THE ASSOCIATIONAL CRITIQUE OF QUATERNARY OVERKILL AND WHY IT IS LARGELY IRRELEVANT TO THE EXTINCTION DEBATE

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The overkill hypothesis has been criticized using a simple observation—-with the exception of New Zealand, there is little evidence for human hunting of extinct Quaternary faunas. We explore the legitimacy of this argument, or what we call the “Associational Critique,” the idea that the paucity of evidence for the subsistence exploitation of extinct taxa weakens or falsifies overkill. Using quantitative and probabilistic models, based on the temporal depth of extinction events, human demography, and taphonomic bias, we ask how many associations with extinct fauna should have been found by this point in time in Australia, North America, and New Zealand. We conclude that such evidence should be rare in Australia, of intermediate abundance in North America, and common in New Zealand, a conclusion very much in accord with the current state of the archaeological record. We reach a similar conclusion using an analysis of the relative frequency of radiocarbon dates from each region dating to the time of coexistence of humans and extinct fauna. We argue that a scarcity of evidence for the exploitation of extinct fauna is not only consistent with overkill but also nearly every other extinction hypothesis that has been proposed, thus rendering the Associational Critique irrelevant.

Over the last 100,000 years, on both continents and islands, a huge number of large mammals, birds, and reptiles suffered extinction. Quaternary extinction events differed regionally in terms of timing, severity, and size selectivity. Of the continents, North America, South America, and Australia were especially hard hit, where dozens of megafaunal taxa suffered extinction, while many large-bodied mammals survived to the present in parts of Africa and Asia.

Global explanations for Pleistocene and Holocene extinctions point to human hunting (e.g., Cione et al. 2009; Flannery 1994; Haynes 2007; Holdaway and Jacomb 2000; Johnson 2006; Martin 1984; Martin and Steadman 1999; Surovell and Waguespack 2009; Surovell et al. 2005) or disease (e.g., MacPhee and Marx 1997) as primary causal agents, while various climatic, ecological, and even extraterrestrial hypotheses have been proposed to explain each regional extinction event or even the extinction of individual taxa (e.g., Firestone et al. 2007; Graham and Lundelius 1984; Grayson and Meltzer 2002, 2003; Guthrie 1984, 2003; Horton 1984; Miller et al. 2000).

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In this paper, we are concerned with the overkill hypothesis, the idea that the majority of animal extinctions that occurred during the late Quaternary were caused by human predation.

The overkill hypothesis receives most of its support from two lines of circumstantial evidence. First, extinction events globally correlate in time to some degree with initial human colonization. Details of chronology remain to be worked out for both colonization and extinction in many places, but this generalization can and has been applied minimally to temperate and arctic Eurasia, Australia, North and South America, Mediterranean islands, multiple Pacific archipelagos, the Caribbean, Madagascar, and New Zealand (Barnosky and Lindsey 2010; Barnosky et al. 2004; Faith and Surovell 2009; Gillespie 2008; Gillespie et al. 2006; Johnson 2006; MacPhee and Marx 1997; Martin 1984; Martin and Steadman 1999; Steadman et al. 2005; Surovell et al. 2005). Second, extinctions on continents were highly selective, preferentially impacting animals of large body mass and/or low reproductive potential, a pattern that is easily explained by human hunting but more difficult to reconcile with other causal agents (Alroy 1999; Brook and Bowman 2004; Johnson 2002; Lyons, Smith, and Brown 2004; Lyons, Smith, Wagner, White, and Brown 2004).

These two facts, the first being the most arguable, provide strong support for overkill, but still the idea of anthropogenic extinction remains highly controversial. The primary argument against humans as global agents of extinction by predation is what we call the “Associational Critique” (Meltzer 1986). The Associational Critique points out that with few exceptions, there is little archaeological evidence for human hunting of extinct species (Adovasio and Page 2002:127–128; Dillehay 2000:72; Grayson 2001; Grayson and Meltzer 2002, 2003; Wroe et al. 2004). If humans caused the extinction of dozens of genera of megafauna worldwide, they must have killed millions of animals in the process. Yet, in North America, there is strong evidence for the hunting of only two to four of the some 35 genera that suffered extinction (Cannon and Meltzer 2004; Grayson and Meltzer 2002, 2003; Surovell and Waguespack 2009), despite archaeologists having completed more than 100 years of fieldwork on that continent. In Australia, there is essentially no direct evidence for human predation of any extinct taxon (Gillespie et al. 2006; Johnson 2006; Roberts and Brook 2010; Wroe et al. 2004). By contrast in New Zealand, archaeologists have investigated more than 100 sites showing human exploitation of moas, and not surprisingly, there is little debate that humans played a major role in the extinction of New Zealand’s giant ratites (Anderson 1989; Grayson 2001; Grayson and Meltzer 2003; Holdaway and Jacomb 2000; Worthy and Holdaway 2002).

