Binford LB. *Constructing Frames of Reference: An Analytical Method for Archaeological Theory Building Using Ethnographic and Environmental Data Sets*. Berkeley, CA: University of California Press; 2001.
15. Kehoe AB. Lewis Binford and his moral majority. *Arqueología Iberoamericana* 2011, 10:8–18.
16. Bettinger RL. Holocene hunter-gatherers. In Feinman GM, Price TD, eds. *Archaeology at the Millennium: A Sourcebook*. New York: Kulwer/Plenum; 2001, 137–195.
17. Foley RA. *Another Unique Species: Patterns in Human Evolutionary Ecology*. Harlow: Longman; 1987.
18. Childe VG. *The Most Ancient East: The Oriental Prelude to European Prehistory*. London: Kegan Paul; 1928.

19. Bell M. Archaeology and green issues. In Bintliff J, ed. *A Companion to Archaeology*. Oxford: Blackwell; 2004, 509–531.
20. Hastorf CA, Johannessen S. Understanding changing people/plant relationships in the prehispanic Andes. In Preucel RW, Hodder I, eds. *Contemporary Archaeology in Theory: A Reader*. Oxford: Blackwell; 1996, 61–78.
21. Hodder I. *Reading the Past: Current Approaches to Interpretation in Archaeology*. Cambridge: Cambridge University Press; 1986.
22. Duke P, Wilson MC. Introduction: postprocessualism and Plains archaeology. In Duke P, Wilson MC, eds. *Beyond Subsistence: Plains Archaeology and the Postprocessual Critique*. Tuscaloosa, AL: University of Alabama Press; 1995, 1–16.
23. Hassan FA. Human agency, climate change and culture: an archaeological perspective. In Crate SA, Nuttall M, eds. *Anthropology and Climate Change: From Encounters to Actions*. Walnut Creek, CA: Left Coast Press; 2009, 39–69.
24. Rosen AM. *Civilizing Climate: Social Responses to Climate Change in the Ancient Near East*. Lanhah, MD: AltaMira Press; 2007, 8.
25. Tilley C. *The Materiality of Stone: Explorations in Landscape Phenomenology 1*. Oxford: Berg; 2004.
26. Fleming A. Post-processual landscape archaeology: a critique. *Camb Arch J* 2006, 16:267–280.
27. Johnson M. *Ideas of Landscape*. Oxford: Blackwell; 2007.
28. Coones P. The unity of landscape. In Macinnes L, Wickham-Jones CR, eds. *All Natural Things: Archaeology and the Green Debate*. Oxford: Oxbow; 1990, 22–40.
29. Uchiyama J, Lindström K, eds. *Keikan no Daihen'yō: Shinsekkika to Gendaika (Landscape at Boiling Point: Neolithisation, Modernisation and Change) [in Japanese]*. Kyoto: Shōwadō; 2011.
30. Hudson MJ, Aoyama M. Occupational apartheid and national parks: the Shiretoko World Heritage site. In Kronenberg F, Pollard N, Sakellariou D, eds. *Occupational Therapies Without Borders: Towards an Ecology of Occupation-Based Approaches*. Edinburgh: Churchill Livingstone/Elsevier; 2011, 247–255.
31. Macinnes L, Wickham-Jones CR, eds. *All Natural Things: Archaeology and the Green Debate*. Oxford: Oxbow; 1990.
32. Greeves T. Archaeology and the Green movement: a case for perestroika. *Antiquity* 1989, 63:659–666.
33. Lyman RL, Cannon KP, eds. *Zooarchaeology and Conservation Biology*. Salt Lake City, UT: University of Utah Press; 2004.
34. Costanza R, Graumlich LJ, Steffen W. Sustainability or collapse: Lessons from integrating the history of humans and the rest of nature. In Costanza R, Graumlich LJ, Steffen W, eds. *Sustainability or Collapse? An Integrated History and Future of People on Earth*. Cambridge, MA: MIT Press; 2007, 3–17.
35. Watsuji T. *Fūdo*. Tokyo: Iwanami; 1935. Trans. by Bownas G. *Climate and Culture: A Philosophical Study*. Westport, CT: Greenwood Press; 1961.
36. Hulme M. *Why We Disagree About Climate Change: Understanding Controversy, Inaction and Opportunity*. Cambridge: Cambridge University Press; 2009, 18.
37. Ingram M, Farmer G, Wigley T. Past climates and their impact on man: A review. In Wigley T, Ingram M, Farmer G, eds. *Climate and History: Studies in Past Climates and their Impact on Man*. New York: Cambridge University Press; 1981, 3–50.
38. Dugmore AJ, Keller C, McGovern TH. Norse Greenland settlement: reflections on climate change, trade, and the contrasting fates of human settlements in the North Atlantic islands. *Arctic Anthropol* 2007, 41:12–36.
39. Berglund BE, ed. *The Cultural Landscape during 6000 Years in Southern Sweden*. Oxford: Blackwell; 1991.
40. Hunt, TL. Rethinking Easter Island's ecological catastrophe. *J Arch Sci* 2007, 34:485–502.
41. Anderson DG, Maasch KA, Sandweiss DH, eds. *Climate Change and Cultural Dynamics: A Global Perspective on Mid-Holocene Transitions*. London: Academic Press; 2007.
42. Steward J. *Basin-Plateau Aboriginal Sociopolitical Groups*. Bureau of American Ethnology Bulletin 120. Washington DC: GPO; 1938.
43. Bettinger RL. Cultural, human, and historical ecology in the Great Basin: fifty years of ideas about ten thousand years of prehistory. In Balée W, ed. *Advances in Historical Ecology*. New York: Columbia University Press; 1998, 169–189.
44. Crumley CL, ed. *New Directions in Anthropology and Environment: Intersections*. Walnut Creek, CA: AltaMira Press; 2001.
45. Balée W, ed. *Advances in Historical Ecology*. New York: Columbia University Press; 1998.
46. Balée W, Erickson CL, eds. *Time and Complexity in Historical Ecology: Studies in the Neotropical Lowlands*. New York: Columbia University Press; 2006.
47. Crate SA, Nuttall M, eds. *Anthropology and Climate Change: From Encounters to Actions*. Walnut Creek, CA: Left Coast Press; 2009.
48. Nickels S, Furgal C, Buell M, Moquin H. *Unikkaaqatigiit—Putting the Human Face on Climate Change: Perspectives from Inuit in Canada*. Ottawa: Joint publication of Inuit Tapiriit Kanatami, Nasivvik Centre for Inuit Health and Changing Environments at Université Laval and the Ajunnginiq Centre at the National Aboriginal Health Organization; 2005.

