How many elephant kills are 14?
Clovis mammoth and mastodon kills in context

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Abstract

Recent evaluation of the use of Pleistocene megafauna by Clovis hunter-gatherers has suggested that a small number of reliable associations between Clovis artifacts and the remains of Proboscideans are documented, with perhaps as few as 14 occurrences currently known. Specifically, we ask whether 14 is a large or a small number of associations given the spatio-temporal dimensions of the Clovis period in North America. To place these 14 occurrences into context, we compare the time–space density and relative frequency of Clovis Proboscidean-bearing sites to those of Old World contexts. We develop models to identify the variables contributing to the archeological record of Proboscidean site creation, destruction, and sampling. While acknowledging potential biases in the record, comparative analysis suggests that the Clovis archeological record, with the possible exception of Lower Paleolithic of Iberia, indicates the highest frequency of subsistence exploitation of Proboscidea anywhere in the prehistoric world.
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1. Introduction

Clovis projectile points and other artifacts have been recovered in association with the remains of mammoths and mastodons from throughout the continental United States (e.g., Sellards, 1952; Haury, 1953; Haury et al., 1959; Leonhardy, 1966; Warnica, 1966; Hester, 1972; Rayl, 1974; Graham et al., 1981; Frison and Todd, 1986; Laub et al., 1988; Hannus, 1989; Overstreet, 1996; Overstreet and Kolb, 2003). From this simple observation, it has been induced that Clovis peoples hunted Proboscideans. This much we can agree is true. In this paper, we accept this basic premise, and address one particular facet of the Paleoindian–Proboscidean relationship; how frequently were mammoths and mastodons taken? One can envision the answer to this question as a continuum, varying from Proboscidean meat being a dietary staple to being one that a person might enjoy once or twice in a lifetime. In order to establish the limits of such a continuum, we quantitatively compare the Clovis record of elephant exploitation with similar records from other parts of the world.

Using the most lenient and problematic standard of Proboscidean use, simple presence in zooarcheological assemblages, we previously estimated that at least 91 individual mammoths and mastodons are known from a total of 26 Clovis sites (Waguespack and Surovell, 2003, Table 2). Based on available data, no other taxon is present in as many sites or is represented by as many individuals. These findings suggested that Proboscideans were utilized more frequently than other types of prey. Using more stringent and taphonomically rigorous standards, Grayson and Meltzer (2002, 2003) found that there are only 14 sites and 15 Clovis components showing secure associations with Proboscideans (see also Cannon and Meltzer, 2004). Two of these contain mastodon and 13, mammoth. Although Grayson and Meltzer's (2002, 2003) studies were concerned primarily with evaluation of Martin's overkill model (Martin, 1973, 1984; Mosimann and Martin, 1975; Martin and Steadman, 1999), they suggest that the rarity of reliable associations between Clovis artifacts and Proboscidean remains indicates that there is "little support for the assertion that big-game hunting was a significant element in Clovis-age subsistence patterns" (Grayson and Meltzer, 2002, p. 348). From the Paleoindian faunal record then, two interpretations widely divergent on the Proboscidean use continuum, have been proposed.

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By contrast, Haynes (1999, p. 23; 2002, p. 183) has argued that the number of Clovis elephant kill sites is extremely high in comparison to the record of elephant hunting from Africa, a considerably larger region and one where humans have coexisted with Proboscideans for a significantly longer period of time:

> *The United States contains more megamammal killsites than there are elephant killsites in all of Africa—a land mass that is much larger than the United States.* Not only is Africa much larger, but its hominin presence extends back at least 100 times the chonostratigraphic span of the human presence in North America. Yet there are fewer than a dozen probable killsites, spanning a time range from Plio-Pleistocene to mid-Holocene … [emphasis in original] (Haynes, 2002)

To Haynes (2002, p. 183), the Clovis data "show how breathtakingly abundant the associations are." These clear differences in opinion are about a relative simple question: is the archeological record of Proboscidean hunting in North America characterized by abundance or scarcity? Examined from a North American-centric perspective it is difficult to evaluate just how many Proboscidean kills equate to "a lot" versus "a little" subsistence use.

In this paper, we use the Grayson and Meltzer (2002, 2003) estimate of 14 reliable subsistence associations with Proboscideans as a benchmark for comparison. In particular, we ask whether 14 is a large number when viewed in a comparative context. Humans have also hunted and likely scavenged Proboscideans in contexts beyond Clovis in Africa, Europe, Asia, and Central and South America. We focus specifically on the record of subsistence use of Proboscideans from the Old World in comparison to Clovis by quantifying the spatio-temporal density and relative frequency of elephant-bearing sites. Following Haynes (1999, 2002), we argue that by using a comparative framework we are able to better evaluate counts of Paleoindian–Proboscidean associations. At this time, we cannot derive an absolute estimate of the frequency of elephant hunting in Clovis times, but we can address whether elephant hunting by Clovis foragers was relatively common or rare as compared to other slices of hunter-gatherer space and time manifested archeologically. Making such quantitative comparisons is not simple or straightforward because numerous sampling issues interfere. The organization of the paper is as follows. We first build a comparative Old World dataset, and to highlight the sampling issues involved and to guide our analyses, we construct formal models of the quantitative abundance of Proboscidean-bearing sites. Finally, we compare quantitative measures of spatio-temporal densities and relative frequencies of Proboscidean kill/scavenge (PKS) sites for the Clovis period and the Old World Paleolithic.

2. The archeological of record subsistence exploitation of elephants in the Old World

By our estimates, hundreds of archeological sites from Africa, Europe, and Asia are known to contain the remains of elephants. For example, Gamble (1986, Tables 7.3 and 7.4) records approximately 100 occurrences of Proboscideans from Middle and Upper Paleolithic cave assemblages from various regions of Europe alone (see also Haynes, 1991, pp. 195–263). Furthermore, archeological associations with elephants are found from the early phases of the Lower Paleolithic (Leakey, 1971; Berthelet and Chavaillon, 2001; Delagnes et al., 2006) to the Holocene (MacCalman, 1967; Haynes, 1991, p. 195), and the archeological history of such finds stretches back to at least the end of the 17th century (Grayson, 1983, pp. 7–8). As in the Clovis case, there has been considerable debate concerning the roles of Proboscideans in various places and times in Old World prehistory, best exemplified by questions of hunting, scavenging, and taphonomy at the Spanish Lower Paleolithic sites of Torralba and Ambrona (Howell, 1966; Freeman, 1973; Howell and Freeman, 1983; Shipman and Rose, 1983; Binford, 1987; Klein, 1987; Villa, 1990; Haynes, 1991; Villa et al., 2005), and the role of mammoth in the Eastern Gravettian and Epigravettian economies of Central and Eastern Europe (Klein, 1973; Kozlowski, 1986; Soffer, 1985, 1993; Haynes, 1991; Svoboda et al., 1996, pp. 154–157). These debates underscore the difficulty of reliably establishing the identification of subsistence use of Proboscideans from the archeological record (Haynes and Stanford, 1984; Haynes, 1991; Grayson and Meltzer, 2002; Cannon and Meltzer, 2004).

We suggest that the best evidence for subsistence use of Proboscideans comes from kill/scavenge sites (Haynes, 2002, p. 183), what Gamble (1999, p. 344) has referred to as "gatherings around single carcasses," or what others have called "single carcass sites" (Delagnes et al., 2006, p. 448). These sites often contain the remains of one to a few animals, often partially articulated, associated with small artifact assemblages typically less than 10 to a few hundred pieces. Limiting the sample this way, we are able to take a vast number of Old World sites containing elephants and pare them down to a manageable sample that we argue provide the best evidence for the subsistence use of elephants. By focusing on "gatherings around carcasses", a phrase that is intentionally ambiguous with respect to the question of hunting or scavenging, the frequency of such occurrences throughout time and space enable large-scale comparisons for identifying differences in Proboscidean use by prehistoric foragers. We also include in our sample two special cases, La Cotte de St. Brelade (England) and Lugovskoye (Russia) that are discussed in greater detail in the following text.