If the overkill hypothesis is correct, it must be able to accommodate the abundance of archaeological evidence for human predation of extinct taxa in New Zealand, the dearth of evidence in North America, and the complete absence of evidence in Australia. This idea is at the heart of the Associational Critique and provides a major challenge to overkill. For example, Grayson and Meltzer (2003) have noted this apparent contradiction with respect to Paul Martin’s (1984) North American overkill arguments:

Martin has attempted to account for the virtual absence of kill sites in an extraordinary way. He argues that it all happened so fast that we should not expect to find empirical evidence of that process... Martin argues quite differently for New Zealand, where he calls on the abundance of archaeological sites containing moa remains to bolster his position that human hunting played a role in the extinction of these animals [Grayson and Meltzer 2003:588].

We will argue that not only is the overkill hypothesis perfectly capable of accommodating these seemingly disparate facts, but also that the Associational Critique has little validity. The Associational Critique rests upon the assumption that if prehistoric humans in North America, Australia, and other parts of the world killed millions of animals in the process of driving them to extinction, then at this point in archaeological history, we should have found direct evidence of it. Based on temporal depth, human demographics, taphonomic processes, the probabilistic nature of archaeological sampling, and empirical properties of the archaeological record, we suggest that the Associational Critique is flawed.
The Theoretical Case

If human predation caused the extinction of Pleistocene megafauna, how many extinct faunal associations (hereafter EFAs) should we have found by the time you have read this sentence? The archaeological abundance of anything, whether EFAs, complete ceramic vessels, or teeth of *Homo ergaster*, should be proportional to its relative frequency in the archaeological record (probability of discovery), and how much effort we have expended in looking (sample size) (Surovell and Waguespack 2008). Therefore, critical to addressing the question of how many EFAs should have been found by this point in time is the question of what factors control their relative frequency in the archaeological record.

To use a simple analogy, imagine a jar (the archaeological record) in which are placed two colors of marbles, red and blue. Red marbles represent EFAs; blue marbles represent every other kind of archaeological site. The relative frequency of red marbles depends on only two things: (1) the number of red marbles placed in the jar, and (2) the number of blue marbles placed in the jar. Therefore, the relative frequency of any archaeological find will be in part controlled by two factors: (1) how frequently that thing happened (human behavior and demography); and (2) how many other things happened in the past (human behavior and demography). Of course, unlike a jar of marbles, the archaeological record is not a static receptacle. Those marbles (or sites) are removed from the jar (or archaeological record) through time because destructive forces, like erosion, operate incessantly. Thus, the relative frequency of a particular type of archaeological find will also depend upon how frequently each of those things (red marbles) and all other things (blue marbles) survive to the present. In other words, we must view relative frequency through the window of geomorphology and taphonomy.

In this framework, teeth of *Homo ergaster* are rare today because (1) populations of *Homo ergaster* were not large at least in comparison to those of later *Homo sapiens*, and only a small group of researchers are looking for them (archaeologists spend a lot more time looking for other things); and (2) hominin teeth, 1.5 million years in age, survive to the present only in sites that have not been destroyed by erosion and have geochemical conditions conducive to bone preservation. How do EFAs in North America, Australia, and New Zealand fit into this framework?

Relative Temporal Depth

A good starting point for addressing the expected relative frequency of EFAs in each region is to estimate the temporal fraction of the archaeological record during which the hunting of extinct fauna could have occurred (Figure 1). This can provide an initial estimate of relative archaeological frequency. Gillespie (2008) has shown that there is clear evidence for temporal overlap, although brief in geologic time, of humans and extinct fauna in all three regions.

In Australia, the earliest dates for human occupation in Australia are roughly synchronous with the youngest dates on extinct fauna, both occurring between 50,000 and 40,000 cal B.P. (Bowler et al. 2003; Gillespie et al. 2006; Miller et al. 1999, 2005; Roberts et al. 2001; Turney et al. 2001). Based on a systematic evaluation of dates on both the earliest Australian archaeological sites and the last megafauna, Gillespie et al. (2006) provide age estimates of 45,700 cal B.P. for initial human colonization and 41,700 cal B.P. for megafaunal extinction. Assuming these estimates are correct, evidence for human hunting of extinct taxa could be recovered from approximately 8.8 percent of the archaeological record, chronologically speaking. In North America, dates from Paisley Cave, Oregon (Gilbert et al. 2008) suggest colonization by 14,200 cal B.P., and faunal extinction appears to have been roughly coincident with the onset of Younger Dryas cooling at ca. 12,800–12,700 cal B.P. (Faith and Surovell 2009; Fiedel 2009; Haynes 2008). Thus, EFAs could be recovered from approximately 10 percent of the archaeological record in North America. In New Zealand, dating of rat bone and rat-gnawed seeds suggest a colonization date of 670 cal B.P. (Wilmshurst et al. 2008). Moa extinction followed very quickly and was likely complete by 500 cal B.P. (Holdaway and Jacomb 2000), so evidence of moa hunting can occur within approximately 25 percent of the record. By this analysis alone, EFAs would be expected to be at least 250 percent more abundant in New Zealand than in Australia and North America.1
Figure 1. Relative temporal depth of periods of human and extinct faunal coexistence in Australia, North America, and New Zealand. Gray bars indicate the presence of extinct fauna. White bars indicate the presence of humans. Hatched bars indicate periods of coexistence of both humans and extinct fauna.
Demographic Dilation

This conclusion, however, rests on the false assumption that all time periods are equally represented in the archaeological record. Population growth inflates the abundance of recent archaeological deposits in comparison to those from the early prehistory of a region. Beginning with demography, if it is assumed that founding populations were small and grew through time, later portions of the archaeological record should be better represented than the centuries immediately following colonization. All else being equal, the magnitude of this effect should correlate with the temporal depth of human occupation in a region because later portions of the record will increasingly swamp out earlier portions.