49. Crate SA, Nuttall M. Introduction: anthropology and climate change. In Crate SA, Nuttall M, eds. *Anthropology and Climate Change: From Encounters to Actions*. Walnut Creek, CA: Left Coast Press; 2009, 9–36.
50. Moran EF. *Environmental Social Science: Human–Environment Interactions and Sustainability*. Malden, MA: Wiley-Blackwell; 2010.
51. Costanza R, Graumlich LJ, Steffen W, eds. *Sustainability or Collapse? An Integrated History and Future of People on Earth*. Cambridge, MA: MIT Press; 2007.
52. Tainter JA. Archaeology of overshoot and collapse. *Annu Rev Anthropol* 2006, 35:59–74.
53. Giddens A. *The Politics of Climate Change*. Cambridge: Polity Press; 2009, 2.
54. Mitchell P. Practising archaeology at a time of climatic catastrophe. *Antiquity* 2008, 82:1093–1103.
55. Beck U. *Risk Society: Towards a New Modernity*. London: Sage; 1992.
56. Barry J. *Environment and Social Theory*. 2nd ed. London: Routledge; 2007, 109.
57. Bailey G.N., ed. *Klithi: Paleolithic Settlement and Quaternary Landscapes in Northwest Greece*. Cambridge: McDonald Institute for Archaeological Research; 1997.
58. Cited in *Publics: Culture, Democracy and Climate Change*. Open University podcast.
59. Whyte I. *World Without End? Environmental Disaster and Collapse of Empires*. London: I.B. Tauris; 2008, 7–8.
60. Kurlansky M. *Cod: A Biography of the Fish that Changed the World*. London: Penguin; 1998, 204.
61. Žižek S. *Living in the End Times*. London: Verson; 2010, 132.
62. Lowenthal D. *The Past is a Foreign Country*. Cambridge: Cambridge University Press; 1985, 65.
63. Albrecht G. 'Solastalgia': A new concept in health and identity. *PAN: Philos Activism Nat* 2005, 3: 41–55.
64. Schneider SH, Kuntz-Duriseti K, Azar C. Costing nonlinearities, surprises, and irreversible events. *Pac Asian J Energy* 2000, 10:81–106.
65. Trigger B. Alternative archaeologies: nationalist, colonialist, imperialist. *Man* 1984, 19:355–370.
66. Habu J, Fawcett C, Matsunaga JM, eds. *Evaluating Multiple Narratives: Beyond Nationalist, Colonialist, Imperialist Archaeologies*. New York: Springer; 2008.
67. Merchant C. *Earthcare: Women and the Environment*. London: Routledge; 1999.
68. Bettinger RL. *Hunter-Gatherers: Archaeological and Evolutionary Theory*. New York: Plenum Press; 1991.
69. Yasuda Y. Kankyō kōkogaku ga chikyū to jinrui o sukū (Environmental archaeology can save the earth and humanity). In Yasuda Y, ed. *Hajimete Deau Nihon Kōkogaku (A First Introduction to Japanese Archaeology) [in Japanese]*. Tokyo: Yūhikaku; 1999, 3–42.
70. Oguma E. *A Geneaology of 'Japanese' Self-images*. Melbourne: Trans Pacific Press; 2002.
71. Thomas JA. *Reconfiguring Modernity: Concepts of Nature in Japanese Political Ideology*. Berkeley, CA: University of California Press; 2002.
72. Hani G. *Tenkeiki no Rekishigaku (The Historiography of Stages of Transformation) [in Japanese]*. Tokyo: Chūōkōronsha; 1946.
73. Hudson MJ. Pots not people: ethnicity, culture and identity in postwar Japanese archaeology. *Crit Anthropol* 2006, 26:411–434.
74. Chakrabarty D. The climate of history: four theses. *Crit Inq* 2009, 35:197–222.
75. Crutzen PJ. Geology of mankind. *Nature* 2002, 415:23.
76. Morton T. *Creativity in the Face of Climate Change: The Role of the Humanities in Awakening Societal Change*. University of California Berkeley Symposium, October 2008. Available as University of California Podcast.
77. McKibben B. *Eaarth: Making a Life on a Tough New Planet*. New York: Times Books; 2010, 98.
78. Jameson F. *Archaeologies of the Future: The Desire Called Utopia and Other Science Fictions*. London: Verson; 2005, 199.
79. Klein N. *The Shock Doctrine: The Rise of Disaster Capitalism*. New York: Picador; 2007.
80. Dörries M. Climate catastrophes and fear. *WIREs Clim Change* 2010, 1:885–890.
81. McAnany PA, Yoffee N, eds. *Questioning Collapse: Human Resilience, Ecological Vulnerability, and the Aftermath of Empire*. Cambridge: Cambridge University Press; 2009.
82. Walker B, Salt D. *Resilience Thinking: Sustaining Ecosystems and People in a Changing World*. Washington DC: Island Press; 2006, 164.
83. Redman CL. Resilience theory in archaeology. *Am Anthropol* 2005, 107:70–77.
84. Gunderson LH, Holling CS, eds. *Panarchy: Understanding Transformations in Human and Natural Systems*. Washington DC: Island Press; 2002.
85. Berkes F, Folke C, eds. *Linking Social and Ecological Systems: Management Practices and Social Mechanisms for Building Resilience*. Cambridge: Cambridge University Press; 1998.
86. Forbes BC, Stammler F, Kumpula T, Meschtyb N, Pajunen A, Kaarlejärvi E. High resilience in the Yamal-Nenets social-ecological system, West Siberian Arctic, Russia. *Proc Natl Acad Sci USA* 2009, 106:22041–22048.