It is important to note, however, that by applying this standard to the archeological record of the Old World, we are not applying one that the Clovis record of mammoth and mastodon exploitation cannot meet. All but one of the

14 sites that Grayson and Meltzer (2002, Table VII) identify as reliable evidence of human predation of North American Proboscideans are sites with small numbers of animals well-associated with artifact assemblages, the exception being Pleasant Lake (Fisher, 1987), which lacks artifacts. Semantically, it might be difficult to fit Naco (Haury, 1953) and possibly Escapule (Hemmings and Haynes, 1969) into the category of "gatherings around carcasses" since they are sometimes interpreted to represent animals that were targets of human predation but escaped (Haynes, 1966; Grayson and Meltzer, 2002, p. 348). However, the association of these animals with Clovis projectile points is undeniable. Also, Lehner (Haury et al., 1959), Colby (Frison and Todd, 1986), and Dent (Figgins, 1933; Brunswig and Fisher, 1993) could be interpreted as not meeting our criteria since they contain at least 7, 13, and 12 animals, respectively. However, at Lehner and Colby, we find the association with Clovis weaponry convincing evidence that at least some of the animals at these sites were hunted, but we agree with Grayson and Meltzer (2002, p. 337) that of these, Dent is certainly the most problematic. Therefore, put another way, in attempting to make a quantitative comparison between Clovis and Old World elephant exploitation, we are only asking of the Old World record that it be qualitatively comparable to that of Clovis.

In sum, we are able to identify a total of 25 sites, localities, or components showing evidence of hunting or scavenging of elephants from Africa, Europe, and Asia (Table 2, Fig. 1). We include sites that could be considered to have somewhat weak associations in our sample (e.g., Torralba, Skaratki, and Zoo Park), and by doing so, we may be artificially inflating our sample of Old World sites relative to Clovis. There are a number of similar sites from North America that could be included in a comparable sample, such as Boaz (Palmer and Stoltman, 1975), Martins Creek (Brush and Smith, 1994; Brush et al., 1994), McLean (Ray and Bryan, 1938; Ray, 1942), and Guest (Rayl, 1974; Hoffman, 1983), but these are excluded. Although we have been criticized for ignoring taphonomic

considerations in the past (Cannon and Meltzer, 2004, p. 1956), by including sites with questionable associations only from Old World contexts, we are biasing our analysis *against* a position we have previously taken, that early Paleoindians in North America preferentially targeted Pleistocene megafauna (Waguespack and Surovell, 2003; Surovell and Waguespack, in press).

Proboscidean kill/scavenge sites are most common in the Lower Paleolithic, representing 56% of the sample. These include five sites dating to the Early Pleistocene, including the remains of two Proboscideans tightly associated with artifact assemblages from two levels of the FLK North Locality at Olduvai Gorge (Leakey, 1971, pp. 64–66, 85–86) a single *Elephas recki* at Barogali in the Republic of Djibouti (Berthelet and Chavaillon, 2001), an *E. recki* associated with more than 2000 Acheulean artifacts at Site 15, Olorgesailie Member I in Kenya (Potts et al., 1999, pp. 768–769), and a similar association at Mwanganda's Village in Malawi (Clark and Haynes, 1970; Kaufulu, 1990). Eight Lower Paleolithic sites dating to the Middle Pleistocene are known. The youngest known kill/scavenge site of an African *E. recki*, dating to ca. 700 ka, is Nadung'a 4 in West Turkana, Kenya, where a single animal was recovered with almost 7000 artifacts (Delagnes et al., 2006). The remaining Lower Paleolithic associations occur outside of Africa in southwest Asia or western Europe and are all associated with *Paleoloxodon antiquus*. These include Gesher Benot Ya'aqov, Israel (Goren-Inbar et al., 1994), Notarchirico, Italy (Piperno and Tagliacozzo, 2001), Aridos I and II (Villa, 1990; Santonja et al., 2001) and Torralba and Ambrona (Howell, 1966; Freeman, 1973, 1975; Villa, 1990; Villa et al., 2005), Spain, and the Southfleet Road and Ealing sites in Great Britain (Brown, 1889; Wenban-Smith et al., 2006).

Four Middle Paleolithic occurrences are known, representing 16% of the sample. All occur in northern Europe and likely date to interglacial periods. Two sites, Lehringen and Gröbern, are located in northern Germany. At Lehringen, a single *P. antiquus* was recovered in association with a 2.5 m long wooden spear (apparently found between
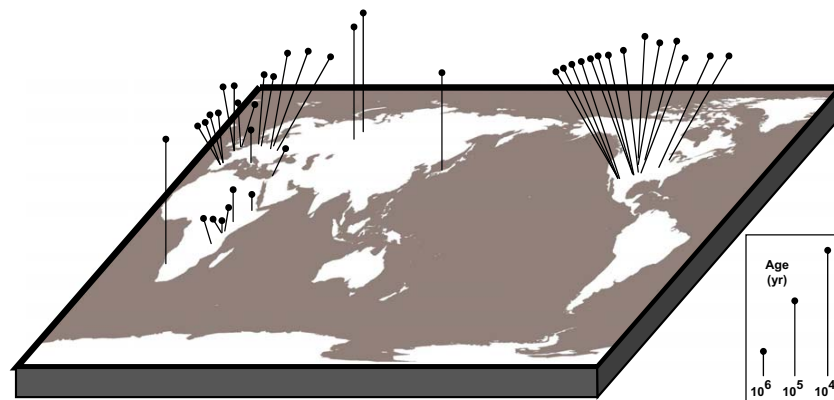

Fig. 1. World map showing the spatio-temporal distribution of Proboscidean kill/scavenge sites for Africa, Europe, Asia, and North America. Site location is indicated by the base of the pin and site age is indicated by pin length. Ages (and pin lengths) are logarithmically scaled.

the ribs of the elephant) and 24 chipped stone artifacts (Movius, 1950; Adam, 1951; Thieme and Veil, 1985; Weber, 2000). This one of the few sites in the Old World for a which a strong argument for a kill can be made due to the association with weaponry (but see Gamble, 1987). Gröbern also produced a single *P. antiquus* in association with 28 lithic artifacts and one possible bone artifact, interpreted to be to a projectile point (Mania et al., 1990; Weber, 2000). At La Cotte de St. Brelade (Channel Islands, England) two levels contain what appear to be cultural piles of wooly mammoth and rhinoceros remains (Scott, 1980, 1986; Callow, 1986). This site does not qualify as a "gathering around a carcass", but we include it in our sample because the site is generally believed to present evidence of two episodes of the killing of mammoths by driving them over a cliff, or by funneling them into a trap (e.g., Scott, 1980, 1986; Lister and Bahn, 1994, p. 129; Mellars, 1996, p. 229).

Seven Upper Paleolithic and Later Stone Age sites occur, accounting for 28% of the sample. Three sites associated with woolly mammoth (*Mammuthus primigenius*) cluster in the early Upper Paleolithic of eastern Europe. This include Nowa Huta (Kozlowski et al., 1970) and Skaratki (Chmielewski and Kubiak, 1962) in Poland, and Halich, Ukraine (Wojtal and Cyrek, 2001). Two *M. primigenius* sites occur in the late Upper Paleolithic of Sibera, Lugovskoye, Russia (Maschenko et al., 2003; Zenin et al., 2003) and Shikaevka II (Vasil'ev, 2003). Lugovskoye (ca. 13.5 ka) is the only site of this group that is not a "gathering around a carcass", but instead, mammoth hunting is inferred from the presence of a steeply retouched blade fragment embedded within a thoracic vertebra of an adult mammoth (Maschenko et al., 2003; Zenin et al., 2003). The Upper Paleolithic site of Lake Nojjiri, Japan has yielded three distinct aggregations of *Palaeoloxodon naumanni* remains and artifacts (Kondo et al., 2001). The youngest site in the Old World sample, Zoo Park, Namibia, believed to date ca. 10 ka contains two elephants (*Loxodonta* sp.) roughly 10 m apart, both associated with artifacts (MacCalman, 1967).