Although any theoretical or empirical demographic model could illustrate this phenomenon, we use a simple logistic growth model. In this framework, the relative frequency of archaeological sites which have the potential to exhibit EFAs ($p_{EFA}$) is expressed as the ratio of the cumulative human population size over the period of coexistence of humans and now extinct fauna to the cumulative population size over the entire span of human occupation of a region:

$$p_{EFA} = \frac{\int_{t=0}^{t_{eq}} \frac{kp_{e}e^{rt}}{k + p_{o}(e^{rt}-1)} dt}{\int_{t=0}^{t_{max}} \frac{kp_{e}e^{rt}}{k + p_{o}(e^{rt}-1)} dt}$$

where $t = 0$ represents initial colonization, $t_{eq}$ is the time elapsed between colonization and extinction, $t_{max}$ is the total time depth of prehistory in a region, $p_{o}$ is the founding population size, $k$ is the carrying capacity, and $r$ is the intrinsic rate of population growth.

A specific example is shown in Figure 2. Modeled roughly after the case of New Zealand, assuming a colonizing population of 100 individuals, a carrying capacity of 150,000 based on estimates of Maori population size at contact (Brewis et al. 1990; Pool 1977), and extinction occurring after 200 years, the resulting dilution of EFAs is presented for five different rates of annual population growth ranging from $r = .001$ to .025. Unlike the actual colonization of New Zealand, which occurred only 700 years ago, the resulting model is shown for a 10,000-year period to illustrate the evolution of the archaeological record over a much longer time span. Depending upon the population growth rate, 700 years after colonization, or 500 years following faunal extinction, between .8 and 22 percent of sites would date to the period of coexistence of humans and extinct fauna. Once 10,000 years have elapsed since colonization in this model, sites with potential EFAs are reduced to between .04 and .002 percent of the record. In the best case 1 in 2,500 sites would be of the right age to contain EFAs; in the worst case, only 1 in 40,000 sites would date to this time period.

Because the actual degree of dilution of EFAs is dependent upon the human demographic history of a region, we hesitate to accept these exact values as meaningful, but the general trend should hold. Due to population growth, which is nonlinear and accelerating, early parts of the archaeological record quickly become swamped out by later sites, and the magnitude of this effect is proportional to temporal depth. Therefore, it would be expected that the relative frequency of EFAs should be lowest in Australia, highest in New Zealand, and intermediate in North America.

Lacking from this analysis is the question of the population dynamics of prey species. If overkill is assumed, populations of extinct taxa would have been steadily and steeply declining while human populations grew. The net effect would be to make extinct animals most likely to be recovered (because their populations would have been greatest) from sites that are most difficult to find (because human population densities would have been at their lowest). By the time human populations have grown substantially, presumably animal populations would have been at their minimum. The net effect would be to reduce the likelihood of the discovery of EFAs even more. Also, consider that the likelihood of finding sites dating to the earliest centuries of human colonization is very low. Likewise, the probability of finding individuals of a species dating near an extinction event is also very low. Therefore, the probability of finding both in association will be the product of the two, and should be an extremely small number.

Taphonomic Bias

While human population growth following faunal extinction will affect the relative abundance of
EFAs, it should not affect their absolute abundance. Taphonomic factors, including the dissolution, weathering, and scavenging of bone, and the erosion of sediments, do cause the loss of EFAs from the archaeological record, and again the magnitude of this effect is proportional to time (Surovell and Brantingham 2007; Surovell et al. 2009).

With colleagues, the first author developed an empirical model of taphonomic bias, or the loss of sedimentary contexts through time, based on the global temporal frequency distribution of radiocarbon dates associated with volcanic deposits (Surovell et al. 2009). Based on that model, Figure 3 illustrates the predicted loss of archaeological sites to destructive processes over time. All things being equal, 500 years after the extinction of moas in New Zealand, at most 75 percent of the original EFAs should still be available for investigation. In comparison, it would be expected that 6.8 percent of North American EFAs should still exist today, and 1.4 percent of those in Australia. These differences, however, consider only the loss of sites to erosion and not the loss of bone to weathering and dissolution. Because diagenetic processes are also time-dependent, they should make these differences even more extreme. The net result is that it would be expected that EFAs should be both relatively and absolutely common in the case of the recent colonization and extinction events in New Zealand and extremely rare in the case of Australia with more than 45,000 years of temporal depth.