87. Hegmon M, Peeples MA, Kinzig AP, Kulow S, Meegan CM, Nelson MC. Social transformation and its human costs in the prehispanic US southwest. *Am Anthropol* 2008, 110:313–324.

88. Cornell S, Costanza R, Sörlin S, van der Leeuw S. Developing a systematic science of the past to create our future. *Glob Environ Change* 2010, 20:426–427.

89. Hasegawa K. *Constructing Civil Society in Japan: Voices of Environmental Movements*. Melbourne: Trans Pacific Press; 2004, 49.

90. Morton T. *Ecology Without Nature: Rethinking Environmental Aesthetics*. Cambridge, MA: Harvard University Press; 2007.

91. Morton T. Queer ecology. *PMLA* 2010, 125:273–282.

92. Walker BL. *Toxic Archipelago: A History of Industrial Disease in Japan*. Seattle, WA: University of Washington Press; 2009.

93. Aoyama M. Indigenous Ainu occupational identities and the natural environment in Hokkaido. In Pollard N, Sakellariou D, eds. *Politics of Occupation-Centred Practice: Reflections on Occupational Engagement Across Cultures*. Oxford: Wiley-Blackwell; 2012, 106–127.

94. Checker M. *Polluted Promises: Environmental Racism and the Search for Justice in a Southern Town*. New York: New York University Press; 2005.

95. Smith R, Lourie B. *Slow Death by Rubber Duck: The Secret Danger of Everyday Things*. Berkeley, CA: Counterpoint; 2009.