3. Modeling spatio-temporal density

Having compiled a dataset, it is tempting to simply begin comparing relative site frequencies with the aim of constructing a continuum of Proboscidean use. Unfortunately, there are numerous sampling issues that make it extremely difficult to directly and meaningfully compare the number of elephant kills between any two regions. Greater numbers of sites evidencing the subsistence use of Proboscideans are expected in regions characterized by greater land areas and/or greater archeological temporal depth. These issues come into play when making comparison between a portion of North America and the significantly larger combined area of Africa, Europe, and Asia. Similarly, prehistoric humans and hominids lived side-by-side with Proboscideans in the Old World for more

than 1 million years, while in the New World, people only coexisted with mammoths and mastodons for a few hundred to a few thousand years. Therefore, we might expect *a priori* that there would be considerably more elephant kills in the Old World than North America. To correct these problems, it is possible to use spatio-temporal densities of elephant kill sites as a proxy for per capita rates of elephant hunting, but a number of additional complicating factors must be considered, such as spatio-temporal variation in past human population densities, taphonomy, and archeological research intensity. In the proceeding section we examine this multitude of variables involved in attempting to answer the question; how many elephant kills are 14?

In the simplest sense, the number of PKS, those sites showing evidence of the subsistence utilization of Proboscideans, known from a region (n_a) can be modeled as a function of two variables: the number of sites in existence today (n_e), and the intensity of archeological research (i):

$$n_a = n_e i \tag{1}$$

where i represents the proportion of sites in existence today that have been discovered and investigated. The number of PKS in existence today (n_e) can be expressed as

$$n_e = n_c x \tag{2}$$

where n_c is the total number of PKS created by human hunters in a region throughout time, and x is the proportion of PKS surviving in the archeological record to the present. Combining these two equations yields a simple model of the total number of kill sites known from a region (n_r):

$$n_r = n_c x i \tag{3}$$

Therefore, the current archeological sample of PKS can be expressed simply as a function of the total number created, the proportion surviving destructive taphonomic processes, and the archeological research intensity in a given region. The spatio-temporal density of PKS (d) is modeled as

$$d = \frac{n_r}{t_h a} = \frac{n_c x i}{t_h a} \tag{4}$$

where t_h is the time depth of elephant hunting and a is the land area of that region.

Eq. (4) is an extremely simplistic portrayal of the system, and most of the terms in the equation can be further decomposed. For example, we are not interested as much in the number of subsistence sites created, but instead how they relate to the relative frequency of elephant use for prehistoric humans, the per capita rate of Proboscidean exploitation. Therefore, we can decompose the term n_c, the total number of PKS created, into more appropriate variables. The variable of interest is the number of elephants used per person per year (r_h). The variable n_c can be expressed as a function of r_h:

$$n_c = p_h a r_h t_h \tag{5}$$

where p_h is the average human population density over time t_h in a region of area a. Substituting this Eq. (5) into Eq. (4) gives

$$d = \frac{p_h a r_h t_h x i}{t_h a}$$

$$d = p_h r_h x i \tag{6}$$

Eq. (6) shows that when counts are divided by space and time, both variables cancel out of the equation, showing that spatio-temporal densities, unlike simple counts, are insensitive to the spatio-temporal dimensions of the region sampled. The critical variables become the average human population density (p_h), the per capita rate of elephant use (r), site preservation (x), and research intensity (i).

There are many ways that we could decompose the term i, archeological research intensity. The term is meant to express the concept of sample size. Hypothetically, if we had a 10% sample of all of the Clovis sites created, but we only have a 1% sample of all of the Paleolithic sites ever created, then even if the rate of elephant use was the same for Clovis and Paleolithic times, the spatio-temporal density of Clovis PKS would appear 10 times greater.

The variable research intensity (i) can be modeled as the total number of archeological sites excavated (s_e) relative to the total number of sites created (s_c):

$$i = \frac{s_e}{s_c} \tag{7}$$

Following Eq. (5), the total number of archeological sites created (n_c) is modeled as

$$n_c = p_t a r_t t_t \tag{8}$$

where p_t is the average human population density over the entirety of archeological time, a is the land area, r_t is the mean per capita rate of archeological site creation, and t_t is the entire archeological time depth. The variables p_t, r_t, and t_t differ from p_h, r_h, and t_h in that the former refer to all of archeological time, while the latter refer to only that time when humans coexisted with Proboscideans in a particular region. Therefore, archeological research intensity can be modeled as

$$i = \frac{s_e}{p_t a r_t t_t} \tag{9}$$

To highlight what we see as one of the most serious sampling problems affecting this analysis, we can also decompose the term s_e, the number of archeological sites excavated to date:

$$s_e = p_a a r_a t_a \tag{10}$$

where p_a is the mean population density of archeologists over the history of archeological research, r_a is the mean per capita rate of site excavation (the number of sites excavated per archeologist per year), and t_a is the time depth of archeological research (the amount of time archeologists have been at work). Combining Eqs. (9)

and (10) yields

$$i = \frac{p_a a r_a t_a}{p_t a r_t t_t}$$

$$i = \frac{p_a r_a t_a}{p_t r_t t_t} \tag{11}$$

Except for the variable *land area* (a), which cancels out of the equation, six variables remain. Research intensity is a function of the population density of archeologists, the per capita rate of excavation, the time depth of archeological research, the average prehistoric population density, the rate of archeological site creation, and the time depth of prehistoric occupation. The most troubling aspect of this equation is that if all variables are assumed to be constant, except the time depth of human occupation, there is a problem of "temporal research dilution" in comparing Clovis to the Paleolithic.

Humans have occupied the New World for approximately 10^4 yr, while elephant-using hominids have occupied Africa, Europe, and Asia for approximately 2×10^6 yr, a difference of two orders of magnitude. If we hold all variables constant, except prehistoric time depth, the research intensity in New World archeology would be expected to be roughly 100 times greater than that of the Old World. To put this problem another way, we can think of 10 archeologists working in two regions: A and B. In Region A, there are 1000 years of prehistory, and in Region B, there are 1,000,000 years of prehistory. In Region A, there is one archeologist for every 100 years of prehistory. In Region B, there is one archeologist for every 100,000 years of prehistory. Therefore, even if the archeologists in both regions work equally hard, the research intensity for Region B will be 1000 times less than for Region A, simply because research in Region B is temporally diluted. Therefore, if we were to simply compare the spatio-temporal densities of elephant kills in Clovis and Old World Paleolithic contexts, then we would necessarily bias our results in favor of Clovis.

Combining Eqs. (6) and (11) provides a model that is considerably more complex than the one we started with:

$$d = p_h r_h x \frac{p_a r_a t_a}{p_t r_t t_t} \tag{12}$$

Furthermore, we have not even approached to question of site preservation. Some of the factors that likely would go into modeling the variable x (the proportion of sites not surviving to the present) might be hunting practices, animal behavior, age, ecology, geomorphology, and climate, but rather than reducing this equation further, we leave it in its current state because it underscores the difficulties involved in using spatio-temporal densities of archeological sites to monitor rates of Proboscidean use.

In the simplest sense, from Eq. (12), we can state that *all things being equal, the spatio-temporal density of PKS* (d) *will be proportional to the* per capita *rate of Proboscidean use* (r_h) The key to that statement, of course, is the phrase

"all things being equal". Those "things" include: (1) the average prehistoric human population density during the time in which humans and elephants coexisted, (2) the proportion of kill sites surviving to the present, (3) the average population density of archeologists over the history of archeological research, (4) the per capita rate of site excavation, (5) the time depth of archeological research, (6) the average prehistoric human population density over all archeological time, (7) the average per capita rate of archeological site creation, and (8) the time depth of human occupation. In order to directly compare spatio-temporal densities between any two regions, then, would require one to control all of these factors, a seemingly daunting task.