In sum, the temporal fraction of the archaeological record in which EFAs can be recovered from Australia, North America, and New Zealand in combination with the effects of population growth and taphonomic bias should cause the relative frequency and likelihood of discovery of EFAs in each region to correlate inversely with temporal depth. In other words, with comparable archaeological samples, evidence for the exploitation of extinct fauna should be most common in New Zealand, least common in Australia, and of intermediate abundance in North America. We hesitate to provide exact predictions as to relative abundance because they will be determined by the unique demographic and taphonomic histories of each case. Nonetheless, given the nonlinear nature of taphonomic loss and population growth, it would be expected that the differences should be extreme.

The Empirical Case

A test of this hypothesis, independent of the known frequencies of EFAs, is possible using databases of age estimates from archaeological deposits in each region. We assume that frequency distributions of radiocarbon assays reflect the relative abundance of archaeological sites through
time in a given region. In other words, if relatively few assays are present from particular segment of time, then few sites of that age are present or at least few have been sampled by archaeologists. It is predicted that the relative frequency of assays falling within the period of overlap of humans and extinct fauna in New Zealand should greatly exceed that of North America, which in turn should be greater than that of Australia.

Accordingly, we compiled a database of nearly 6,000 radiocarbon assays from the three regions. Those from New Zealand include 498 determinations from the New Zealand Radiocarbon Database (NZARD 2003). The North American sample encompasses 5,188 assays compiled from six statewide databases, including those from California (Breschini et al. 2004), Kentucky, Ohio, and West Virginia (Maslowski et al. 1995), Louisiana (McGimsey and van der Koogh 2001), and Wyoming (Wyoming SHPO 2010). Australian assays were taken from the AustArch1 Database, which includes 499 14C estimates from Australia's arid zone. (Williams et al. 2008).

With the exception of the Kentucky, Ohio, and West Virginia database (Maslowski et al. 1995), which lacks sample material information, to minimize contamination problems only assays on charcoal were included in the analysis. All age estimates were calibrated using CalPal calibration software and the CalPal 2007 Hulu curve (Weninger and Jöris 2008; Weninger et al. 2009). After calibration those assays exceeding estimated colonization ages for each region (Australia: 45,700 cal B.P.; North America: 14,200 cal B.P.; New Zealand: 670 cal B.P.) were discarded. The remaining assays were divided into those pre- and post-dating estimated faunal extinction dates (Australia: 45,700 cal B.P.; North America: 12,800 cal B.P.; New Zealand: 500 cal B.P.), and the relative proportion of assays falling into the period of coexistence of human and extinct fauna was calculated.

A couple of caveats are necessary before proceeding. Except in the cases where age estimates were explicitly labeled as “noncultural” by the authors of a database or exceeded estimated colonization ages, were any attempts made to vet the databases of dates of questionable cultural association. Therefore, it is not only possible but also likely that some fraction of the assays used in this analysis is of questionable association to cultural remains. Also, because the date of colonization of Australia is near to the temporal limit of the radiocarbon method, small amounts of contamination can produce serious dating errors for samples greater than 40,000 years in age (Taylor 1987:116–117). Finally, we suspect that the earliest time periods in these datasets are somewhat overrepresented, particularly for the cases of North America and Australia, for the reason that when building such databases extra effort is often made to include the oldest known estimates from a region. Such estimates not only have high value socially and scientifically, but they also establish the extreme values or limits of the data. For all these reasons, we consider this analysis to provide only rough approximations of the relative frequency of archaeological sites in each region dating to the period of coexistence of humans and extinct fauna; but for the purposes of this study, rough estimates should be more than adequate.

Mean calibrated radiocarbon ages dating to the period of coexistence of humans and moas in New Zealand (670–500 cal B.P.) are extremely common (Figure 3), representing more than 40
percent of all assays on charcoal from the country (95 percent C.I.: 43.4 ± 4.4 percent). By comparison, radiocarbon assays from North America pre-dating 12,800 cal B.P. represent less than 1 percent of the record as a whole (.3 ± .2 percent), or approximately 1 out of every 300 sites (see also Peros et al. 2009). Sites dating before 45,000 cal B.P. in Australia are even less common. Of the 499 assays included in the analysis, only one (.2 ± .4 percent) dates to this time period (see also Attenbrow 2004; Hiscock 2008; Johnson 2006). In brief, based only on the relative frequency of radiocarbon assays from archaeological sites, EFAs can be expected to be more than two orders of magnitude more abundant in New Zealand than in both North America and Australia for samples of similar size.

This analysis, however, fails to consider that in order to discover EFAs archaeologically, not only must dateable deposits be present, but also that those deposits must preserve faunal remains. A large-scale systematic study of the time-dependent nature of bone preservation is thus warranted, but for the purposes of this study, it is unnecessary. Instead, a handful of comparative observations about the preservation of extinct fauna in North America and New Zealand should suffice to illustrate that there are vast differences in preservation of bone that can easily be explained by temporal depth.