96. Frost NR. Environmental education: Perspectives for archaeology. In Smardz KE, Smith SJ, eds. *The Archaeology Education Handbook: Sharing the Past with Kids*. Walnut Creek, CA: AltaMira; 2000, 377–393.

97. Hector SM. Archaeology and young students: Making the environmental education connection. *Proc Soc Calif Arch* 2002, 16:9–12

98. Aoyama M, ed. *Kanzaki no rekishi kara manabō: Shizen to hito no kurashi (Learning from the History of Kanzaki: Nature and Human Livelihoods) [in Japanese]*. Kanzaki: Human Activity and Sustainability Group; *in press*.

99. Ehrlich PR. A personal view: environmental education—its content and delivery. *J Environ Stud Sci* 2011, 1:6–13.

100. Fagan B. *The Great Warming: Climate Change and the Rise and Fall of Civilizations*. New York: Bloomsbury Press; 2008.

101. Diamond J. *Collapse: How Societies Choose to Fail or Succeed*. New York: Viking Penguin; 2005.

102. Adger WN, Paavola J, Huq S. Toward justice in adaptation to climate change. In Adger WN, Paavola J, Huq S, Mace MJ, eds. *Fairness in Adaptation to Climate Change*. Cambridge, MA: MIT Press; 2006, 1–19.

103. Dow K, Kasperson RE, Bohn M. Exploring the social justice implications of adaptation and vulnerability. In Adger WN, Paavola J, Huq S, Mace MJ, eds. *Fairness in Adaptation to Climate Change*. Cambridge, MA: MIT Press; 2006, 79–96.

104. Hassan FA. The lie of history: nation-states and the contradictions of complex societies. In Costanza R, Graumlich LJ, Steffen W, eds. *Sustainability or Collapse? An Integrated History and Future of People on Earth*. Cambridge, MA: MIT Press; 2007, 169–196.

105. Hudson MJ. Kodomo to kikō hendō (Children and climate change). In Nishikyūshū Daigaku Kodomogaku Kenkyūkai, eds. *Kodomogaku no Susume (The Future of Childrens Studies) [in Japanese]*. Saga: Saga Shinbunsha; 2012, 112–125.

106. McGuire RH. *Archaeology as Political Action*. Berkeley, CA: University of California Press; 2008, 3.

107. Kjellen B, Foreword. In Adger WN, Paavola J, Huq S, Mace MJ, eds. *Fairness in Adaptation to Climate Change*. Cambridge, MA: MIT Press; 2006, vii–x.

108. Costanza R. The need for a transdisciplinary understanding of development in a hot and crowded world. In Bhaskar R, et al., eds. *Interdisciplinarity and Climate Change: Transforming Knowledge and Practice for our Global Future*. London: Routledge; 2010, 135–148.

109. Buell L. *The Future of Environmental Criticism: Environmental Crisis and Literary Imagination*. Oxford: Blackwell; 2005.

110. Greeves T. Reclaiming the land: why archaeology is green. In Macinnes L, Wickham-Jones CR, eds. *All Natural Things: Archaeology and the Green Debate*. Oxford: Oxbow; 1990.

111. Berry W. *What are People For?* San Francisco, CA: North Point Press; 1990.

112. Heise UK. *Sense of Place and Sense of Planet: The Environmental Imagination of the Global*. Oxford: Oxford University Press; 2008.

113. Schneider SH, Lane J. Dangers and thresholds in climate change and the implications for justice. In Adger WN, Paavola J, Huq S, Mace MJ, eds. *Fairness in Adaptation to Climate Change*. Cambridge, MA: MIT Press; 2006, 23–51.

FURTHER READING

Fisher CT, Hill JB, Feinman GM, eds. *The Archaeology of Environmental Change: Socionatural Legacies of Degradation and Resilience*. Tucson, AZ: University of Arizona Press; 2009.

Kirch PV. Archaeology and global change: the Holocene record. *Annu Rev Environ Resour* 2005, 30:409–440.

Redman CL. *Human Impact on Ancient Environments*. Tucson, AZ: University of Arizona Press; 1999.

Redman CL, James SR, Fish PR, Rogers JD, eds. *The Archaeology of Global Change: The Impacts of Humans on Their Environment*. Washington DC: Smithsonian Institution; 2004.

Tainter JA. *The Collapse of Complex Societies*. Cambridge: Cambridge University Press; 1988.

van der Leeuw S, Redman CL. Placing archaeology at the center of socio-natural studies. *Am Antiq* 2002, 67:597–605.

The Association for Environmental Studies and Sciences (www.aess.info) is an umbrella organization for inter-disciplinary approaches and has recently begun a new *Journal of Environmental Studies and Sciences*.