Our point is not to suggest that such an analysis is impossibly difficult or hopeless. We only wish to point out that such analyses are far more complex than they are commonly portrayed to be. The most serious problem in this case, we argue, is temporal research dilution. There is simply too much time in the Old World and too few archeologists to treat research intensities as equivalent for Clovis and the Paleolithic. While vastly more Paleolithic sites have been excavated in comparison to Clovis, it is likely that the known Clovis archeological record is actually a larger sample in comparison to the total number of sites in existence. Another problem that we think presents a similar obstacle to comparing spatio-temporal densities is the population density of archeologists. Considering the vastness of Africa and East Asia (including Siberia) and the relatively small numbers of archeologists working in these regions, again in comparison to Clovis, these areas have yet to be sampled archeologically to the same extent as North America. Site preservation and destruction is another term that is highly problematic. We have treated it as a constant, and yet it undoubtedly could be modeled as a function of time, in that the probability of a site surviving to the present should be inversely proportional to its age (Surovell and Brantingham, 2007), and in this sense, we suspect that huge numbers of Paleolithic sites have been lost to destructive geomorphic and taphonomic factors in comparison to Clovis. Likewise, the probability of finding evidence of the use of elephants from the Paleolithic of central Africa or southeast Asia (or eastern North America) is very low due to geochemical conditions not conducive bone preservation. One factor that might act to bias the analysis in the opposite direction is prehistoric human population density. We suspect that average population densities for Clovis were significantly lower than for much of the Upper Paleolithic, and in this sense large numbers of elephant-bearing sites in Clovis contexts suggests greater frequencies of exploitation in comparison to the Upper Paleolithic.

If these problems are not difficult enough, there are additional assumptions built into the model. For example, it is assumed that archeological research is unbiased and produces a representative sample of time–space patterning in the archeological record, an assumption unlikely to be valid. Our efforts to mathematically model the compounding factors influencing the archeological record of Proboscidean subsistence use may appear to produce an overwhelming array of "what if's", it is important to consider that all variables must be addressed before declarations regarding the relative abundance or paucity of elephant hunting in particular times and places are made. After all, any archeological interpretation regarding the frequency of particular behaviors through time or across space must account for the variables outlined in our model.

3.1. Quantifying spatio-temporal density

In order to estimate spatio-temporal densities, we must also control for space and time. Beginning with the question of space, we can simply sum the areas of the continents of Africa, Asia, and Europe, but to do so would be to ignore two important factors. First, the repeated growth and recession of glaciers over during the Pleistocene resulted in regular fluctuations in the area of habitable land.[1] Also, humans did not occupy all of Europe, Africa, and Asia during all of this time. While the question of the timing of initial migration out of Africa continues to be debated (Roebroeks and Kolfschoten, 1994; Swisher et al., 1994; Gibert et al., 1998; Klein, 1999; Roebroeks, 2001; Klein and Edgar, 2002; Dennell, 2003), it is clear that hominids entered Eurasia prior to the Bruhnes/Matuyama boundary at 780 ka (Carbonell et al., 1995; Gabunia et al., 2001; Belmaker et al., 2002). Also, humans apparently did not colonize arctic environments until 30 ka (Pitulko et al., 2004). Various species of Proboscideans did, however, occupy virtually all of this area during the Pleistocene (Todd and Roth, 1996). For Clovis, the same problems could apply, especially if Clovis is assumed to be a colonizing population. With respect to time, there is the question of the timing of the extinction of elephants in the Old and New Worlds, and that they did not go extinct in portions of Africa and Asia. The timing of Proboscidean extinctions appears to have varied considerably across Eurasia (Tchernov, 1984; Soffer, 1993, pp. 41–44; Stuart and Lister, 2001; Stuart et al., 2002, 2004; Baryshnikov, 2003; Kuzmin et al., 2003; Ugan and Byers, in press), while in North America, extinction was temporally more constrained with many of the latest occurrences of mammoth and mastodon appearing in association with Clovis artifacts or are contemporaneous with Clovis (Meltzer and Mead, 1985; Haynes, 1993; Grayson and Meltzer, 2002, 2003; Haynes, 2002).

We opted to simplify our calculations and proceed bearing in mind these potential complicating factors because we are trying to identify coarse differences at large scales. For our Old World sample, the total area of Africa,

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[1]Changes in sea level have also increased habitable area at time in the past, but because these areas have not been sampled, they have no impact on spatio-temporal densities.

Table 1
Clovis sites showing secure subsistence associations with Proboscideans

Site and locality	State	Latitude	Longitude	Age[a] (ka)	Taxon
Hebior	Wisconsin	43N	88W	12.5	*Mammuthus primigenius*
Colby	Wyoming	44.0N	107.9W	11.2	*Mammuthus columbi*
Domebo	Oklahoma	35.0N	98.4W	11.1	*Mammuthus imperator*
Lubbock Lake	Texas	33.6N	101.9W	ca. 11	*Mammuthus columbi*
Blackwater Draw Mammoth Pit	New Mexico	34.3N	103.3W	ca. 11	*Mammuthus columbi*
Escapule	Arizona	31.6N	110.2W	ca. 11	*Mammuthus columbi*
Blackwater Draw El Llano Dig No. 1	New Mexico	34.3N	103.3W	ca. 11	*Mammuthus columbi*
Kimmswick	Missouri	38.4N	90.4W	ca. 11	*Mammut americanum*
Miami	Texas	35.6N	100.6W	ca. 11	*Mammuthus columbi*
Naco	Arizona	31.4N	109.9W	ca. 11	*Mammuthus columbi*
Lehner	Arizona	31.3N	110.1W	10.9	*Mammuthus columbi*
Murray Springs	Arizona	31.6N	110.2W	10.9	*Mammuthus columbi*
Lange-Ferguson	South Dakota	43N	103W	10.8	*Mammuthus* sp.
Dent	Colorado	40.3N	104.8W	10.8	*Mammuthus columbi*

[a]Uncalibrated radiocarbon ages.

Europe, and Asia is $84{,}852{,}000\,km^2$, and temporally, the sites stretch from approximately 1.75 ma to 13.5 ka, a span of 1.74 million years. For the New World sample, the area of the 48 continental United States is roughly $8{,}081{,}000\,km^2$. The age range for Clovis was calculated using age difference for the calibrated ages of the oldest and youngest sites. The Hebior mammoth produced three dates ranging between $12{,}480\pm60$ (CAMS 28303) and $12{,}590\pm50$ ^{14}C yr BP (Overstreet and Kolb, 2003), and the Clovis occupation at Murray Springs is dated to approximately $10{,}900\pm50$ ^{14}C yr BP based on the average of eight charcoal dates (Haynes, 1992). After calibration,[2] the sites span a total of approximately 2000 years. The total sample of elephant associations from Clovis contexts includes 14 sites (Table 1), but because Hebior lacks artifacts, we exclude it from our sample. The North American sample remains 14 because Blackwater Draw contains two separate localities (Table 1; Fig. 1). Our Old World sample includes a total of 25 localities, components, or sites (Table 2; Fig. 1).

Using these data, it is possible to calculate spatial, temporal, and spatio-temporal densities for the Clovis and Old World samples (Fig. 2). Beginning with spatio-temporal densities for Clovis, there are approximately 0.87 sites per billion km^2 yr, and 0.0002 sites per billion km^2 yr for the Old World sample (Fig. 2a). In other words, elephant subsistence sites are roughly 5000 times more abundant in Clovis when standardized to space and time. Looking only at time, for the Clovis sample there are 7.0 sites per thousand years, and for the Old World sample there are 0.014 sites per thousand years (Fig. 2b). Therefore, Clovis elephant subsistence sites are approximately 600 times more abundant with respect to time. Of course, both of these analyses are problematic because of the temporal research dilution problem discussed previously. One solution to this dilemma is to ignore time, using only

spatial densities. Although this analysis should in theory bias the sample toward the Old World, where considerably more time is represented, Clovis still comes out on top. There are approximately 1.73 Clovis sites per million km^2 as compared to only 0.29 per million km^2 in the Old World (Fig. 2c).