The Archaeological Records of New Zealand, North America, and Australia Compared

The first Polynesians arrived in New Zealand roughly 700 years ago (ca. A.D. 1280). Within a couple of centuries (ca. A.D. 1400–1450), more than half a dozen species of moa were lost to extinction. Europeans first reached the shores of New Zealand about 200 years later in the mid-seventeenth century, but colonies were not truly established until the early AD 1800s. Therefore, when people of European descent began to explore the islands of New Zealand, moas had not likely walked that ground for some 400 years. Although there were few persons of European descent in New Zealand in the early nineteenth century, by the 1840s not only had they found remains of moas (Anderson 1989:11–16), but also archaeological evidence that moas had been hunted by the ancestors of the native Maori (Anderson 1989:97–109). Furthermore, the cultural memory of the hunting of the extinct birds was still very much alive in Maori language and oral history (Anderson 1989:88–94).

The first European colonies were established in the Americas in the early-sixteenth century, although no permanent North American settlements were formed until the late-sixteenth and early-seventeenth centuries. When Europeans arrived in the New World, mammoths, horses, camels, and ground sloths had been extinct for more than 12,000 years. Although fossils of Pleistocene megafauna were known to Europeans in the New World by the early-eighteenth century (Jefferson 1984; Simpson 1943), clear evidence that the ancestors of Native Americans had preyed upon extinct species was not found until some 330 years after initial European colonization (Meltzer 2006).

In other words, in New Zealand, it took only a few decades for a very small population of colonial Europeans to discover archaeological evidence of moa predation. In the New World, it took a few centuries for a very large population of “nonnative Americans” to discover archaeological evidence of mammoth predation. The reason for the difference is clear. Archaeological evidence for predation of moas in New Zealand is not only relatively common, but it is also common in the absolute sense. Neither variety of commonness describes evidence of human predation of mammoths in North America.

Consider the nature of the record of moa predation in New Zealand. Not only are a huge number of sites known both from the North and South Islands, but many of those sites are in near-surface contexts, or in some cases they are found lying directly on the ground surface (Anderson 1984, 1989; Cassels 1984; Trotter and McCulloch 1984). In brief, so little time had elapsed between the extinction event and the first archaeological sampling of that event that a huge fraction of the material evidence showing human involvement in that event was, and remains today, quite well preserved. This record is so abundant and well preserved that a relatively small number of archaeologists, both professional and avocational (the population of New Zealand today is less than one percent of that of the United States), have been able to amass a huge
amount of evidence dating to the time of coexistence of humans and extinct species.

By contrast, in North America after a huge number of archaeologists have combed the ground for EFAs for more than a century, fewer than 30 sites have anything whatsoever to say about the subsistence practices of the earliest hunter-gatherers of the continent (Cannon and Meltzer 2004; Surovell and Waguespack 2009; Waguespack and Surovell 2003). This difference cannot be explained entirely by a shortage of sites. The Paleoindian Database of the Americas (Anderson et al. 2005) as of April 2009 includes more than 4,400 finds of Clovis points from hundreds of localities across North America. Most of these projectile points were found in surface or near surface contexts, and were associated with no bone whatsoever. Given the function of projectile points, the lack of association of faunal remains with weaponry would speak to a largely missing and silent record of subsistence. In other words, it is clear that a huge amount of bone has been lost from the early Paleoindian record from near surface contexts that still preserve abundant evidence for predation of moas in New Zealand.

Some 200 years after the initial European colonization of Australia, EFAs remain unknown. This absence can in part be explained by the delayed history of professional archaeology in that country, having the effect of reducing the sample size of investigated archaeological sites relative to North America (Kelly 2003; Lourandos 1997; Mulvaney and Kamminga 1999:11–14); but like North America, sites dating the period of coexistence of humans and extinct fauna are rare.

By this point, a simple objection to our analysis should be obvious. One could argue that there are other perfectly reasonable explanations for why EFAs are rare in North America and absent from Australia; that is, humans rarely hunted extinct fauna in North America and when they did, it was only a few select taxa. In Australia, humans never hunted extinct species. Although we think this argument is logical, reasonable, and at this point in time, difficult to refute, we have two responses.

First, our argument is that if overkill occurred in all three regions, the archaeological record would be expected to be structured exactly as it is. In other words, there is nothing about the archaeological record of EFAs as it exists today that is problematic for the overkill hypothesis. Similarly, if the archaeological records of North America and Australia showed that humans were doing something other than the hunting extinct taxa during the period of human and faunal coexistence, then it would be difficult to make the argument that human predators were agents of extinction. In other words, does the archaeological record speak to subsistence strategies that are incompatible with the overkill hypothesis?

In brief, we think the answer is no. While the subject of early Paleoindian subsistence in North America has been fodder for recent debate (Bar-
ton et al. 2004; Byers and Ugan 2005; Cannon and Meltzer 2004; Graf and Schmitt 2007; Speth et al. 2012; Surovell and Waguespack 2009; Waguespack and Surovell 2003; Walker and Driskell 2007), extinct megafaunal taxa occur in up to 97 percent of North American early Paleoindian sites, and 18 locally or globally extinct genera of megafauna have been recovered from early Paleoindian contexts, although most of those associations are ambiguous with respect to their significance to subsistence (Surovell and Waguespack 2009:88–91). Furthermore, the few sites in North America that clearly date to the time of the coexistence of humans and extinct taxa exhibit excellent bone preservation, and have been published to the extent that the evidence for subsistence can be clearly evaluated, consistently showing evidence for the preferential targeting of megafaunal taxa (Surovell and Waguespack 2009; Waguespack and Surovell 2003).

Even though humans and megafauna overlapped temporally in Australia (Garling 1998; Gillespie et al. 2006; Golson 1993; Mountain 1993), no megafaunal kill sites have been discovered. Furthermore, there is no compelling evidence for any kind predator/prey relationship between humans and extinct megafauna (Gillespie et al. 2006; Roberts and Brook 2010). Part of the reason for this scarcity of evidence may be because very little archaeological material at all is known from this time period (Hiscock 2008:43, O’Connor and Veth 2006). Additionally, in many early sites, only lithic artifacts have been recovered, and often very few of those (O’Connell and Allen 2007; O’Connor and Veth 2006). Moreover, it is difficult to evaluate these and other early Australian sites for artifact content because relatively little is published about them. Pleistocene megafauna have been recovered from fewer than 200 paleontological localities across Australia throughout all time (Field et al. 2008), and only a few more than a dozen archaeological sites even date to the estimated period of overlap between humans and megafauna (see Johnson 2006:59). But most importantly, there is hardly any published evidence or analysis of any kind of subsistence strategy employed by the earliest inhabitants of Australia, at least evidence that unambiguously predates megafaunal extinctions. In other words, the absence of evidence for human exploitation of extinct Australian megafauna does not speak whatsoever to the question of megafaunal exploitation by humans.

Discussion

In 1973 Paul Martin wrote, “an explosive model will account for the scarcity of extinct animals associated with Paleo-Indian artifacts in obvious kill sites” (Martin 1973:972) Using taphonomic arguments founded on actualistic research, in 2007 Gary Haynes (2007:85–86) wrote of the North American case, “the fact that we have not found unambiguous kill sites of camels or any other extinct taxon is not a good enough reason to reject the Overkill hypothesis.” For Australia, Brook et al. (2007:562) have also argued that “absence of evidence for kill sites is not evidence of absence,” and Brook and Johnson (2006) have shown how modest levels of selective hunting of juvenile *Diprotodon* can cause a sudden population crash, which would be very difficult to detect in the archaeological record. We have come to similar conclusions for different reasons herein. Our argument can be summarized as follows: *If overkill was responsible for the extinction of large bodied animals in Australia, North America, and New Zealand, with similar sample sizes, the frequency of EFAs known from the faunal record of each region should be proportional to the age of each extinction event.* In other words, the abundance of direct evidence for the predation of New Zealand moa is predicted by the overkill hypothesis, as is the absence of evidence for predation of Australian megafauna and the paucity of evidence for the hunting of extinct North American taxa.

The case of Madagascar provides an interesting example of importance of archaeological sample size in this discussion. Madagascar was colonized approximately 2,000 years ago, in comparison with North America and Australia, a very recent date. Therefore, it would be predicted that if overkill was responsible for the extinction of Madagascar’s giant lemurs, elephant birds, and hippos, evidence of that event should not be particularly difficult to find. However, in comparison
to the three case studies examined in this paper, the size of our current archaeological sample in Madagascar is very small (Dewar and Wright 1993). Nevertheless, evidence of human exploitation of giant lemurs (Perez et al. 2005), elephant birds (Burney 1999), and hippos (MacPhee and Burney 1991) has been discovered, providing a hint that if intensive archaeological research were performed there with the intent of discovering EFAs, it would probably be successful.

Eurasian megafaunal extinctions could be considered problematic for overkill in this framework because unlike Australia and the Americas, modern humans and extinct megafauna coexisted for some 30,000 years. Thus, one could argue that if humans were responsible for the extinction of elephants, mammoths, rhinos, giant deer, and other extinct taxa, then evidence for the exploitation of those taxa should not be difficult to discover archaeologically because predation would have occurred over a prolonged period of time. We would argue, however, that this coexistence is more apparent than real. While both humans and extinct fauna existed on both continents for much of the Upper Pleistocene, multiple independent analyses suggest that until the terminal Pleistocene, humans and mammoths (and other extinct taxa) largely occupied different regions. Humans were sequestered in temperate regions while mammoths remained largely unexploited in high latitude areas (Pushkina and Raia 2008; Surovell et al. 2005; Ugan and Byers 2008). In fact, we would argue that there is no evidence for the kind of long term spatial overlap of humans and extinct megafauna in any part of Eurasia that would produce a highly visible archaeological record of EFAs. It is also worth noting that temperate European megafaunal taxa, such as *Palaeoloxodon Antiquus*, appear to have gone extinct shortly after the arrival of modern humans (40–50 ka), and only those species adapted to arctic conditions can be shown to have survived to the latest Pleistocene and early Holocene (Stuart 2005).