From Fig. 1, it is clear that sites with evidence for subsistence use of elephants are considerably more common in Europe than in Africa or Asia, despite that Europe represents the smallest land area. This pattern is likely due in part to differences in research intensity. Consequently, it seems fruitful to repeat the analysis comparing only the European record to that of Clovis. The continent of Europe is roughly $10{,}000{,}000\,km^2$ in area, and our European sample includes 14 sites, spanning a period of roughly 650,000 years. In comparison to Clovis, the European record of elephant use is quite impoverished when time is figured into the equation (Fig. 2b and c). For example, there are only 0.02 PKS per thousand years in the European record as compared to 7 for Clovis, a difference of two orders of magnitude. The spatial densities of the two regions however, are quite comparable with 1.4 sites per million km^2 for Europe versus 1.73 sites per million km^2 for Clovis. Furthermore, during multiple glaciations, a larger proportion of Europe was covered by ice than for North America in Clovis times, suggesting that the true spatial densities for these two regions are likely quite similar. It remains difficult to make conclusive interpretations of these findings due to complicating factors such as a much greater time span of human occupation in Europe.

Although admittedly course-grained, according to this preliminary analysis the archeological record of Clovis appears to be especially rich in sites showing the subsistence use of elephants with 14 occurrences known from a relatively small slice of space and time. The record of elephant use in Europe, which spans a time period more than 300,000 times that of Clovis, approaches Clovis in spatial density. There are numerous assumptions that must

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[2]Radiocarbon dates were calibrated using OxCal v. 3.9 (Ramsey, 2003).

Table 2
Old World sites showing evidence of subsistence use of Proboscideans

| Site and locality	Country	Latitude	Longitude	Phase	Age	Taxon
FLK North Upper Bed I	Tanzania	3S	35E	LP	1.7–1.8 ma	*Elephas recki*
FLK North Lower Bed II	Tanzania	3S	35E	LP	1.2–1.7 ma	*Deinotherium* sp.
Barogali	Djibouti	11N	42E	LP	1.3–1.6 ma	*Elephas recki*
Olorgesaille Member I Site 15	Kenya	2S	36E	LP	974–992 ka	*Elephas recki*
Mwanganda's Village	Malawi	10S	34E	LP	0.6–1.2 ma (?)	*Elephas* sp. (?)
Gesher Benot Ya'aqov	Israel	33.0N	35.6E	LP	ca. 750 ka	*Palaeoloxodon antiquus*
Nadung'a 4	Kenya	4N	36E	LP	ca. 700 ka	*Elephas recki*
Notarchirico	Italy	41N	16E	LP	600–740 ka	*Palaeoloxodon antiquus*
Aridos I	Spain	40.3N	3.5W	LP	300–500 ka (?)	*Palaeoloxodon antiquus*
Aridos II	Spain	40.3N	3.5W	LP	300–500 ka (?)	*Palaeoloxodon antiquus*
Southfleet Road	UK	51.4N	0.3E	LP	ca. 400 ka	*Palaeoloxodon antiquus*
Ealing	UK	51.5N	0.3W	LP?	300–500 ka (?)	*Palaeoloxodon antiquus* (?)
Ambrona	Spain	41N	2.5W	LP	200–400 ka (?)	*Palaeoloxodon antiquus*
Torralba	Spain	41N	2.5W	LP	200–400 ka (?)	*Palaeoloxodon antiquus*
La Cotte de St. Brelade Level 3	UK	49.2N	2.3W	MP	120–200 ka	*Mammuthus primigenius*
La Cotte de St. Brelade Level 6	UK	49.2N	2.3W	MP	120–200 ka	*Mammuthus primigenius*
Lehringen	Germany	52.8N	9.5E	MP	ca. 120 ka	*Palaeoloxodon antiquus*
Gröbern	Germany	51.8N	12.5E	MP	ca. 120 ka	*Palaeoloxodon antiquus*
Lake Nojiri	Japan	36.8N	138.2E	UP?	33–39 ka[a]	*Elephas naumanni*
Nowa Huta	Poland	50N	20E	UP	35 ka (?)[a]	*Mammuthus primigenius*
Skaratki	Poland	52.0N	19.8E	UP?	29–32 ka (?)[a]	*Mammuthus primigenius*
Halich	Ukraine	49.1N	24.7E	UP	20–24 ka[a]	*Mammuthus primigenius*
Shikaevka II	Russia	56.3N	66.4E	UP	18 ka[a]	*Mammuthus primigenius*
Lugovskoye	Russia	61.0N	68.5E	UP	ca. 13.5 ka[a]	*Mammuthus primigenius*
Zoo Park	Namibia	22.5S	17.1E	LSA	10 ka (?)[a]	*Loxodonta* sp. (?)

[a]Uncalibrated radiocarbon age.
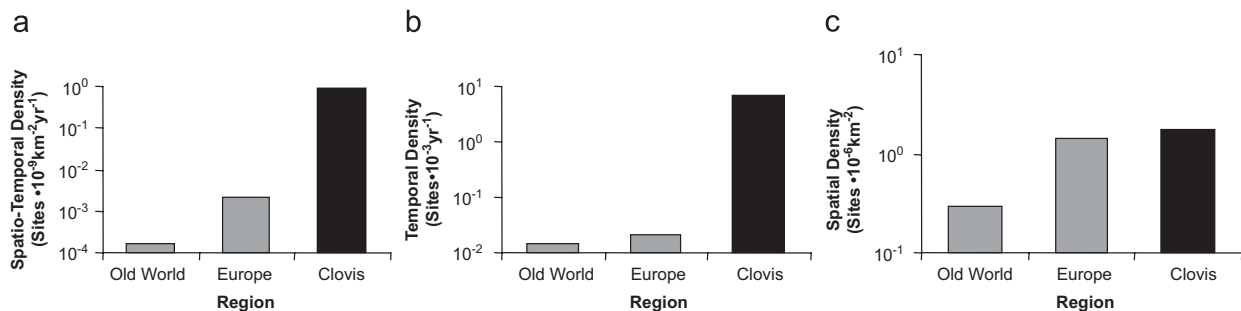
Fig. 2. Spatio-temporal (a), temporal (b), and spatial (c) densities of Proboscidean kill/scavenge sites for the Old World (Africa and Eurasia), Europe, and Clovis.

be made if one wishes to take these results at face value, and many of those assumptions are tenuous. We simplify the problem considerably by supplementing this initial analysis with one based on the relative proportions of elephant-bearing sites for various divisions of space and time. As we show in the following text, such an analysis allows us to eliminate many of the problematic, yet necessary, assumptions when comparing spatio-temporal densities.

4. Modeling relative site frequencies

Instead of standardizing counts of elephant-bearing sites to space and time, if we standardize them relative to the total sample of sites known from a given spatio-temporal region, we can make fewer and perhaps more justifiable assumptions. To model the relative frequency of PKS, we need only two terms, one describing the number of PKS excavated to date and a second term describing the total number of sites excavated to date. From above, the numerator of Eq. (6) describes the total number of elephants subsistence sites excavated to date (n_e) for a spatio-temporal region of area (a) and time span (t_h):

$$n_e = p_h a r_h t_h x i \quad (13)$$

where p_h is the average human population density, r_h is the per capita rate of elephant site creation, d is the proportion of sites not surviving to the present, and i is the research intensity. The total number of sites (n_s) excavated within

that spatio-temporal region can be modeled the same way:

$$n_e = p_h a r_s t_h x i \tag{14}$$

where r_s is the per capita rate of archeological site formation. Taking the ratio of these two equations then allows us to model the relative frequency of elephant subsistence sites (f):

$$f = \frac{p_h a r_h t_h x i}{p_h a r_s t_h x i}$$

$$f = \frac{r_h}{r_s} \tag{15}$$

Therefore, the relative frequency of elephant subsistence sites (f) should be a function of only two variables, the per capita rate of elephant subsistence site creation (r_h) and the per capita rate of site creation. All of the remaining variables cancel out of the equation because they are assumed to be constant.