Returning to the North American case, if we were to ask which extinction hypotheses are also compatible with a scarcity of evidence for the hunting of extinct North American megafauna, the answer could easily be “all of them.” It is conceivable, for example, that minimal predation of Pleistocene megafauna occurred, but that climate change was ultimately responsible (e.g., Guthrie 1984). The same argument could be made about the extraterrestrial impact (Firestone et al. 2007), hyperdisease (MacPhee and Marx 1997), sitzkrieg (Diamond 1989), keystone herbivore (Owen-Smith 1987), multicausal (Haynes 1984), and other hypotheses. This renders the archaeological record of human predation of extinct animals largely irrelevant to the exercise of testing extinction hypotheses. If a prediction is common to all hypotheses, that prediction cannot be used to distinguish among them. For example, if one is trying to distinguish between a Chevrolet Corvette, a Ford Mustang, and a Dodge Charger, counting the wheels of a car is a pointless exercise.

We recognize that this idea will be controversial. Many archaeologists will not be fond of the notion that the abundance of direct archaeological evidence is largely irrelevant to testing an archaeological hypothesis. For example, Grayson and Meltzer (2003:585) have suggested that this mode of argumentation “removes the [overkill] hypothesis from the realm of science and places it squarely in the realm of faith,” but we disagree. “Faith” refers to belief in the absence of evidence, but the overkill hypothesis could be characterized as faithful only if one form of evidence is permitted to be germane to the process of hypothesis testing. For example, there is little to no evidence that prehistoric North Americans hunted giant ground sloths. Does it then require faith to argue that humans hunted ground sloths to extinction? No, it does not because there are other lines of evidence that can be brought to bear on the question.

Ground sloths had a large geographic range (Kurtén and Anderson 1980) which would have provided some insulation from climate change but not from predation by a colonizing human population. Multiple genera of ground sloths had survived dozens of prior glacial to interglacial transitions (Kurtén and Anderson 1980) casting doubt on the power of glacial climatic oscillations to cause large-scale extinctions in the Order Edentata. Multiple genera of giant ground sloth suffered extinction in North America within a few millennia of initial human colonization (Faith and Surovell 2009), putting humans on the ground at the time of extinction. The extinction of ground sloths was one part of a mass extinction event
that disproportionately affected large animals (Alroy 1999). Where we do have evidence of human hunting from this time period, humans preferentially targeted large-bodied animals (Surovell and Waguespack 2009; Waguespack and Surovell 2003). Ground sloths survived the climatic swings of the Pleistocene-Holocene transition on various Caribbean islands until suffering extinction upon human colonization (Steadman et al. 2005). On a global scale, the arrival of behaviorally modern humans to previously unoccupied areas was almost universally followed shortly by animal extinctions (Martin 1984; Martin and Steadman 1999). All of these empirical observations are consistent with overkill. While they do not show direct evidence of human predation of ground sloths, in sum, they make a circumstantial case, based on theory and data, supporting the idea that if humans had never colonized North America, ground sloths would be roaming the continent today.

Conclusion

If archaeologists hold overkill hostage by insisting upon abundant direct evidence for the predation for all extinct North American taxa, we are going to be waiting a long time. Our analysis of radiocarbon dates shows that archaeological sites dating to the time of the coexistence of humans and extinct fauna are rare. Those that preserve bone are considerably more rare, and of those, only a very few show unambiguous evidence of human hunting of any type of prey whatsoever. Therefore, it is going to take an enormous archaeological sample, orders of magnitudes larger than the one we currently have, to be able to assess whether the current absence (or scarcity) of direct evidence for the hunting of ground sloth and other extinct North American taxa is truly meaningful. Rather than waiting decades or lifetimes for such material evidence to materialize (or not), a much more prudent approach would be to focus on other lines of evidence relevant to the extinction debate, lines of evidence that can more effectively be used to distinguish between different extinction hypotheses.

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References Cited

Adovasio, James. M., and Jake Page

Alroy, John

Anderson, Atholl


Anderson, David G., Shane Miller, Stephen J. Yerka, and Michael K. Faught

Attenbrow, V. J.

Balmé, Jane, D. Merrilees, and J. K. Porter
1978 Late Quaternary Mammal Remains Spanning around 30,000 Years from Excavations in Devil’s Lair, Western Australia. Journal of the Royal Society of Western Australia 61:33–65.

Barnosky, Anthony D., and Emily L. Lindsey

Barnosky, Anthony D., Paul L. Koch, Robert S. Feranec, Scott L. Wing, and Alan B. Shabel

Barton, C. Michael, Steven Schmich, and Steven R. James


Breschini, G. S., T. Haversat, and J. Erlandson

Brewis, Alexandra A., Maureen A. Molloy, and Douglas G. Sutton

Brook, Barry W., and David M. J. S. Bowman
Brook, Barry W., and Christopher N. Johnson

Brook, Barry W., David A. Burney, Timothy F. Flannery, Michael K. Gagan, Richard Gillespie, Christopher N. Johnson, Peter Kershaw, John W. Magee, Paul S. Martin, Gifford H. Miller, Benny Peiser, and Richard G. Roberts

Burney, David A.