Are these assumptions reasonable? With respect to population density, area, and time these assumptions are unquestionable since time and space are held constant. The assumptions that research intensity (i) and site preservation (x) are constant for PKS and all other sites are clearly tenuous. For example, geomorphic and taphonomic factors might bias preservation for or against sites showing evidence for the use elephants relative to other site types. Also, research bias might increase or decrease the likelihood that a PKS will be excavated relative to other site types. However, in contrast to using spatio-temporal densities as a measure of the relative frequency of Proboscidean exploitation, when using site proportions, these are the only two assumptions that are necessary.

4.1. Quantifying relative site frequencies

Data reporting the percentage of sites containing Proboscidean remains from various spatio-temporal regions of the Old World were compiled from four sources (Soffer, 1985; Gamble, 1986, Tables 7.3–7.5; Borziyak, 1993; Vasil'ev, 2003).[3] These data (Table 3) are based on the presence or absence of Proboscideans with no concern for taphonomy. Therefore, we begin by comparing these data to our estimate for Clovis, which is also based solely on presence or absence in faunal assemblages (Waguespack and Surovell, 2003). In our study, we found that Proboscidean remains are present in 79% of Clovis sites that have faunal assemblages. Some regions of the Old

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[3]The data in Tables 2 and 3 were compiled independently, and for those in Table 3, in particular, we relied on the work of others (as cited). As much as we would have liked to include spatio-temporal regions in Table 3 that included all of the PKS in Table 2, it would have been extremely difficult to do so. This would require compiling nearly complete samples of excavated sites with faunal remains from many parts of Africa, Europe, and Asia. There are numerous difficulties involved in doing so, most notably, it would require an impressive level of linguistic competence that we admittedly lack. As such, we decided in would be prudent to rely on compilations already produced by regional experts.

World show comparable and even higher frequencies of elephant remains (Fig. 3). For example, elephants are found in 98% of Upper Paleolithic sites from the Central Russian Plain (Soffer, 1985), and in 90% of cave assemblages from the Upper Paleolithic (35–20 ka) of Southern Germany (Gamble, 1986). On the other end of the scale, fewer than 10% of Middle and Upper Paleolithic sites from Cantabrian Spain and southern France contain elephant remains, and various spatio-temporal regions show intermediate values (Gamble, 1986).

On the surface it appears that the frequency of elephant exploitation seen in Clovis may not be particularly unique. However, these data, including those for Clovis, are problematic since they include all occurrences of elephants, whether they represent reliable subsistence associations or not. Consider for example, the two cases where Proboscideans are more common than Clovis; many doubts linger concerning whether elephants played any role in the subsistence economies of these areas. For example, for the Central Russian Plain, Soffer reports:

> At present, therefore, I conclude that mammoth did not play the major role in subsistence that has been widely attributed to them in both Soviet and Western literature. While some mammoth were undoubtedly hunted, how many remains a question for future research, as does determination of the frequency of mammoth kills … (Soffer, 1985, p. 281)

> Unfortunately, no unequivocal kill sites have been found in the study area. (Soffer, 1985, p. 309)

In fact, *none* of Soffer's sites would qualify as a subsistence association using our criteria, essentially turning the 98% frequency figure for the Central Russian Plain to 0% (see also Soffer, 1985, Table 5.16). Likewise, for the Upper Paleolithic of southern Germany, Niven reports:

> Indisputable evidence of mammoth hunting has not yet been documented in southern Germany although mammoth remains are found in 90% of cave localities in this region during the Upper Paleolithic. (Niven, 2001, p. 323)

Therefore, the 90% frequency data point for Southern Germany, like the Central Russian Plain, can potentially be reduced to 0%. What about Clovis?

Clovis contrasts starkly with these areas, and we argue that it is like few other spatio-temporal regions archeologically documented. In contrast to the regions from Table 3 where Proboscidean remains are quite common in the archeological record (e.g., the Central Russian Plain, Siberia, England, the Crimea, and southern Germany) in Clovis not only are elephant remains common, but Clovis sites that include elephant remains in their faunal assemblage frequently exhibit evidence of subsistence exploitation of these animals (Haynes, 1999).

If we were to revise our original estimate of 79% by eliminating questionable associations, 46.7% of Clovis sites

Table 3
The relative frequency of the occurrence of Proboscideans in faunal assemblages from various Old World spatio-temporal regions in comparison to Clovis

| Region	Time period	% of sites or components with Proboscideans	Sites and components	Reference
Central Russian Plain	Upper Paleolithic	93	16	Soffer (1985), Table 5.8
Southern Germany	35–20 kyr	90[a]	20	Gamble (1986), Table 7.4
North America	*Clovis*	*79*	*33*	Waguespack and Surovell (2003), Table 2
Crimea	118–35 kyr	69[a]	13	Gamble (1986), Table 7.3
England	35–20 kyr	66[a]	13	Gamble (1986), Table 7.4
Southern Germany	118–35 kyr	63[a]	20	Gamble (1986), Table 7.3
Dnestr River, Moldova	Late Upper Paleolithic	44	25	Borziyak (1993), Table 1
Siberia	Middle Upper Paleolithic	35	40	Vasil'ev (2003), Table 4
Siberia	Early Upper Paleolithic	32	31	Vasil'ev (2003), Table 3
Siberia	Middle Paleolithic	30	33	Vasil'ev (2003), Table 2
Bükk Mountains, Hungary	35–20 kyr	30[a]	20	Gamble (1986), Table 7.4
Southern Germany	20–10 kyr	19[a]	47	Gamble (1986), Table 7.5
SW France	35–20 kyr	17[a]	46	Gamble (1986), Table 7.4
Siberia	Late Upper Paleolithic	15	235	Vasil'ev (2003), Table 5
England	20–10 kyr	15[a]	33	Gamble (1986), Table 7.5
Switzerland	118–35 kyr	14[a]	14	Gamble (1986), Table 7.3
SW France	20–10 kyr	9[a]	70	Gamble (1986), Table 7.5
SW France	118–35 kyr	8[a]	59	Gamble (1986), Table 7.3
S. France	118–35 kyr	7[a]	38	Gamble (1986), Table 7.3
Cantabrian Spain	20–10 kyr	6[a]	54	Gamble (1986), Table 7.5
Cantabrian Spain	118–35 kyr	5[a]	19	Gamble (1986), Table 7.3
Cantabrian Spain	35–20 kyr	3[a]	19	Gamble (1986), Table 7.4

[a]Sample includes only cave assemblages.
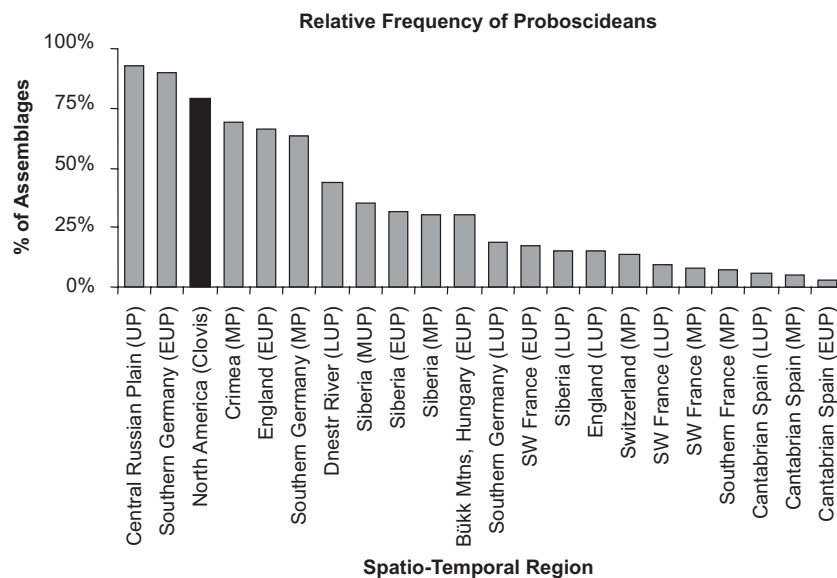
Fig. 3. The relative frequency of the occurrence of Proboscideans in faunal assemblages from various Old World spatio-temporal regions in comparison to Clovis. UP = Upper Paleolithic, EUP = Early Upper Paleolithic, MUP = Middle Upper Paleolithic, LUP = Late Upper Paleolithic, MP = Middle Paleolithic.