Byers, David A., and Andrew Ugan

Cannon, Michael D., and David J. Meltzer

Cassels, Richard

Cione, Alberto L., Eduardo P. Tonni, and Leopoldo Soibelzon

Clausen, C. J., A. D. Cohen, C. Emeliani, J. A. Holman, and J. J. Stuipp

Dewar, Robert E., and Henry T. Wright

Diamond, Jared M.

Dillehay, Tom D.

Faith, J. Tyler, and Todd A. Surovell

Ferring, C. Reid
2001 *The Archaeology and Paleoeocology of the Aubrey Clovis Site (41DN479), Denton County, Texas*. Center for Environmental Archaeology, Department of Geography, University of North Texas, Denton.

Fiedel, Stuart

Field, Judith, Melanie Filiois, and Stephen Wroe


Flannery, Timothy F.

Garling, Stephanie J.

Gilbert, M., Thomas P., Dennis L., Jenkins, Anders Gótherstrom, Nuria Naveran, Juan J. Sanchez, Michael Hofreiter, Philip Francis Thomsen, Jonas Binladen, Thomas F. G. Higham, Robert M. Yohe, Roberb Parr, Linda Scott Cummings, and Eske Willerslev

Gillespie, Richard

Gillespie, Richard, Barry W. Brook, and Alexander Baynes

Golson, Jack

Graf, Kelly, and Dave N. Schmitt

Graham, Russell W., and Marvin Kay

Graham, Russell W., and Ernest L. Lundeisius, Jr.

Grayson, Donald K.

Grayson, Donald K., and David J. Meltzer

Grin, Rainier, Stephen Eggins, Maxime Aubert, Nigel A. Spooner, and Allistair W. G. Pike

Guthrie, R. Dale


Haynes, C. Vance, Jr.


Hiscock, Peter

Johnson, C. N.


Kelly, Robert L.

Kurtén, Björn, and Elaine Anderson

Lourandos, Harry

Lyons, J. H. Brown

Lyons, S. K., F. A. Smith, and J. H. Brown

McGimsey, Charles R., and Josetta van der Kooij
2001 Louisiana’s Archaeological Radiometric Database. Special Publication of the Louisiana Archaeological Society No. 3, Baton Rouge.

MacPhee, Ross D. E., and David A. Burney

MacPhee, Ross D. E., and P. A. Marx

Martin, Paul S.


Martin, Paul S., and David W. Steadman

1995 The Kentucky, Ohio and West Virginia Radio carbon Database. West Virginia Archeologist 47(1&2).

Meltzer, David J.


Miller, G. H., Marilyn L. Fogel, John W. Magee, Michael K. Gagan, Simon J. Clarke, and Beverly J. Johnson

Miller, Gifford H., John W. Magee, Beverly J. Johnson, Marilyn L. Fogel, Nigel A. Spooner, Malcolm T. McCulloch, and Linda K. Ayliffe

Mithen, Steven

Mountain, Mary-Jane

Mulvaney, John, and Johan Kammenga
1999 Prehistory of Australia. Smithsonian Institution Press, Washington, D.C.

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O’Connell, James F., and J. Allen

2007 Pre-LGM Sahul (Pleistocene Australia-New Guinea) and the Archaeology of Early Modern Humans. In Re-thinking the Human Revolution: New Behavioural and Bi-


Notes

1. If we consider only the prehistoric portion of the archaeological record, the calculation for New Zealand is affected dramatically. Roughly 35 percent of the record would date to the period of coexistence of humans and moas. The differences in the North American and Australian calculations would be negligible.

2. It is important to note here that the Overkill hypothesis by its very nature predicts a greater frequency of hunting of extinct taxa than other extinction hypotheses, so this argument is not entirely fair. It does, however, mean that assessing the significance of very small numbers of associations in differentiating between extinction hypotheses must be done very carefully (e.g., Surovell and Waguespack 2008), particularly when the rate of predation that separates driving a species to extinction or not is a threshold value (e.g., Mithen 1993; Stiner et al. 2000).

3. Whether there is evidence for exploitation of ground sloths depends upon what is considered to constitute evidence. Although there are no finds that could be deemed strong evidence for subsistence association, a dermal ossicle of Glossotherium was recovered from the camp area at the Aubrey site (Ferring 2001:117). Glossotherium remains were also recovered from the Kimmswick site (Graham and Kay 1988), and Megalonyx was recovered at Little Salt Spring (Clausen et al. 1979).

4. Many inferences made by archaeologists about prehistory are based on indirect or circumstantial lines of evidence. For example, we have no direct evidence that early Paleoindians in North America wore pants, so must one be “faithful” to argue that Clovis and Folsom peoples spent the winter sans pants in Montana? There are clear theoretical reasons (based on known aspects of climate and human physiology) to believe these people would have worn pants, not to mention indirect evidence for tailoring in the form of bone needles (e.g., Wilmesen and Roberts 1984:131).
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