or localities still show strong evidence for the subsistence use of elephants. To derive this second figure, we exclude Boaz, Schaefer, Leikem, and McLean because if we remove the association with mammoths or mastodons in these sites, they effectively lack culturally associated faunal remains of any kind. Also, we count Blackwater Draw twice since two localities provide evidence of mammoth hunting (or scavenging?). We estimate that approximately one-half of Clovis sites with preservation of bone show strong evidence for the subsistence use of Proboscideans. A second independent estimate is derived from Grayson and Meltzer (2003). By querying the FAUNMAP database

under the terms "Clovis" and "Paleoindian", Grayson and Meltzer (2002, p. 317) identified 76 sites in which "extinct mammal remains of any kind were found in what appeared to be a Clovis or Paleoindian archeological context." Of these, 47 "failed to produce minimally acceptable evidence of an association between artifacts and extinct mammals" (Grayson and Meltzer, 2002, p. 321), leaving a total sample of 29 sites. The 47 sites eliminated were cut due to insufficient data, the presence of only bone tools, and/or doubtful archeological status. Using solely these data, it is difficult to determine precisely how many of these sites are indeed archeological and Clovis, but their hesitance to even include them in their careful analysis does warrant some caution in using them to estimate the frequency of elephant subsistence sites. Using their total sample ($n = 76$), 18.4% of sites have reliable associations with Proboscideans. However, according to Grayson and Meltzer (2003) in this sample, 21 sites have archeological status that is "doubtful", and an additional five sites are characterized only by the presence of bone tools. Eliminating these sites provides a minimum estimate of 28% of Clovis faunal assemblages showing reliable evidence for the use of Proboscideans. Alternatively, using their reduced sample of 29 sites, 46.7% show reliable use of mammoth or mastodon (again counting Blackwater Draw twice), precisely the figure we derived from our sample.[4] Therefore, combining the estimates derived from Grayson and Meltzer (2002) and Waguespack and Surovell (2003), we can say with some degree of confidence that between 28% and 46.7% of Clovis sites with faunal remains show strong evidence of the use of Proboscideans. Again, we are left with the difficult task of determining whether these values represent "a lot" or "a little" evidence of Proboscidean subsistence use.

Comparing this to our Old World sample, Clovis appears to be somewhat unique with respect to the abundance of reliable subsistence associations with elephants. Fig. 1 shows the spatio-temporal distributions of sites showing strong or possible evidence for the use of Proboscideans for the Old World and Clovis samples. The Clovis record shows a clear cluster in space and time, while the record of elephant exploitation in the Old World is considerably more dispersed. Perhaps the spatio-temporal region most similar to Clovis is the Lower Paleolithic of the Iberian Peninsula where four localities, Aridos I and II, Torralba, and Ambrona cluster fairly tightly in space and time. Other possible regions include the Lower Paleolithic of East Africa, with four sites represented (over a period of more than 1 million years), the Middle Paleolithic of northern Germany with two sites, the Upper Paleolithic of

Eastern Europe with two sites, and the late Upper Paleolithic of Siberia with two sites.

Do any of these regions even meet the minimum estimate of Clovis with 28% of sites with faunal remains being elephant subsistence sites? In part, the answer to this question depends on how the spatio-temporal regions are defined. If a region is defined very narrowly encompassing one or two elephant-bearing sites and little else, then elephant subsistence sites will appear very common. If a region is defined broadly, then such sites become diluted in larger samples. Using our sample of Old World sites, there is at least one reasonably sized region nears Clovis in terms of the relative frequency of Proboscidean exploitation sites—the Lower Paleolithic of the Iberian Peninsula where four sites are known. A compilation Lower Paleolithic sites and components from this region from Straus (1992), Carbonell et al. (1995), Gibert et al. (1998), and Santonja and Villa (1990) yielded a total of 15 additional archeological components with lithics and fauna.[5] Including, Torralba and Ambrona, 21% of the Lower Paleolithic sites from this area are elephant subsistence sites, and in comparison to the minimum and maximum estimate for Clovis, these differences are not statistically significant (Fisher's exact test, Iberia versus Clovis Min., $p = 0.398$; Iberia versus Clovis Max., $p = 0.064$).

The Middle Paleolithic of Germany, like the Lower Paleolithic of Spain, has two sites, Lehringen and Gröbern, showing strong evidence for the use of Proboscideans, but unlike Iberia, it has a much greater number of sites that do not (e.g., Gamble, 1986, 1999; Conard and Prindiville, 2000). The same is true of the Late Upper Paleolithic of Siberia where two sites, Lugovskoye and Shikaevka II, suggest the subsistence use of mammoth, but Vasil'ev (2003) reports 234 additional archeological components with faunal remains. Similarly, in the Upper Paleolithic of Eastern Europe, despite mammoth bone being very common in sites of this region, sites with evidence for the subsistence use of mammoth (Nowa Huta, Halich, and Skaratki according to our definitions) are swamped out by those that do not (e.g., Klein, 1973; Soffer, 1985; Kozlowski, 1986). Lower Paleolithic East Africa also contains far more localities with artifacts and faunal assemblages that do not show subsistence use of elephants than do (e.g., Leakey, 1971; Isaac, 1977; Chavaillon et al., 1979; Bunn, 1982; Clark et al., 1984).

Therefore, with the single possible exception of the Lower Paleolithic of Iberia, Clovis appears to be uniquely rich in evidence of the subsistence use of elephants. Although we have identified other possible regions where there appear to be minor clusters in elephant use, such as Lower Paleolithic East Africa, Middle Paleolithic Germany, and Upper Paleolithic Eastern Europe,

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[4]The reduced Grayson and Meltzer (2002, 2003) sample, what they call "sites that made the first cut", includes four sites that contain only proboscidean remains (Boaz, Schaefer, Burning Tree, and Pleasant Lake). If the associations at these sites are eliminated, there is no evidence for the use of any other taxa at these sites, and removing these sites from the sample increases the Clovis estimate to 53%.

[5]These are El Castillo (Levels 24, 25a, 25b, 26), Pinedo, Arganda II, Oxígeno, San Isidro, Cúllar-Baza I, Solan del Zambotino (Multiple Levels), Cueva Horá, Gran Dolina (Levels TD4 and TD6), Barranco León-5, and Fuentenueva-3a.

elephants and hominids have occupied most of Africa, Europe, and Asia for hundreds of thousands of years; yet, for most of archeological time and space, there is little if any evidence of the subsistence utilization of Proboscideans.

5. Discussion

In recent years, it has become commonplace to question many of the things that we once "knew" about Clovis. The "old Clovis model" can be succinctly stated as follows. Clovis peoples were highly mobile, prodigiously reproducing, specialized hunters of large game, who migrated to the unpopulated continent of North America from Asia via the ice-free corridor approximately 12,000 years ago, and upon their arrival promptly hunted the Pleistocene megafauna to extinction. Virtually every descriptive phrase in this statement has been questioned despite having once been widely accepted. While we strongly believe that questioning and of reevaluating entrenched ideas is a good thing, we suggest that it is time to step back and truly evaluate what the archeological record of Clovis represents and detach issues of Clovis adaptations from Clovis origins (Meltzer, 1989, p. 477). With this so-called "paradigm-shift" (Bonnichsen and Turnmire, 1999) in Paleoindian archeology, it has become routine, for example, to discount the record of Clovis large game hunting using various arguments ranging from the theoretical to the empirical (Meltzer and Smith, 1986; Meltzer, 1993; Dixon, 1999; Dillehay, 2000; Adovasio and Page, 2002; Grayson and Meltzer, 2002, 2003; Cannon and Meltzer, 2004; Chilton, 2004; Byers and Ugan, 2005). One way of doing this is to point out a perceived rarity of evidence of the exploitation of extinct elephants:

> That there are *so few* actual sites of mammoth kills (and virtually none of horse, camel, or sloth kills) is a major embarrassment to the overkill theory … [emphasis added] (Adovasio and Page, 2002, p. 127)

> Clovis is the only firmly documented New World archaeological complex positively associated with mammoth procurement. However, *only about twelve* archaeological sites have been reported where Clovis projectile points are associated with the bones of these large extinct elephant-like creatures … Although there is no doubt that some Clovis people hunted mammoth and possibly mastodon, current research suggests that these rather spectacular kill sites are probably not typical of Clovis culture. [emphasis added] (Dixon, 1999, p. 216)

Obviously, given our arguments above, we should not be arguing that there are "so few" or "only about twelve" mammoth kills, but instead asking why there are so many? In over 1 million years of archeology spread over four continents, we have attempted to demonstrate that there is likely nothing that has yet to be documented archeologically that compares to Clovis in terms of the frequency of

Proboscidean exploitation, with the single possible exception of the Lower Paleolithic of Iberia.

Certainly, 14 sites do not seem like a very large number, but when viewed in a comparative context, it is in fact a very large number. Furthermore, the number of elephant kill sites in Clovis is truly remarkable when we consider the total number of *elephant kills* documented from four continents. Of the 21 sites we have identified in the Old World, only two or three have weaponry associated with carcasses. The two best cases are Lehringen and Lugovskoye, and the third case, Gröbern, is questionable. Therefore, in the entire archeological records of Africa, Europe, Asia, and North America, there are a total of 16 strong cases for hunting of elephants, and 14 of these are found in Clovis. Furthermore, between of 28% and 46.7% of excavated Clovis sites that have preserved fauna are mammoth or mastodon kill sites. Why?

According to our model of the archeological frequency of elephant subsistence sites, there are three possible answers. The first possibility is that Clovis hunter-gatherers regularly hunted mammoth and mastodon, or at least did so more frequently than people did in any other time and place in the world. The second possibility is that the archeological record of North America is strongly biased toward elephant kills, and/or the record of the Old World is biased against elephant kills. In other words, our sample of archeological sites from the Clovis record is not random, and in particular, it is biased toward the discovery elephant-bearing sites over sites that do not contain elephants. Such biases can conceivably come from many different factors, such as site preservation, discovery, or excavation. The third possibility is that both factors are operating. Clovis peoples frequently hunted Proboscideans, and the record is biased toward the discovery of these sites.

At this point, we are somewhat at a loss. Despite attempts to show that the Clovis faunal record is biased (Cannon and Meltzer, 2004), it is impossible to directly test a hypothesis about sample bias without a theoretical or empirical null model of the population that is sampled (see Surovell and Waguespack, in press). Therefore, the most that we are willing to conclude with any confidence is that the archeological record of Clovis Proboscidean exploitation is unique. Whether that is a function of the behavior of Paleoindians, Paleoindian archeologists, or geological systems is very difficult to address, and ultimately may have to be resolved with large sample sizes and/or different methods of sampling the archeological record. For the time being, we are, by necessity, forced to make arguments concerning the plausibility of sample bias and the frequent killing of Proboscideans.

Elsewhere, we have presented theoretical arguments concerning the plausibility and likelihood of specialized large mammal hunting in late Pleistocene North America (Waguespack, 2003; Waguespack and Surovell, 2003). We argue that a focal large game subsistence economy during Clovis times is not only plausible but also likely and

theoretically expected (but see Byers and Ugan, 2005). Concerning the issue of sample bias, we begin with discovery bias, perhaps the most frequently invoked bias in discussions of Clovis subsistence. Grayson (1988) and Meltzer (1989) have argued that Clovis elephant kill sites have a greater probability of discovery than other Clovis sites because elephant bones are extremely visible in cutbanks, backhoe trenches, or surface exposures (see also Cannon and Meltzer, 2004). In contrast, an exposed Clovis-aged flake or rabbit bone does not have the same visibility and therefore probability of discovery. This would inevitably bias discovery toward elephant-bearing sites, and we agree. However, this bias should not be unique to Clovis, and there is no reason to believe that it would not apply to our Old World sample as well. In fact, many of the sites we have identified were discovered this way- first the elephant bone, then the artifacts. In other words, there very well may be a bias operating but in this comparative framework, it should be more or less constant.

Is there a preservation bias? Grayson and Meltzer (2002, 2003) have pointed out that four of the sites in the Clovis sample are from one very small corner of southeastern Arizona, and Holliday (2003, p. 1373) attributes this cluster to "fortuitous circumstances of preservation and exposure". Similarly, Grayson (1988) has written:

> In short, the history of the discovery of Clovis sites in Southwest and Plains is such as to suggest that we have an extraordinarily biased sample of those sites, one that may have given us a greatly exaggerated impression of the importance of large mammals in the daily lives of those people. (Grayson, 1988, p. 115)

There is no question that the geochemical and geomorphic conditions in Eastern North America and the Far West leave a lot to be desired with respect to the preservation of Paleoindian faunal assemblages. Certainly, the vast majority of Clovis sites with faunal remains come from a limited portion of North America, and extrapolating what we see in the Plains and Southwest to the remainder of the North America is a precarious practice (Meltzer and Smith, 1986; Meltzer, 1988, 1989, 1993). However, sites in both the East and the Far West evidencing the possible subsistence use of elephants do exist (e.g., Rayl, 1974; Gustafson et al., 1979; Graham et al., 1981; Laub et al., 1988; Overstreet and Kolb, 2003). Furthermore, the sample we have is the sample with which we must work, and in that sample, elephant kill sites are remarkably common.

Could it be that Clovis elephant kills have a greater chance of preservation than Old World elephant kills? Certainly, because Clovis sites are considerably younger than virtually our entire Old World sample, they have withstood considerably less time over which destructive forces have operated. However, when we quantify the relative frequency of elephant subsistence sites for various spatio-temporal regions, site preservation is a constant and factors out of the equation (Eq. (15)). The critical question is whether Clovis elephant kills relative to other Clovis sites

have a greater probability of preservation than the same ratio for Old World contexts. This question is extraordinarily difficult to answer. Certainly, African elephants often die near water (Conybeare and Haynes, 1984; Haynes, 1987, 1991), and archeologically, elephant subsistence sites are found near ancient water sources, but this is true for the Old and New World samples. Obviously, wet lowland settings act as sediment traps increasing the likelihood of burial and preservation over upland settings. However, campsites, with or without elephant bone, are often found in similar contexts. At this point, we are content to leave this question unresolved.

Let us surmise for a moment that the abundance of elephant kill sites in the Clovis record is due to human behavior. Is it reasonable to expect that one out of two, or even one out of four archeological sites created during Clovis times were elephant kills? We suspect not. To us, this number seems very high and strongly suggests that some biases are likely operating. However, those same biases should operate in the Old World as well, and therefore, we suspect that a strong behavioral signal is coming through our sample, biased or not. In other words, the abundance of mammoth and mastodon kills known from Clovis contexts relative to Old World contexts is largely a product of past human behavior. Does this mean that mammoth meat was served on the dinner table every night in the latest Pleistocene of North America? Absolutely not. From our analysis, we cannot estimate an absolute frequency of elephant hunting. All we can say is that in comparison to the Old World record, Clovis peoples seem to have exploited elephants with much greater frequency than in any other time and place.

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